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ARTICLE

Development and validation of the sitting balance assessment for spinal cord injury (SitBASCI)

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STUDY DESIGN: Multicentric psychometric study.
OBJECTIVES: The aim of this study is to introduce the development of the Sitting Balance Assessment for Spinal Cord Injury (SitBASCI) and assess its inter-rater reliability and internal consistency.
SETTING: The study was developed among the three Spinal Units of San Bortolo Hospital in Vicenza, Niguarda Hospital in Milan and AOU Careggi in Florence.
METHODS: SitBASCI is a 13-item scale developed to evaluate trunk control in individuals with SCI. Subjects were filmed while performing the 13 items of the scale. The videotapes were submitted to 25 examiners who evaluated patients' performances with the scale. The power of the study was estimated. The interclass correlational coefficient (ICC) was used to assess the inter–rater reliability of the examiner's evaluations regarding each item and the total. Cronbach's alpha was used to assess internal consistency of the scale and internal consistency of the scale on the eliminated item.
RESULTS: The study showed to have a significant power. The inter-rater reliability for the total score was $p_{tot} = 0.997$ (item's values were $p = 0.876$–0.998). The internal consistency of the scale was alpha = 0.925, while the internal consistency of the scale on the eliminated item was alpha = 0.912–0.930.
CONCLUSION: SitBASCI had a high inter-rater reliability and internal consistency. Items had also good inter-rater reliability and item-total correlation. Therefore, SitBASCI could be proposed as a good and reliable instrument for Italian clinicians to evaluate sitting balance and trunk control in patient with SCI despite of aetiology and level of injury.

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INTRODUCTION

After a Spinal Cord Injury (SCI), the damage to the ascending and descending pathways of the spinal cord consequently results in an alteration in the postural control system [1, 2]. Postural control refers to the ability of maintaining balance against internal and external perturbances, with the goal of keeping the body centre mass within the base of support [3]. However, it has been proposed that following a SCI, a gradual development of specific motor synergies for balance control in sitting involving even non-postural muscles would lead to reorganisation of the individual's balance control system. These strategies are essential, as sitting is one of the most fundamental activities of daily living for persons with SCI and this ability determines their level of independence for many activities of daily living. [4, 5]. In order to make subjects with SCI independent to the maximum possible extent, therapists spend a significant time providing balance training to those individuals who cannot sit unsupported. To assess their sitting balance abilities, valid and reliable assessment measures are required [6–8]. For this reason, our first step was making a bibliographic search, from which several scales emerged. Among those, the quantitative ones that use force platforms and electromyography to register changes in the centre of gravity and muscle activation patterns are noteworthy. Although these measurements provide precise and quantitative data, their use in clinical practice is limited because of time constraints, equipment cost and the need for experience in use and interpretation [2, 9]. Clinical tests have the advantage of being able to be conducted in practically any situation and in every patient.

There are tests to clinically assess trunk control in other pathologies and situations that have been used in individuals with SCI. One of them, the Berg Balance Scale (BBS), originally created to assess balance capacities for geriatric and stroke populations, was analysed for use in SCI patients in two studies. Both of them determined that the Berg scale had a ceiling effect [10, 11]. Other instruments, such as the Scale Community Balance & Mobility Scale (CB&M), the Activities-specific Balance Confidence (ACB) Scale, the Function in Sitting Test (FIST) and the Sitting Balance Score (SBS), adapted and validated for SCI populations, were tested only for limited types of injury (iSCI) or chronic SCI and needed major revisions [11–14]. Furthermore, the Sitting Balance Scale (SBS) had not already been validated for SCI population [15].

Among all the clinical tests for the evaluation of trunk balance, only a few were created for individuals with SCI. The Trunk Control Test (TCT) evaluates static and dynamic equilibrium in patients

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with SCI using 13 tasks. In a study of 2014, it was assessed that this test needed more studies to verify its prognostic value for functional independence [2]. The Thoracic—Lumbar Control Scale (TLCS) is a Brazilian validated 10-task scale used to quantify trunk disfunction in individuals with SCI. It had good reliability and underwent a cross-cultural validation in English. However, it is not suitable for individuals with complete cervical lesion [3]. The Sitting Balance Measure (SBM) is a 24-item scale designed for the evaluation of sitting balance in patients with SCI. A Study of 2015 showed that the scale had item redundancy and more studies were needed to eliminate the additional tasks [6]. Moreover, even now it is only validated in Hindi. The Activity-Based Balance-Level Evaluation (ABLE) Scale was validated in the United States. It consisted of 30 items, whereas it is not suitable for every level of injury because it evaluated standing and walking in addition to sitting [16]. Finally, the modified Functional Reach Test (mFRT), the Seated Reach Distance, the Maximal Balance Range, the Upper Body Sway and the Balance Tests (LOS/SWS), which had been proven to be reliable for SCI, appeared to cover only some aspects of sitting stability, in order to convey the wide concept of sitting balance. Moreover only few of them could correlate their values with information about ability and independence of subjects [6, 14, 17, 18].

In the light of the foregoing, literature appeared to lack of scales which address trunk disfunction and sitting balance in individuals with SCI despite of aetiology and level of injury [10]. Furthermore, the modality of evaluation of trunk balance in Italian SCI rehabilitation centres was investigated by the National Coordination of Professional Operators of Spinal Units (CNOPUS). A questionnaire was sent to 320 clinicians in 50 structures (Spinal Units and Rehabilitation Centres in Italy). From the analysed data, only 1 centre used an instrument for the evaluation of balance and trunk control, which was self-produced and not validated; all the others carried out the evaluations exclusively with observation and description of patient's functional performances. In conclusion, almost no centre assessed balance and trunk using validated tools, according to the results obtained from the questionnaire [19].

For these reasons, it became necessary to create the new Sitting Balance Assessment for Spinal Cord Injury (SitBASCI). It is a 13-item scale designed for individuals with every type and level of injury. Its purpose is to evaluate and highlight the differences between the various types of SCI. This new instrument evaluates sitting balance and trunk control and allows therapists to figure out the functional condition of the patients. Hence, it could be used as an effective evaluating tool but also as a rehabilitation instrument.

The Italian and first version of this scale was created in 2014 by the collaboration between the experts of the Spinal Units of Niguarda Hospital of Milan and Careggi Hospital of Firenze. The items were created taking inspiration from some tasks of the Sitting Balance Scale (SBS) [6, 15], some exercises proposed during rehabilitation sessions and finally including the unique item of the mFRT [6, 14]. Front validity of SitBASCI was investigated and an online assessment was sent to some physiotherapists from Spinal Units of Milan, Ancona, Perugia, Florence and Turin in Italy. It investigated 4 dimensions of the scale: adequacy, intelligibility, reliability and sensibility. Each dimension obtained a high score (medium score of 5 out of 6), which was superior to cut-off (3.5 out of 6).

The scale underwent several steps of validation which were not published. The study involved 80 subjects with SCI; they were evaluated with SitBASCI, SBS, ASIA Impairment Scale (AIS), Upper Extremity and Lower Extremity Motor Score (UEMS and LEMS), SCIM III and TLCS [20–23]. It resulted in a high internal consistency of the scale and a high item-total correlation on the eliminated task (Cronbach's alpha = 0.9525–0.9609). At the same time, the scale underwent a component analysis to find and reduce factors which could influence patient's evaluation. An ANCOVA model was used to analyse the covariance and remove differences in the sample. Results

assessed that lesion level and AIS score were the only variables which could influence scale's final score.

Construct validity was evaluated using the concurrent validity. Results of SitBASCI regarding the 80 subjects were compared to the ones of SBS through Pearson's correlation. The results assessed a high correlation between the scales ($r = 0.98$). Moreover, since in literature was found a strong correlation between functional abilities and trunk control in individuals with SCI, an hypothetical correlation between SCIM III and SitBASCI was evaluated [20, 21]. It was found that the scale had a good correlation ($r = 0.8303$).

In 2016 by the collaboration between Verona University and Spinal Units of San Bortolo Hospital, Niguarda Hospital and Careggi Hospital, the scale underwent a inter-rater and internal consistency preliminary study. A sample of 10 patients staying at San Bortolo Hospital were filmed while performing the 13 items of the scale. The videotapes were shown to 20 physiotherapists who evaluated patients' performances with SitBASCI. Results showed a high inter-rater reliability (Pearson's $r = 0.95$) and a strong internal consistency (Cronbach's alpha = 0.892).

All the mentioned steps were necessary to pre-test the scale in order to obtain an efficient tool, which is the object of this work. Therefore, the aim of this study is to assess inter-rater reliability and internal consistency of the first Italian version of SitBASCI.

METHODS

This is a multicentric psychometric study performed among the Spinal Units of three medical centres in Italy: San Bortolo Hospital in Vicenza, Niguarda Hospital in Milan and Careggi Hospital in Florence. The study period was November 2018-September 2019. The study was approved by the Institutional Review Board of San Bortolo Hospital (IEC ULSS 8 Berica). All the enroled patients signed a consent form.

Instruments of measuring

SitBASCI is a 13-item scale designed for SCI patients, which globally evaluates sitting balance and trunk control. Its items are summarized in the Appendix 1. All items must be performed starting from a standardized sitting position, with 90° knee's flexion, hands on knees and feet on the ground. They assess maintaining the sitting position with and without support, with eyes opened or closed; anterior trunk flexion and lateral inclination; maintaining the sitting position while resisting anterior, posterior and lateral perturbations; making trunk rotations; touching an object on the ground; maintaining the sitting position on a proprioceptive pillow; stretches on elbows; target reaching; taking the feet on a lift. For each task, the patient could take 3 attempts and the score is given referring to the best try, ranging from 0 to 4 points. For the entire evaluation, it could be reached a maximum of 52 points.

Subjects

Individuals of both sexes which satisfied the inclusion and exclusion criteria were included. The inclusion criteria were age 18–79 years; clinical diagnosis of traumatic or not-traumatic, complete or incomplete Spinal Cord Injury (AIS A, B, C, D); lesion level C3-L5 according to the American Spinal Injury Association (ASIA) classification; time from injury >2 months; achievement of sitting position; the individual must have done some balance training during rehabilitation sessions [22, 23].

The exclusion criteria consisted of absence of stable clinical condition; presence of orthoses; presence of psychiatric, neurological or other comorbidities; presence of serious skeletal deformations, range of motion (ROM) limitations or pression ulcers; previous amputations or sense organs' deficits.

Examiners

The study was proposed to the expert physiotherapists and occupational therapists of the 3 Spinal Units involved. Some of them proposed

Fig. 1 View of the front fixed shots - Execution of item 2. Mantaining the sitting position without support with eyes open.

Fig. 2 View of the aerial shots - Execution of item 12. Reaching of targets identified by the therapist.

themselves voluntarily. Twenty-five examiners with a minimum working experience in Spinal Units > 5 years were finally recruited.

Procedures

The patients were filmed while performing the 13 items of the scale. A professional camera was used for the fixed shots (Fig. 1) and a smartphone camera for the aerial shots (Fig. 2). During recordings, patients were seated on a rehabilitation bed and needed a proprioceptive pillow, a wood platform (50 cm × 5 cm × 20 cm) and a pen to perform some tasks of the scale. A chronometer, a centimetric pole and a marker on the patients were used to give visual parameters for patient performances' evaluation. All the videos were recorded at the rehabilitation gym of San Bortolo Hospital in Vicenza. One physiotherapist leaded all the evaluations while recording.

Then, the videotapes have been assembled and given to the examiners through a Google Drive™ account. A group of 5 videos were uploaded approximately every month for a total of 4 groups. On the same account, were loaded a copy of SitBASCI, a short handbook with some explanations about the items and a paper with a standardized table in which examiners had to note the patients' performances for each item and the performance's total score. Each examiner could only watch each video once, but could stop viewing whenever they wanted. Gradually, evaluations' papers were collected, and values were brought together in an excel file.

Statistical analysis

For data analysis the IBM SPSS Statistics version 26 for macOS was used. We estimated mean and standard deviation (SD) for continuous variables, and frequencies and percentage for qualitative variables. The power of the study was estimated using the following formula

$$K = 1 + \frac{2n(U_a + U_b)^2}{(l_n C_o)^2 (n-1)}$$

assuming that K = required number of subjects (sample size); p_0 = the minimally acceptable level of reliability; p_1 = specific underlying value of $p$under H_1: $p > p_o$; n = number of raters/repetition for each subjects; $C_o = (1 + n\theta_o\ /\ (1 + n\theta)$; $\theta_0 = p_o/(1 - p_0)$; $\theta = p_1/(1 - p_1)$; α = type I error; β = type II error; $U_\alpha = 100(1 - \alpha)$; $U_\beta = 100(1 - \beta)$) [24].

The interclass correlation coefficient (ICC), reported with 95% confidence limits, was used to evaluate the inter-rater reliability of the examiners' evaluations regarding each item and the total of the scale [25]. The internal consistency of the scale, which shows the correlation between items in the instrument, and the internal consistency of the scale on the eliminated item, which could give a good interpretation of item-total correlation, were evaluated by Cronbach's alpha [26].

RESULTS

From 25 patients with SCI from the outpatient and hospitalized lists, 20 met the inclusion criteria and were recruited for the study. Sample characteristics are summarized in Table 1. In all, 90% of the patient were male. The mean age was 45.9 (s.d. ± 15.7, range 21–72 years). The estimated neurological levels were tetraplegia (range C3–C8, $n = 6$, 30%), high paraplegia (range T1–T8, $n = 10$, 50%) and low paraplegia (range T9-L5, $n = 4$, 20%). Overall, grade A complete lesions were present in 60% of the patients, according to AIS, grade B incomplete lesions in 20%, grade C incomplete lesions in 5% and grade D incomplete lesions in 15%.

Twenty-five examiners were recruited: 68% were women and 44% of the total came from the Spinal Unit of Vicenza. The average work activity was 15,8 years (s.d. ± 10).

Concerning the power of the study, assuming an expected reliability (ICC) of $p_0 = 0.85$, with 95% confidence level and an expected precision of 0.1, the required number of subjects estimated with the above-mentioned formula for $n = 25$ raters should be K = 15 [24]. Our study included K = 20 subjects.

Then, a total of 500 evaluation papers were examined to determine the inter-rater reliability of examiners' evaluations for each item and the total score of the scale, the internal consistency of the scale and of the scale on the eliminated item. Results are summarized in Table 2.

For the inter-rater reliability regarding the total, an average ICC of $p_{tot} = 0.997$ (s.d. ± 0.002) was found. For the items, the value varied from $p = 0.876$ (Item 1), to $p = 0.998$ (Item 13), with a mean of $p_m = 0.980$ (s.d. ± 0.039). The scale shows an internal consistency of Cronbach's alpha = 0.925, while internal consistency on the eliminated item varied from alpha = 0.912 (Item 12) to alpha = 0.930 (Item 1).

DISCUSSION

The aim of this study was to introduce and validate SitBASCI, assessing its inter-rater reliability and internal consistency. According to the results, in opposition to the previously nominated tools, the scale appeared to be a reliable test, which could enrich literature about the evaluation of sitting balance and trunk control in SCI individuals.

First of all, the power of the study was investigated. The study was compared with a theorical one, which had good power (n = 25 raters and a good reliability (ICC) of $p_0 = 0.85$, with 95%

Table 1. Subjects demographic characteristics.

Subject n.	M/F		Lesion level		ASIA Impairment Scale (AIS)
1	M		T6		D
2	M		C6		C
3	M		C6		A
4	M		T3		A
5	M		T6		B
6	M		T11		A
7	M		C6		B
8	M		C6		A
9	F		C6		A
10	M		L4		B
11	M		T4		A
12	M		T4		A
13	M		T6		A
14	F		T4		A
15	M		T4		A
16	M		L3		B
17	M		L1		D
18	M		C5		D
19	M		T5		A
20	M		T8		A
Male (M)	18 subjects (90%)		Female (F)		2 subjects (10%)
Lesion level	C3-C8, 6 subjects (30%)		T1-T8, 10 subjects (50%)		T9-L5, 4 subjects (20%)
AIS	A, 12 subjects (60%)	B, 4 subjects (20%)		C, 1 subject (5%)	D, 3 subjects (15%)

Table 2. Inter-rater reliability (ICC with 95% confidence limits) of the items, internal consistency (Cronbach's Alpha) of the scale on the eliminated item.

		CI 95%		
	Inter-rater reliability	Below	Upper	Internal consistency of SitBASCI on the eliminated item
Item 1	0.876	0,782	0,942	0.930
Item 2	0.983	0,970	0,992	0.925
Item 3	0.994	0,990	0,997	0.921
Item 4	0.994	0,990	0,997	0.916
Item 5	0.982	0,969	0,992	0.916
Item 6	0.989	0,981	0,995	0.915
Item 7	0.985	0,974	0,993	0.916
Item 8	0.982	0,968	0,992	0.917
Item 9	0.996	0,992	0,998	0.917
Item 10	0.993	0,987	0,997	0.925
Item 11	0.982	0,969	0,992	0.923
Item 12	0.991	0,984	0,996	0.912
Item 13	0.998	0,996	0,999	0.916
Mean	0.980	/	/	0.919
Standard deviation	0.039	/	/	0.005

confidence level and an expected precision of 0.1). For this one, the required number of subjects was assessed to be K = 15 using the above-mentioned formula [24]. Therefore, having the same requirements, a higher number of subject (K = 20) and better reliability (ICC of $p_{tot} = 0.997$, s.d. ± 0.002), our study showed a higher power compared to the other one.

Raters' evaluations for each item (ICC of $p = 0.876 - 0.998$) and for the total (ICC of $p_{tot} = 0.997$, s.d. ± 0.002) showed a high inter-rater reliability. These values reinforced the one found in the preliminary study (Pearson's r = 0.95) and proved that SitBASCI and its items are reliable too. Therefore, therapists could use them as good instruments to evaluate the same subject without the problem of obtaining completely different outcomes. Moreover, the high internal consistency (Cronbach's Alpha = 0.925) proved that the scale is a specific tool, and each item evaluates a determined aspect of trunk control and creates a perfect balance. In fact, the high inter-rater reliability of the items (average $p_m = 0.980$, s.d. ± 0.039), with a maximum of $p = 0.998$ (item 13) and a minimum of $p = 0.876$ (item 1) and the good item-total correlation, given by the values of the internal consistency of the scale on the eliminated item (alpha = 0.912–0.930), could suggest that all of them are necessary to the equilibrium of the instrument because they give sensibility to the scale and their potential removal could result in an increase of the general internal consistency. In this case, SitBASCI could become too specific and not suitable to evaluate subjects with poor health conditions.

For the same reason, we had to make a separate interpretation for results of Item 1. This item obtained the lowest value for the inter-rater reliability ($p = 0.876$), thus the highest score regarding its correlation with the total (Cronbach's alpha = 0.930). These results suggested that, despite the value of ICC, its removal could cause a significant increase in the internal consistency of the scale and consequently in its specificity. Therefore, it was decided to examine the results from a rehabilitation view. To perform this first task, subjects were asked to maintain the sitting position with support, which represents a necessary ability for SCI people to develop a good trunk control. It follows that subjects who did not pass this task with a high score would probably obtain poor results also in the other performances, causing what is called as the "pavement effect". This may happen because item 1 expresses the highest grade of sensibility of SitBASCI and becomes essential during the evaluation of subjects with very poor functional and motor abilities. In fact, for future directions, it could be useful to use this item as a "gate task" and study if it could allow therapists to make a forecast prevision of subjects' other 12 performances, basing the evaluation on the first one. For this reason and because of their good values concerning inter-rater reliability, the same reasoning could not be valid for other items, such as item 2 and item 10, which obtained high Cronbach's alpha score too.

This study presents some limits. First of all, the enroled sample was small. Therefore, further studies enroling large samples for other tertiary referral centres for people with spinal cord injury are mandatory to test definitely the validity and consistency of SitBASCI, developed by this group of clinicians.

Secondary, SitBASCI was developed in the authors' language, Italian, so a trans-cultural adaptation is mandatory to apply it in the other countries.

CONCLUSIONS

In this study, Sitting Balance Assessment for Spinal Cord Injury (SitBASCI) showed a high inter- rater reliability and internal consistency. Items had also good inter-rater reliability and item-total correlation, except for item 1 which, however, gives sensibility to the scale and allows to early identify and distinguish individuals with low and high independence and trunk control. Therefore, SitBASCI could be proposed as a good and reliable instrument for Italian clinicians to evaluate sitting balance and trunk control in SCI patients despite of aetiology, level and type of injury.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Peeters LHC, de Groot IJM, Geurts ACH. Trunk involvement in performing upper extremity activities while seated in neurological patients with a flaccid trunk – A review. Gait Posture. 2018;62:46–55. https://doi.org/10.1016/j.gaitpost.2018.02.028. Available from
2. Quinzaños J, Villa AR, Flores AA, Pérez R. Proposal and validation of a clinical trunk control test in individuals with spinal cord injury. Spinal Cord. 2014;52:449–54.
3. Pastre CB, Lobo AM, Oberg TD, Pithon KR, Yoneyama SM, Lima NMFV, et al. Validation of the Brazilian version in Portuguese of the Thoracic-Lumbar Control Scale for spinal cord injury. Spinal Cord. 2011;49:1198–202.
4. Serra-Añó P, Pellicer-Chenoll M, Garcia-Massó X, Brizuela G, García-Lucerga C, González Moreno LM, et al. Sitting balance and limits of stability in persons with paraplegia. Spinal Cord. 2013;51:267–72.
5. Poncumhak P, Saengsuwan J, Kamruecha W, Amatachaya S. Reliability and validity of three functional tests in ambulatory patients with spinal cord injury. Spinal Cord. 2013;51:214–7.
6. Wadhwa G, Aikat R. Development, validity and reliability of the "Sitting Balance Measure" (SBM) in spinal cord injury. Spinal Cord. 2016;54:319–23.
7. Sayenko DG, Alekhina MI, Masani K, Vette AH, Obata H, Popovic MR, et al. Positive effect of balance training with visual feedback on standing balance abilities in people with incomplete spinal cord injury. Spinal Cord. 2010;48:886–93.
8. Field-Fote EC, Ray SS. Seated reach distance and trunk excursion accurately reflect dynamic postural control in individuals with motor-incomplete spinal cord injury. Spinal Cord. 2010;48:745–9.
9. Mitchell MD, Yarossi MB, Pierce DN, Garbarini EL, Forrest GF. Reliability of surface EMG as an assessment tool for trunk activity and potential to determine neurorecovery in SCI. Spinal Cord. 2015;53:368–74.
10. Lemay JF, Nadeau S. Standing balance assessment in ASIA D paraplegic and tetraplegic participants: Concurrent validity of the Berg Balance Scale. Spinal Cord. 2010;48:245–50.
11. Chan K, Guy K, Shah G, Golla J, Flett HM, Williams J, et al. Retrospective assessment of the validity and use of the community balance and mobility scale among individuals with subacute spinal cord injury. Spinal Cord. 2017;55:294–9.
12. Shah G, Oates AR, Arora T, Lanovaz JL, Musselman KE. Measuring balance confidence after spinal cord injury: the reliability and validity of the activities-specific balance confidence scale. J Spinal Cord Med. 2017;40:768–76.
13. Abou L, Sung JH, Sosnoff JJ, Rice LA. Reliability and validity of the function in sitting test among non-ambulatory individuals with spinal cord injury. J Spinal Cord Med. 2020;43:846–53.
14. Jørgensen V, Elfving B, Opheim A. Assessment of unsupported sitting in patients with spinal cord injury. Spinal Cord. 2011;49:838–43.
15. Medley A, Thompson M. Development, reliability, and validity of the sitting balance scale. Physiother Theory Pract. 2011.
16. Ardolino EM, Hutchinson KJ, Zipp GP, Clark MA, Harkema SJ. The ABLE scale: The development and psychometric properties of an outcome measure for the spinal cord injury population. Phys Ther. 2012;92:1046–54.
17. Gao KL, Chan KM, Purves S, Tsang WWN. Reliability of dynamic sitting balance tests and their correlations with functional mobility for wheelchair users with chronic spinal cord injury. J Orthop Transl. 2015;3:44–9. https://doi.org/10.1016/j.jot.2014.07.003. Available from
18. Galeoto G, Berardi A, Tofani M, MA Marquez. Measuring Spinal Cord Injury. A Pratctical Guide of Outcome Measures. Springer Ed, 2021.
19. Bianconi T, Rossi G. Italina Outcome Measure Toolkit for Spinal Cord Injury. Fondazione Serena Ed. 2017.
20. Itzkovich M, Gelernter I, Biering-Sorensen F, Weeks C, Laramee MT, Craven BC, et al. The Spinal Cord Independence Measure (SCIM) version III: Reliability and validity in a multi-center international study. Disabil Rehabil. 2007;29:1926–33.
21. Bluvshtein V, Front L, Itzkovich M, Aidinoff E, Gelernter I, Hart J, et al. SCIM III is reliable and valid in a separate analysis for traumatic spinal cord lesions. Spinal Cord. 2011;49:292–6.
22. Harvey L, Graves D. International Standards for the Neurological Classification of Spinal Cord Injury. J Physiother. 2011;57:129.
23. Kirshblum S, Waring W. Updates for the international standards for neurological classification of Spinal Cord Injury. Phys Med Rehabil Clin N Am. 2014;25:505–17. https://doi.org/10.1016/j.pmr.2014.04.001. Available from
24. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Stat Med. 1998;17:101–10.
25. Bonett DG. Sample size requirements for estimating intraclass correlations with desired precision. Stat Med. 2002;21:1331–5.
26. Wadhwa G, Aikat R. Development, validity and reliability of the "Sitting Balance Measure" (SBM) in spinal cord injury. Spinal Cord. 2016;54:319–23. https://doi.org/10.1038/sc.2015.148. Available from

AUTHOR CONTRIBUTIONS

Research project—conception: TB, PA and BB; organization: PA, TB and BB; execution: PA, EG, AG and FC. Statistical analysis—design: AG, PA, AG and FC; execution: AG; review and critique: MS and GB. Manuscript—writing of the first draft: AG and TB; review and critique: GS and TB.

COMPETING INTERESTS

The authors declare no competing interests.

ETHICS

Authors certify that all applicable institutional and government regulations concerning the ethical use of human volunteers were followed during the course of this research. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all partecipants for being included in the study. Institutional Review Board approval was obtained by San Bortolo Hospital (IEC USLL 8 Berica).

ADDITIONAL INFORMATION

Correspondence and requests for materials should be addressed to Tatiana Bianconi.