Table 1: Psychometric properties for the assessments used at the different ICF levels

A. Body Structure and Function level outcomes

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Reliability | | | Validity | | | | Responsiveness |
| Intra-rater | Inter-rater | Test-Retest | Concurrent | Construct | Content | Face |
| Fugl-Meyer Assessment | [1] | [2] | [2] | [3] | [4] | [5] | [5] | [6] |
| Motor performance Kinematic measures |  |  | [7] | [8] |  |  |  | [7] |
| Movement pattern Kinematic measures |  |  | [7] | [9] |  | [10] |  | [11] |
| Modified Ashworth’s Scale | [12] | [12] |  | [13] | [14] |  |  | [15] |
| Original Ashworth’s scale | [16] | [16] |  |  |  |  |  |  |
| Grip strength |  | [17] | [18] | [19] |  |  |  | [20] |
| Pinch Strength |  | [17] | [18] | [19] |  |  |  | [21] |
| Isometric strength of upper limb muscles | [22] | [22] |  | [23] | [24] |  |  | [20] |
| Motricity Index | [25] | [25] |  | [26] | [26] |  |  | [27] |
| MEPs and motor thresholds obtained using TMS |  |  | [28] | [28] |  |  |  | [29] |
| Goniometry to measure range of motion | [30] | [30] |  |  |  |  |  | [30] |
| Brunnstrom’s stage of motor recovery |  | [31] |  | [32] |  |  |  |  |
| fMRI |  |  | [33] |  |  |  |  |  |
| Reaching Performance Scale in Stroke | [34] | [34] | [10] | [34] |  | [10] |  | [11] |
| Manual Function Test [35] |  | [35] | [35] | [35] |  |  |  | [35] |
| Chedoke McMaster Stroke Assessment | [36] | [36] |  | [36] |  | [36] |  | [37] |
| Stroke Impact Scale-Strength |  | [38] |  | [39] | [40] | [41] |  | [42] |

B. Activity Limitation outcomes

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Reliability | | | Validity | | | | Responsiveness |
| Intra-rater | Inter-rater | Test-Retest | Concurrent | Construct | Content | Face |
| Wolf Motor Function Test |  | [43] | [44] | [43] | [45] | [46] |  | [47] |
| Box and Blocks Test |  | [2] | [48] | [49] |  |  |  | [49] |
| Motor Activity Log |  |  | [50] | [51] | [52] |  |  | [50] |
| Action Research Arm Test | [53] | [53] | [2] | [2] | [54] | [55] |  | [6] |
| Jebsen Test of Motor Function | [56] | [56] |  | [21] |  |  |  | [21] |
| Functional Independence Measure |  | [57] | [58] | [58] | [59] |  |  | [58] |
| Barthel Index |  | [60] | [61] | [60] |  |  |  | [60] |
| Nine Hole Peg Test |  | [48] | [48] | [49] |  |  |  | [21] |
| Chedoke Arm and Hand Activity Inventory |  | [62] | [62] | [62] | [63] | [63] |  | [64] |
| ABILHAND |  |  | [65] | [66] | [67] |  |  | [66] |
| Stroke Impact Scale ADL |  | [38] |  | [39] | [40] | [41] |  | [42] |
| Nottingham Extended Activities of Daily Living (NEADL) |  |  | [61] | [66] | [68] |  |  | [69] |
| Assessment of Motor and Process Skills |  |  | [70] | [71] |  |  |  | [72] |
| Functional Test of the Hemiparetic Upper Extremity |  | [73] |  | [73] | [74] |  |  |  |
| Canadian Occupational Performance Measure |  |  | [75] | [76] |  |  |  | [77] |
| Fatigue Severity Scale |  |  | [78] | [78] | [78] |  |  | [78] |

C. Contextual Factors and Participation level outcomes

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Reliability | | | Validity | | | | Responsiveness |
| Intra-rater | Inter-rater | Test-Retest | Concurrent | Construct | Content | Face |
| Intrinsic Motivation Inventory |  |  | [79] |  | [80] | [81] |  |  |
| Stroke Impact Scale [40] |  |  | [40] | [40] |  |  |  | [40] |
| Short Form- 36 |  | [82] | [82] | [83] | [84] |  |  | [85] |
| Beck’s Depression Inventory |  |  | [86] | [87] |  |  |  | [88] |
| EuroQoL 5D |  |  | [89] | [90] |  |  |  | [89] |
| Stroke Specific Quality of Life |  |  | [91] | [92] | [93] | [94] |  | [94] |
| Hamilton Depression Rating Scale |  |  | [95] | [87] |  |  |  | [96] |

References

1. Duncan PW, Propst M, Nelson SG. Reliability of the Fugl-Meyer assessment of sensorimotor recovery following cerebrovascular accident. Phys Ther. 1983;63:1606-10.

2. Platz T, Pinkowski C, van Wijck F, et al. Reliability and validity of arm function assessment with standardized guidelines for the Fugl-Meyer Test, Action Research Arm Test and Box and Block Test: a multicentre study. Clin Rehabil. 2005;19:404-11.

3. Kim H, Her J, Ko J, et al. Reliability, concurrent validity, and responsiveness of the Fugl-Meyer assessment (FMA) for hemiplegic patients. J Phys Ther Science. 2012;24:893-899.

4. Woodbury ML, Velozo CA, Richards LG, et al. Longitudinal stability of the Fugl-Meyer Assessment of the upper extremity. Arch Phys Med Rehabil. 2008;89:1563-9.

5. Gladstone DJ, Danells CJ, Black SE. The Fugl-Meyer Assessment of motor recovery after stroke: a critical review of its measurement properties. Neurorehabil Neural Repair. 2002;16:232-40.

6. Rabadi MH, Rabadi FM. Comparison of the Action Research Arm Test and the Fugl-Meyer assessment as measures of upper-extremity motor weakness after stroke. Arch Phys Med Rehabil. 2006;87:962-6.

7. Wagner JM, Rhodes JA, Patten C. Reproducibility and minimal detectable change of three-dimensional kinematic analysis of reaching tasks in people with hemiparesis after stroke. Phys Ther. 2008;88:652-63.

8. Rohafza M, Fluet GG, Qiu Q, et al., editors. Correlation of reaching and grasping kinematics and clinical measures of upper extremity function in persons with stroke related hemiplegia. 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society; 2014: IEEE.

9. Subramanian SK, Yamanaka J, Chilingaryan G, et al. Validity of movement pattern kinematics as measures of arm motor impairment poststroke. Stroke. 2010;41:2303-8.

10. Subramanian SK, Banina MC, Chilingaryan G, Levin MF. Reaching Performance Scale for stroke: test-retest reliability and concurrent and discriminant validity in individuals with chronic stroke .World Congress of Neurological Rehabilitation; May 2016; Philadelphia, PA.2016.

11. Subramanian SK, Lourenco CB, Chilingaryan G, et al. Arm motor recovery using a virtual reality intervention in chronic stroke: randomized control trial. Neurorehabil Neural Repair. 2013;27:13-23.

12. Gregson JM, Leathley MJ, Moore AP, et al. Reliability of measurements of muscle tone and muscle power in stroke patients. Age Ageing. 2000;29:223-8.

13. Pundik S, McCabe J, Skelly M, et al. Association of spasticity and motor dysfunction in chronic stroke. Ann Phys Rehabil Med. 2019;62:397-402.

14. Pandyan AD, Price CI, Rodgers H, et al. Biomechanical examination of a commonly used measure of spasticity. Clin Biomech (Bristol, Avon). 2001;16:859-65.

15. Chen CL, Chen CY, Chen HC, et al. Responsiveness and minimal clinically important difference of Modified Ashworth Scale in patients with stroke. Eur J Phys Rehabil Med. 2019;55:754-760.

16. Brashear A, Zafonte R, Corcoran M, et al. Inter- and intrarater reliability of the Ashworth Scale and the Disability Assessment Scale in patients with upper-limb poststroke spasticity. Arch Phys Med Rehabil. 2002;83:1349-54.

17. CDCdeM F, Aguiar L, Lara E, et al. Dynamometry for the assessment of grip, pinch, and trunk strength in subjects with chronic stroke: reliability and various sources of outcome values. Int J Phys Med Rehabil. 2013;1(168):2. DOI:10.4172/2329-9096.1000168

18. Aguiar LT, Martins JC, Lara EM, et al. Dynamometry for the measurement of grip, pinch, and trunk muscles strength in subjects with subacute stroke: reliability and different number of trials. Braz J Phys Ther. 2016;20:395-404.

19. Bae JH, Kang SH, Seo KM, et al. Relationship between grip and pinch strength and activities of daily living in stroke patients. Ann Rehabil Med. 2015;39:752-62.

20. Lang CE, Edwards DF, Birkenmeier RL, et al. Estimating minimal clinically important differences of upper-extremity measures early after stroke. Arch Phys Med Rehabil. 2008;89:1693-700.

21. Beebe JA, Lang CE. Relationships and responsiveness of six upper extremity function tests during the first six months of recovery after stroke. J Neurol Phys Ther. 2009;33:96-103.

22. Riddle DL, Finucane SD, Rothstein JM, et al. Intrasession and intersession reliability of hand-held dynamometer measurements taken on brain-damaged patients. Phys Ther.1989;69:182-94.

23. Pang MY, Eng JJ. Muscle strength is a determinant of bone mineral content in the hemiparetic upper extremity: implications for stroke rehabilitation. Bone. 2005;37:103-11.

24. Wagner JM, Lang CE, Sahrmann SA, et al. Relationships between sensorimotor impairments and reaching deficits in acute hemiparesis. Neurorehabil Neural Repair. 2006;20:406-16.

25. Collin C, Wade D. Assessing motor impairment after stroke: a pilot reliability study. J Neurol Neurosurg Psychiatry. 1990;53:576-9.

26. Bohannon RW. Motricity Index scores are valid indicators of paretic upper extremity strength following stroke. J Phys Ther Sci. 1999;11:59-61.

27. Safaz I, Yilmaz B, Yasar E, et al. Brunnstrom recovery stage and Motricity Index for the evaluation of upper extremity in stroke: analysis for correlation and responsiveness. Int J Rehabil Res. 2009;32:228-31.

28. Koski L, Lin JC, Wu AD, et al. Reliability of intracortical and corticomotor excitability estimates obtained from the upper extremities in chronic stroke. Neurosci Res. 2007;58:19-31.

29. Koski L, Mernar TJ, Dobkin BH. Immediate and long-term changes in corticomotor output in response to rehabilitation: correlation with functional improvements in chronic stroke. Neurorehabil Neural Repair. 2004;18:230-49.

30. Gajdosik RL, Bohannon RW. Clinical measurement of range of motion. Review of goniometry emphasizing reliability and validity. Phys Ther. 1987;67:1867-72.

31. Shah S. Reliability of the original Brunnstrom recovery scale following hemiplegia. Aust Occup Ther J. 1984;31:144-151.

32. Naghdi S, Ansari NN, Mansouri K, et al. A neurophysiological and clinical study of Brunnstrom recovery stages in the upper limb following stroke. Brain Inj. 2010;24:1372-1378.

33. Kimberley TJ, Khandekar G, Borich M. fMRI reliability in subjects with stroke. Exp Brain Res. 2008;186:183-90.

34. Levin MF, Desrosiers J, Beauchemin D, et al. Development and validation of a scale for rating motor compensations used for reaching in patients with hemiparesis: the Reaching Performance Scale. Phys Ther. 2004;84:8-22.

35. Kim HJ, Min K, Lee CH, et al. Clinical applicability and psychometric properties of Manual Function Test for patients with stroke. Tohoku J Exp Med. 2017;243:85-93.

36. Gowland C, Stratford P, Ward M, et al. Measuring physical impairment and disability with the Chedoke-McMaster Stroke Assessment. Stroke. 1993;24:58-63.

37. Mangold S, Schuster C, Keller T, et al. Motor training of upper extremity with functional electrical stimulation in early stroke rehabilitation. Neurorehabil Neural Repair. 2009;23:184-190.

38. Carod-Artal FJ, Ferreira Coral L, Stieven Trizotto D, et al. Self- and proxy-report agreement on the Stroke Impact Scale. Stroke. 2009;40:3308-14.

39. Duncan PW, Lai SM, Tyler D, et al. Evaluation of proxy responses to the Stroke Impact Scale. Stroke. 2002;33:2593-9.

40. Duncan PW, Wallace D, Lai SM, et al. The Stroke Impact Scale version 2.0. Evaluation of reliability, validity, and sensitivity to change. Stroke. 1999;30:2131-40.

41. Duncan PW, Bode RK, Min Lai S, et al. Rasch analysis of a new stroke-specific outcome scale: the Stroke Impact Scale. Arch Phys Med Rehabil. 2003;84:950-63.

42. Guidetti S, Ytterberg C, Ekstam L, et al. Changes in the impact of stroke between 3 and 12 months post-stroke, assessed with the Stroke Impact Scale. J Rehabil Med. 2014;46:963-8.

43. Wolf SL, Catlin PA, Ellis M, et al. Assessing Wolf Motor Function Test as outcome measure for research in patients after stroke. Stroke. 2001;32:1635-9.

44. Morris DM, Uswatte G, Crago JE, et al. The reliability of the Wolf Motor Function Test for assessing upper extremity function after stroke. Arch Phys Med Rehabil. 2001;82:750-5.

45. Woodbury M, Velozo CA, Thompson PA, et al. Measurement structure of the Wolf Motor Function Test: implications for motor control theory. Neurorehabil Neural Repair. 2010;24:791-801.

46. Wolf SL, Lecraw DE, Barton LA, et al. Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head-injured patients. Exp Neurol. 1989;104:125-32.

47. Lin JH, Hsu MJ, Sheu CF, et al. Psychometric comparisons of 4 measures for assessing upper-extremity function in people with stroke. Phys Ther. 2009;89:840-50.

48. Chen HM, Chen CC, Hsueh IP, et al. Test-retest reproducibility and smallest real difference of 5 hand function tests in patients with stroke. Neurorehabil Neural Repair. 2009;23(5):435-40.

49. Lin KC, Chuang LL, Wu CY, et al. Responsiveness and validity of three dexterous function measures in stroke rehabilitation. J Rehabil Res Dev. 2010;47:563-71.

50. Van der Lee J, Beckerman H, Knol D, et al. Clinimetric properties of the Motor Activity Log for the assessment of arm use in hemiparetic patients. Stroke. 2004;35:1410-1414.

51. Uswatte G, Taub E, Morris D, et al. The Motor Activity Log-28: assessing daily use of the hemiparetic arm after stroke. Neurology. 2006;67:1189-1194.

52. Chuang I-C, Lin K-C, Wu C-Y, et al. Using Rasch analysis to validate the Motor Activity Log and the lower functioning Motor Activity Log in patients with stroke. Phys Ther. 2017;97:1030-1040.

53. Yozbatiran N, Der-Yeghiaian L, Cramer SC. A standardized approach to performing the Action Research Arm Test. Neurorehabil Neural Repair. 2008;22:78-90.

54. Chen H-f, Lin K-c, Wu C-y, et al. Rasch validation and predictive validity of the Action Research Arm Test in patients receiving stroke rehabilitation. Arch Phys Med Rehabil. 2012;93:1039-1045.

55. Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. Int J Rehabil Res. 1981;4:483-492.

56. Ferreiro KN, Santos RL, Conforto AB. Psychometric properties of the portuguese version of the Jebsen-Taylor test for adults with mild hemiparesis. Rev Bras Fisioter. 2010;14:377-82.

57. Ottenbacher KJ, Hsu Y, Granger CV, et al. The reliability of the Functional Independence Measure: a quantitative review. Arch Phys Med Rehabil. 1996;77:1226-1232.

58. Hsueh I-P, Lin J-H, Jeng J-S, et al. Comparison of the psychometric characteristics of the functional independence measure, 5 item Barthel index, and 10 item Barthel index in patients with stroke. J Neurol Neurosurg Psychiatr. 2002;73:188-190.

59. Lundgren ÅN, Tennant A. Past and present issues in Rasch analysis: the Functional Independence Measure (FIM) revisited. J Rehabil Med. 2011;43:884-891.

60. Hsueh I-P, Lee M-M, Hsieh C-L. Psychometric characteristics of the Barthel activities of daily living index in stroke patients. J Formos Med Assoc. 2001;100:526-532.

61. Green J, Young J. A test-retest reliability study of the Barthel Index, the Rivermead Mobility Index, the Nottingham Extended Activities of Daily Living Scale and the Frenchay Activities Index in stroke patients. Disabil Rehabil. 2001;23:670-676.

62. Barreca SR, Stratford PW, Masters LM, et al. Validation of three shortened versions of the Chedoke Arm and Hand Activity Inventory. Physiother Canada. 2006;58:148-156.

63. Barreca S, Gowland C, Stratford P, et al. Development of the Chedoke Arm and Hand Activity Inventory: theoretical constructs, item generation, and selection. Top Stroke Rehabil. 2004;11:31-42.

64. Harris JE, Eng JJ, Miller WC, et al. A self-administered Graded Repetitive Arm Supplementary Program (GRASP) improves arm function during inpatient stroke rehabilitation: a multi-site randomized controlled trial. Stroke. 2009;40:2123-2128.

65. Ekstrand E, Lindgren I, Lexell J, et al. Test-retest reliability of the ABILHAND questionnaire in persons with chronic stroke. PM R. 2014;6:324-31.

66. Wang T-n, Lin K-c, Wu C-y, et al. Validity, responsiveness, and clinically important difference of the ABILHAND questionnaire in patients with stroke. Arch Phys Med Rehabil. 2011;92:1086-1091.

67. Penta M, Tesio L, Arnould C, et al. The ABILHAND questionnaire as a measure of manual ability in chronic stroke patients: Rasch-based validation and relationship to upper limb impairment. Stroke. 2001;32:1627-34.

68. Chen H-f, Wu C-y, Lin K-c, et al. Rasch validation of a combined measure of basic and extended daily life functioning after stroke. Neurorehabil Neural Repair. 2013;27:125-132.

69. Wu C-y, Chuang L-l, Lin K-c, et al. Responsiveness, minimal detectable change, and minimal clinically important difference of the Nottingham Extended Activities of Daily Living Scale in patients with improved performance after stroke rehabilitation. Arch Phys Med Rehabil. 2011;92:1281-1287.

70. Poulin V, Korner-Bitensky N, Dawson DR. Stroke-specific executive function assessment: a literature review of performance-based tools. Aust Occup Ther J. 2013;60:3-19.

71. Marom B, Jarus T, Josman N. The relationship between the Assessment of Motor and Process Skills (AMPS) and the Large Allen Cognitive Level (LACL) test in clients with stroke. Phys Occup Ther Geriatr. 2006;24:33-50.

72. Bjorkdahl A, Nilsson AL, Grimby G, et al. Does a short period of rehabilitation in the home setting facilitate functioning after stroke? A randomized controlled trial. Clin Rehabil. 2006;20:1038-49.

73. Filiatrault J, Arsenault AB, Dutil E, et al. Motor function and activities of daily living assessments: a study of three tests for persons with hemiplegia. Am J Occup Ther. 1991;45:806-810.

74. Rowe VT, Winstein CJ, Wolf SL, et al. Functional test of the Hemiparetic Upper Extremity: a Rasch analysis with theoretical implications. Arch Phys Med Rehabil. 2017;98:1977-1983.

75. Cup EH, Scholte op Reimer WJ, Thijssen MC, et al. Reliability and validity of the Canadian Occupational Performance Measure in stroke patients. Clin Rehabil. 2003;17:402-9.

76. Hill VA, Fisher T, Schmid AA, et al. Relationship between touch sensation of the affected hand and performance of valued activities in individuals with chronic stroke. Top Stroke Rehabil. 2014;21:339-46.

77. Phipps S, Richardson P. Occupational therapy outcomes for clients with traumatic brain injury and stroke using the Canadian Occupational Performance Measure. Am J Occ Ther. 2007;61:328-334.

78. Lerdal A, Kottorp A. Psychometric properties of the Fatigue Severity Scale-Rasch analyses of individual responses in a Norwegian stroke cohort. Int J Nurs Stud. 2011;48:1258-65.

79. Mihelj M, Novak D, Milavec M, et al. Virtual rehabilitation environment using principles of intrinsic motivation and game design. Presence (Camb). 2012;21:1-15.

80. Leng EY, Baki R, Mahmud R. Stability of the intrinsic motivation inventory (IMI) for the use of Malaysian form one students in ICT literacy class. EURASIA J Math Sci Tech. 2010;6:215-226.

81. McAuley E, Duncan T, Tammen VV. Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. Res Q Exs Sport. 1989;60:48-58.

82. Cabral DL, Laurentino GE, Damascena CG, et al. Comparisons of the Nottingham Health Profile and the SF-36 health survey for the assessment of quality of life in individuals with chronic stroke. Rev Bras Fisioter. 2012;16:301-8.

83. Dorman P, Slattery J, Farrell B, et al. Qualitative comparison of the reliability of health status assessments with the EuroQol and SF-36 questionnaires after stroke. Stroke. 1998;29:63-68.

84. Dallmeijer AJ, de Groot V, Roorda LD, et al. Cross-diagnostic validity of the SF-36 physical functioning scale in patients with stroke, multiple sclerosis and amyotrophic lateral sclerosis: a study using Rasch analysis. J Rehabil Med. 2007;39:163-169.

85. Rønning OM, Stavem K. Determinants of change in quality of life from 1 to 6 months following acute stroke. Cerebrovasc Dis. 2008;25:67-73.

86. Healey AK, Kneebone II, Carroll M, et al. A preliminary investigation of the reliability and validity of the Brief Assessment Schedule Depression Cards and the Beck Depression Inventory‐Fast Screen to screen for depression in older stroke survivors. Int J Geriatr Psychiatry. 2008;23:531-536.

87. Aben I, Verhey F, Lousberg R, et al. Validity of the Beck Depression Inventory, Hospital Anxiety and Depression Scale, SCL-90, and Hamilton Depression Rating Scale as screening instruments for depression in stroke patients. Psychosomatics. 2002;43:386-393.

88. House A, Dennis M, Mogridge L, et al. Mood disorders in the year after first stroke. Br. J. Psychiatry. 1991;158:83-92.89.

89. Hunger M, Sabariego C, Stollenwerk B, et al. Validity, reliability and responsiveness of the EQ-5D in German stroke patients undergoing rehabilitation. Qual Life Res. 2012;21:1205-1216.

90. Chen P, Lin K-C, Liing R-J, et al. Validity, responsiveness, and minimal clinically important difference of EQ-5D-5L in stroke patients undergoing rehabilitation. Qual Life Res. 2016;25:1585-1596.

91. Fernandez-Concepcion O, Verdecia-Fraga R, Alvarez-Gonzalez M, et al. Stroke-specific quality of life scale (ECVI-38): an evaluation of its acceptance, reliability and validity. Rev Neurologia. 2005;41:391-398.

92. Lin K-C, Fu T, Wu C-Y, et al. Psychometric comparisons of the stroke impact scale 3.0 and stroke-specific quality of life scale. Qual Life Res. 2010;19:435-443.

93. Silva SM, Correa FI, de Morais Faria CDC, et al. Psychometric properties of the stroke specific quality of life scale for the assessment of participation in stroke survivors using the rasch model: a preliminary study. J Phys Ther Sci. 2015;27:389-392.

94. Williams LS, Weinberger M, Harris LE, et al. Development of a stroke-specific quality of life scale. Stroke. 1999;30:1362-1369.

95. Akdemir A, Türkçapar M, Örsel S, et al. Reliability and validity of the Turkish version of the Hamilton Depression Rating Scale. Compr Psychiatry. 2001;42:161-165.

96. Valiengo LC, Goulart AC, de Oliveira JF, et al. Transcranial direct current stimulation for the treatment of post-stroke depression: results from a randomised, sham-controlled, double-blinded trial. J Neurol Neurosurg Psychiatry. 2017;88:170-175.