doi: 10.2490/prm.20200031 Progress in Rehabilitation Medicine 2020; Vol. 5, 20200031

ORIGINAL ARTICLE

Development of a New Daily Activities Scale for the Affected Hand after Stroke

Koshi Matsuoka, MSc, OT [a,b] Aki Watanabe, PhD, OT [b,c] Takayuki Kawaguchi, PhD, OT [d] Koji Misawa, OT [a] Keiichi Murakami, PhD, MD [a] and Michinari Fukuda, MD [b,c]

Objectives: There are few scales that reflect the function of the stroke-affected arm as it relates to the performance of daily activities while also indicating the difficulty of scale items. In this study, we developed the Activities Specific Upper-extremity Hemiparesis Scale (ASUHS) to evaluate daily activities performable by the affected arm after stroke. We also clarified the validity, reliability, and item difficulty of the scale. **Methods:** The participants were 145 patients with stroke who were consecutively admitted to a convalescent rehabilitation ward. The unidimensionality of ASUHS was assessed by principal component analysis. Analyses of item discrimination and content validity were conducted to assess the overall validity. Reliability was evaluated by assessing internal consistency and inter-rater reliability. Item difficulties were determined by Rasch analysis. **Results:** Unidimensionality, high discrimination, and good content validity were shown for all items. ASUHS consists of a dominant hand scale and non-dominant hand scale. Both scales showed good internal consistency (Cronbach's α coefficient = 0.99) and substantial inter-rater reliability (Cohen's Kappa coefficient = 0.74 and 0.75, respectively). Item difficulty was determined as being in the range –8.71 to +5.18 logit. **Conclusions:** This study suggested good validity and reliability of ASUHS. Furthermore, because the item difficulties of daily activities performed by the affected arm were clarified, therapists can use ASUHS to identify the process that should be the next focus for training. Consequently, therapists may be able to train patients in daily activities that match the affected arm's ability step by step rather than determining training activities empirically.

Key Words: daily activity; Rasch analysis; scale; stroke; upper extremity

INTRODUCTION

The major purpose of improving affected upper extremity function in stroke rehabilitation is to allow practical use of the affected arm in daily activities. Recently, many training methods, e.g., constraint-induced movement therapy,[1] robot therapy,[2] and mirror therapy,[3] have been conducted in patients with stroke to rehabilitate the affected arm. Other strategies have also been developed to make the affected arm usable for daily living.[4]

To date, the Barthel Index[5] and the Functional Independence Measure (FIM)[6] have been developed as measures for assessing activities of daily living (ADL); however, these scales evaluate the degree of independence of daily activities in general and not the activities performable with the affected arm after stroke. A systematic review identified the Leeds Adult Spasticity Impact Scale (LASIS), the Motor Activity Log (MAL), and ABILHAND as measures reported

Received: October 5, 2020, Accepted: December 2, 2020, Published online: December 22, 2020
[a] Department of Rehabilitation Medicine, Tamakyuryo Hospital, Machida, Japan
[b] Graduate School of Medical Science, Kitasato University, Sagamihara, Japan
[c] Department of Rehabilitation, School of Allied Health Sciences, Kitasato University, Sagamihara, Japan
[d] Department of Community Mental Health & Law, National Institute of Mental Health, National Center of Neurology and Psychiatry, Kodaira, Japan
Correspondence: Koshi Matsuoka, MSc, OT, Department of Rehabilitation Medicine, Tamakyuryo Hospital, 1491 Shimooyamada-machi, Machida-shi, Tokyo 194-0297, Japan E-mail: reha-ot-kanri@tamakyuryo.or.jp

to evaluate real-life function or actual performance in the affected arm of stroke patients.[7] LASIS evaluates the ability to hold and stabilize objects with the affected arm.[8] MAL is used to evaluate the amount of use and the quality of movement of an arm in some daily activities via a self-completed form.[9] ABILHAND contains several items for assessing active unilateral and bimanual function.[10] Furthermore, Fugl-Meyer assessment, which is often used to evaluate arm dysfunction,[11] is based on the recovery process of hemiplegia after stroke reported by Brunnstrom.[12] However, these assessment scales evaluate only dysfunction or a limited set of daily activities; no scale is currently available to evaluate many of the general daily activities that are performed in real life. Although MAL and ABILHAND evaluate whether daily activities are performable, they do not allow detailed evaluation of which particular process in these activities is difficult. The difficulty level of some daily activities has been clarified in ABILHAND,[10] but overall, the difficulty level and specific processes remain unclear. Training of appropriate difficulty is important in rehabilitation,[13] and appropriate difficulty is also important when setting goals.[14] Moreover, training differs depending on the therapist's experience.[15] These considerations also apply to training and goal setting in daily activities performed by the affected arm in stroke patients. It is difficult to determine which processes within daily activities should be the next focus for training because it is challenging for therapists to know the level of difficulty of the daily activities performed with the affected arm; consequently, they have to select practice programs and goals empirically. Therefore, we considered that developing a scale to evaluate the specific processes of daily activities performed with the stroke-affected arm and knowing their difficulty levels would contribute to effective training and goal setting for stroke patients.

The purposes of this study were to develop the Activities Specific Upper-extremity Hemiparesis Scale (ASUHS) for evaluating the activities performable by stroke-affected arms; to assess its internal consistency, inter-rater reliability, item discrimination, and content validity; and to clarify the difficulty of items in the daily activities evaluated by ASUHS.

METHODS

Item Generation

Questionnaire Construction. ASUHS was designed to measure upper extremity activity outcomes of rehabilitation services provided to inpatients with post-stroke hemiparesis. The Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) checklist provides criteria for evaluating the statistical method, internal consistency, reliability, and content validity of health status measurement instruments. These design criteria were addressed in the present study.[16,17] Scale development includes four phases: (1) item generation, (2) item reduction and validity, (3) reliability, and (4) hierarchies of item difficulties.[18,19]

Item Generation. In creating the ASUHS items, 33 previously developed scales that focus on the measurement of motor paralysis of stroke patients, e.g., MAL and ABILHAND, and ADL and instrumental ADL scales such as the Barthel Index, FIM, and Lawton scale[20] were considered. Based on these 33 scales, 46 items relating to upper extremity activities were extracted; excluded were those items not implemented because of seasonal, gender, or cultural differences. Furthermore, the preliminary items of ASUHS were created from these 46 items by combining the overlapping items and dividing all items into sub-steps. The preliminary items evaluate the activities performed by the dominant hand (251 items) or non-dominant hand (175 items) in patients with post-stroke hemiparesis. When the dominant hand is paralyzed, the actions mainly performed by the dominant hand are evaluated, and when the non-dominant hand is paralyzed, the actions performed by the non-dominant hand are evaluated. However, unlike some other measures, ASUHS includes activities requiring the use of both hands, such as manipulating buttons. Consequently, ASUHS evaluates the use of the affected arm in bilateral hand movements. The preliminary items of ASUHS were broken down into three categories with increasing levels of specificity: Category A consisted of items relating to ADL and instrumental ADL with reference to the FIM[6] and Frenchay Activities Index.[21] Category B consisted of the items of ADL and instrumental ADL in category A divided into units for each activity with reference to scales such as MAL; ABILHAND; and the Disabilities of the Arm, Shoulder and Hand.[22] Furthermore, category C consisted of the activities of category B divided into four specific processes (**Fig. 1**). Although there were many items, the activities evaluated were different. Each category C item was scored by assigning points to each response according to the following four levels: 1 point (not attempted with the affected arm), 2 points (affected arm partially used for the activity), 3 points (affected arm used for the activity but is slow or inaccurate), and 4 points (arm movement appears to be normal).

Implementation of ASUHS. All ADL and instrumental ADL activities were evaluated in the occupational therapy

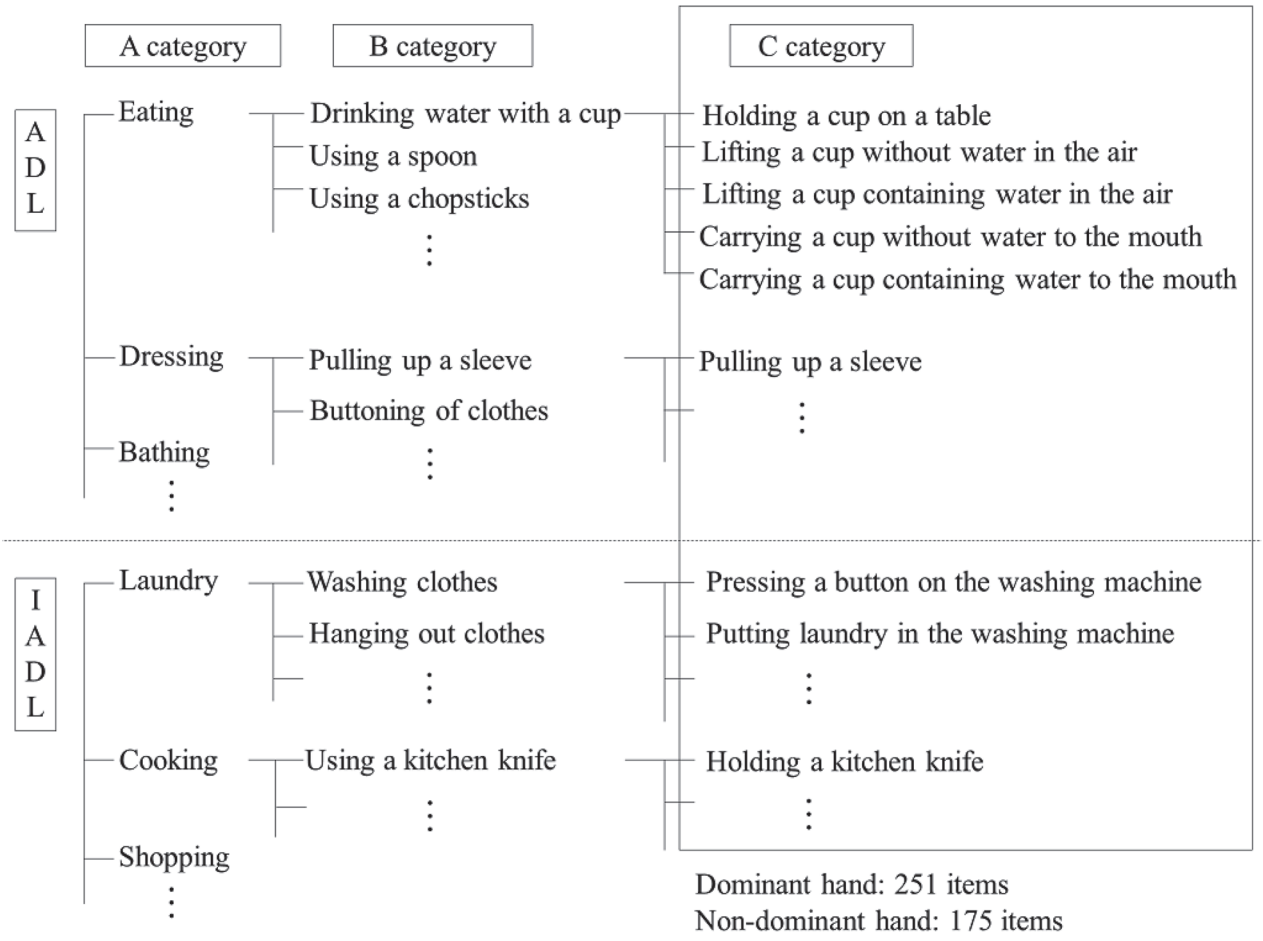

Fig. 1. The preliminary items of ASUHS. Category A consists of items relating to activities of daily living (ADL) and instrumental activities of daily living (IADL). Category B consists of Category A items subdivided into more detailed items, and category C consists of category B items subdivided into more detailed items.

department. Therapists scored all these activities through observation. Although not necessarily applicable to all items, actions that were clearly difficult to perform and actions that could be performed with no difficulty were not carried out, and 1 point and 4 points were respectively assigned to these tasks. For example, if it is difficult for the subject to hold a spoon for "spoon operation" in category B, then "pretending to scoop food using a spoon" and "scooping up a 1-cm block using a spoon" in category C would clearly also be difficult. Therefore, the other items under "spoon operation" would not be assessed and would be assigned 1 point. In the present study, the assessment of all ASUHS items took about 30–60 min to complete. However, in actual clinical use, the ASUHS has the advantage of it being acceptable to assess only selected category B items, in which case the time to complete the assessment is approximately 5 min. Because ASUHS includes many daily activities and processes, it is possible to know which processes are performable and how much of each process is performable with respect to overall daily activities. Further, because ASUHS indicates the difficulty level of each item, it is easier for patients and therapists to understand the daily activities that patients should be capable of doing next. Therefore, therapists can set daily activities that patients should be able to perform next as goals and can provide the activities as training tasks. As a result, ASUHS facilitates goal setting and the provision of practice programs according to the functional level of the affected arm and not to goals and practice programs empirically selected by therapists.

Item Reduction and Validity

Sample and Data Collection. The participants were 145 inpatients with stroke consecutively admitted to a convalescent rehabilitation ward between April 2015 and

August 2019. The inclusion criteria were right-handed patients with their first-ever stroke who were hospitalized in a convalescent rehabilitation ward. Stroke was diagnosed according to the World Health Organization definition.[23] Patients had unilateral upper extremity hemiplegia/paresis. Moreover, only right-handed people were targeted because some left-handed people sometimes mainly use their right hand, depending on the activity. The exclusion criteria were patients with severe aphasia, apraxia, and dementia (<10 of 30 on the Mini-Mental State Examination)[24] who could not follow directions; patients with unilateral spatial neglect (<6 of 9 on the Behavioural Inattention Test)[25]; patients with balance disorder preventing them from sitting for more than 30 min; patients with intense pain caused by the affected upper extremity; and patients who could not be moved due to complex regional pain syndrome or fractures. Four occupational therapists with an average experience of 6.5 ± 1.7 years were registered as evaluators of ASUHS. Furthermore, they conducted an observational evaluation after being taught the ASUHS evaluation method.

Unidimensionality. Rasch analysis was used to develop ASUHS. Rasch analysis statistically manipulates ordinal data to create a linear measure on an interval scale, and the units of measurement have equal intervals along the scale to account for the magnitude of change.[26] Because Rasch analysis requires that a single construct be measured, the unidimensionality of ASUHS was assessed a priori by principal component analysis (PCA).[22,27] In PCA, selection of the number of factors is based on established rules: eigenvalues (ε) >1, the scree test, and the percentage of the common variance explained by the different components.[22]

Rasch Analysis. Rasch analysis yields an infit mean square (MnSq) accompanied by a standardized Z-score (Zstd), which indicates significance.[28] Fit statistics are interpreted to indicate whether an item belongs to the underlying dimension representing the construct and whether the measure obtained for a person is valid. According to previous studies, items in the present study with infit MnSq values of ≥1.4 and Zstd values of ≥2.0 were deleted as misfits.[26,28–30] After each misfit item was deleted, Rasch analysis was reconducted until all items fitted the criteria of infit MnSq and Zstd.

Discrimination. Item discrimination describes how well items discriminate between test-takers. When a floor or ceiling effect is present, the affected ASUHS items will have poor discrimination ability. Items with discrimination parameters <0.5 were deleted as poor items.[31]

Content Validity. Five stroke rehabilitation experts with a mean experience of 10.4 ± 6.1 years reviewed the items for content validity. They confirmed whether the category C items reflected the daily activities or function of the affected arm of patients with stroke by answering the following questions. Can the scale evaluate the daily activities? Does the scale reflect the function of the affected arm? Can the scale be useful in clinical assessment or practice? Is the scale easy to evaluate? Can the scale evaluate the effectiveness of rehabilitation interventions? The experts scored each item on a five-point scale: from 1 (not appropriate) to 5 (appropriate). Next, the items were revised or deleted until all items scored a perfect 5 points; finally, the items were decided with the agreement of all five experts. Furthermore, to divide ASUHS into two scales – one for dominant hand paralysis and one for non-dominant hand paralysis – when reviewing the items for content validity, the subjects were divided into two groups: those with dominant hand paralysis and those with non-dominant hand paralysis. Differences in categorical variables were analyzed by χ^2 test, and differences in ordinal variables were analyzed by Mann-Whitney U test.

Reliability

Internal Consistency. The internal consistency reliability was assessed using Cronbach's α coefficient, which summarizes the inter-item correlations among all items and category B items in a scale.

Inter-rater Reliability. In evaluating the inter-rater reliability, patients were assessed twice by two different occupational therapists within a 3-day period to minimize any change in function. The concordance between the two therapists was quantified by Cohen's Kappa coefficients.[32] Reliability was considered almost perfect if the coefficients were between 0.81 and 1.00, substantial if the values were between 0.61 and 0.80, moderate if between 0.41 and 0.60, fair if between 0.21 and 0.40, and slight if between 0 and 0.20.[33]

Hierarchies of Item Difficulties. Rasch analysis was also used to determine hierarchies and ranges of item difficulties in ASUHS. In Rasch analysis, a "logit" is the natural log-odds of the difficulty level of a particular item in relation to all other items in the scale; consequently, it expresses the level of item difficulty on the scale. This analysis places both the items and the subjects into two parallel hierarchies.[18]

Statistical Analysis

The statistical method, internal consistency, reliability, and content validity of the scale were evaluated according to the COSMIN checklist. Analyses of PCA results, comparisons between two groups, internal consistency, and inter-rater reliability were completed using the IBM Statistical Pack-

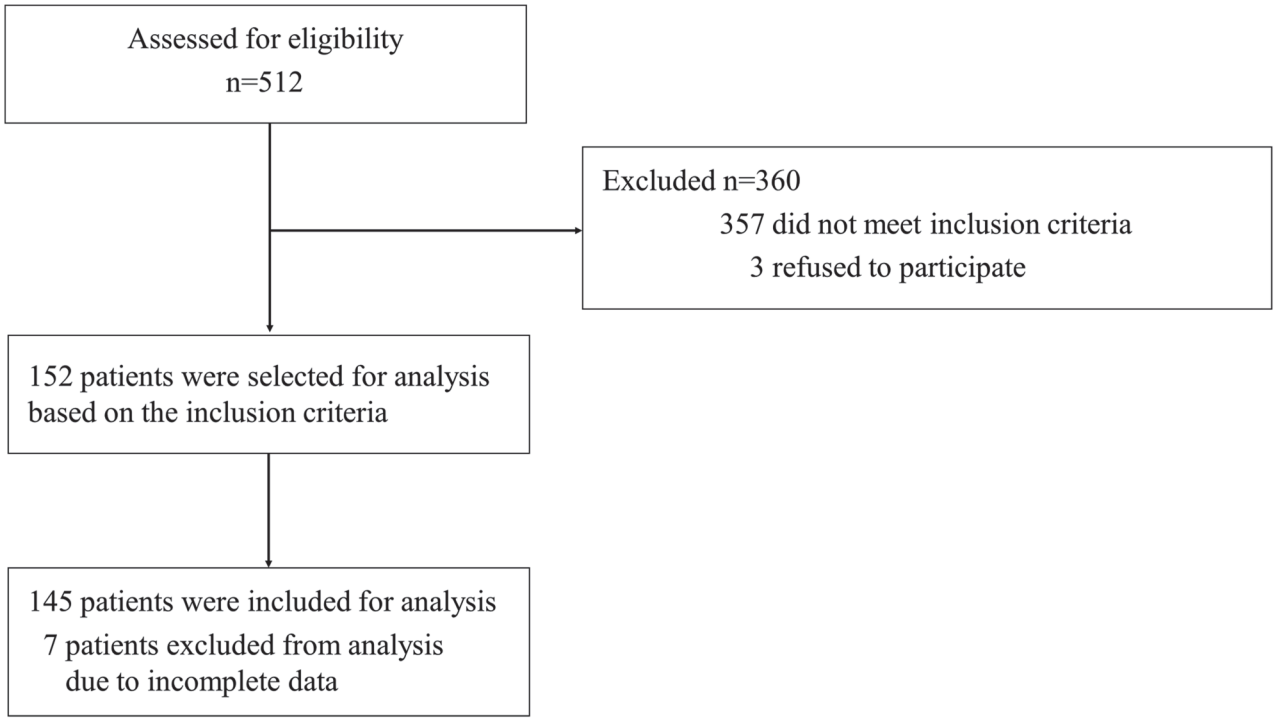

Fig. 2. Schematic of the patient selection process. We enrolled 512 stroke patients with hemiparesis affecting either the dominant or non-dominant hand who were admitted to a convalescent rehabilitation ward. Of these 512 patients, 145 patients finally participated in the study according to the inclusion and exclusion criteria.

age for Social Science (SPSS), version 26.0. A P value <0.05 was considered statistically significant. Rasch analysis was performed using Rasch model software WINSTEPS version 3.91.0. Item discrimination was estimated using IRTPRO version 4.2, which analyzes the two-parameter model of item response theory.

Ethics

Ethical approval was obtained from Tamakyuryo Hospital, Japan (No. 29-2), prior to the start of the study, and written informed consent was obtained from all participants.

RESULTS

Item Reduction and Validity

Study Participation. Of the 512 patients screened for eligibility, 145 underwent evaluation (**Fig. 2**). Patient characteristics are given in **Table 1**.

Unidimensionality. PCA was conducted to confirm the unidimensionality of ASUHS. The first factor of ASUHS had an eigenvalue (amount of variation in the total sample accounted for by that factor) of 227.6, which explained 90.7% of the total variance of the score. The unidimensionality of the scale was found to be strong as a result of the substantial differences between the first and the second factors because the eigenvalue of the second factor of ASUHS was 5.9. First factor loading for each item of ASUHS was as high as 0.75–0.99. The unidimensionality of ASUHS was therefore confirmed by PCA.

Rasch Analysis. Among the 145 participants, 24 of 251 category C items did not fit the Rasch model because their infit MnSq exceeded 1.4 and their Zstd values exceeded 2.0. Examples of these items were “Holding a cup on the table,” “Holding a spoon,” “Holding a hair dryer,” “Picking up a 1.5-cm marble with chopsticks and carrying it to the mouth,” “Writing your name on 10-mm graph paper,” and “Hanging a bath towel on an overhead pole with both hands”; consequently, these items were excluded from ASUHS.

Discrimination. All 227 remaining items in ASUHS showed acceptable discrimination parameters (>0.5).

Content Validity. The ASUHS items were revised based on feedback from the five stroke rehabilitation experts. In particular, items representing activities performed less frequently in daily life and those similar to other items, e.g., “Pressing the button of the washing machine,” “Putting body soap on a towel and lathering,” “Pinching a clothespin to

Table 1. Clinical characteristics of the participants

Characteristic	All participants (n = 145)	Dominant hand paralysis (n = 78)	Non-dominant hand paralysis (n = 67)	P Value
Age, years	68.5±12.8	69.3±12.7	65.4±15.0	0.391
Gender, male	86 (59.3)	51 (65.4)	35 (52.2)	0.108
Time after stroke, days	60.0±30.3	54.3±29.6	66.8±29.9	0.001
Ischemic stroke	94 (64.8)	52 (66.7)	42 (62.7)	0.617
Fugl-Meyer assessment	40.0±22.2	40.8±23.2	39.0±21.1	0.285
Mini-Mental State Examination	24.7±4.1	25.7±4.0	23.9±4.1	0.083
Functional Independence Measure	85.1±27.1	84.6±27.9	85.9±26.2	0.850
Activities Specific Upper-extremity Hemiparesis Scale	2.4±1.1	2.5±1.2	2.3±1.1	0.319

open and close it," and "Wringing out a cloth," were deleted. Each category B item in ASUHS was structured to contain four category C items. For example, category B item "using a rice bowl" was divided into four items in category C: "holding a rice bowl on the table," "lifting a rice bowl in the air," "holding a rice bowl at chest height," and "carrying a rice bowl to the mouth." After revisions, ASUHS was reduced to 168 items. Furthermore, two ASUHS scales were created: one scale consisted of 168 items performed by the affected dominant hand (ASUHS Dominant hand scale; ASUHS-D), and the other scale consisted of a subset of 116 of the overall 168 items performed by the affected non-dominant hand (ASUHS Non-Dominant hand scale; ASUHS-ND) (see Appendix). There were no significant differences between the dominant and non-dominant hand paralysis groups except for the time after stroke (**Table 1**). The five experts made positive comments regarding the relevance and comprehensiveness of the scale, suggesting the validity of the content.

Reliability

Internal Consistency. Cronbach's α coefficient was 0.99 for both ASUHS-D and ASUHS-ND. Furthermore, in ASUHS-D, Cronbach's α for each category B item (42 categories) ranged from 0.96 to 0.99, and in ASUHS-ND, Cronbach's α for each category B item (29 categories) ranged from 0.95 to 0.99.

Inter-rater Reliability. Subjects were randomly selected, and inter-rater reliability was assessed in 8 of 78 participants for ASUHS-D and 7 of 67 participants for ASUHS-ND. Regarding assessment of the characteristics of the subjects, Fugl-Meyer assessment was 40.1 ± 21.8 and 41.3 ± 18.9 and that of ASUHS was 2.4 ± 1.0 for ASUHS-D and 2.1 ± 1.0 for ASUHS-ND. Cohen's Kappa coefficients were 0.74 for ASUHS-D and 0.75 for ASUHS-ND, indicating good inter-rater reliability for both scales.

Hierarchies of Item Difficulties. The item calibrations in the Rasch analysis of ASUHS ranged from +5.18 logit for the most difficult item (brushing teeth) to –8.71 logit for the least difficult item (holding a plastic bottle). Rasch analysis places item difficulty and person ability along the linear continuum of the logit scale.[34] A person–item map displaying the ASUHS item difficulty and the subjects' ability is shown in **Fig. 3**. The mean value of item difficulty is located at 0 logit on the person–item map. The mean value of person ability in terms of ASUHS was located at –1.57 logit on the person–item map.

DISCUSSION

ASUHS Verification

ASUHS showed unidimensionality by PCA and high compatibility with the Rasch model by Rasch analysis. High discrimination and content validity were shown for all items, and the objectivity of the results of ASUHS-D and ASUHS-ND was sufficient. Furthermore, the 168 items of ASUHS-D and the 116 items of ASUHS-ND showed good internal consistency. The Kappa coefficients for inter-rater reliability of ASUHS-D and ASUHS-ND were 0.74 and 0.75, respectively, indicating that high reliability was obtained with "substantial agreement."[33] These results supported the clinical use of ASUHS in patients with stroke. However, the inter-rater reliability of ASUHS was lower than that obtained in patients with stroke using well-established clinical scales for the upper limb [Fugl-Meyer assessment: intraclass correlation coefficient (ICC) = 0.99,[35] Action Research Arm Test: ICC = 0.99[36]]. The Kappa coefficient should be increased by the provision of an instruction manual that clearly describes the evaluation criteria for each item.

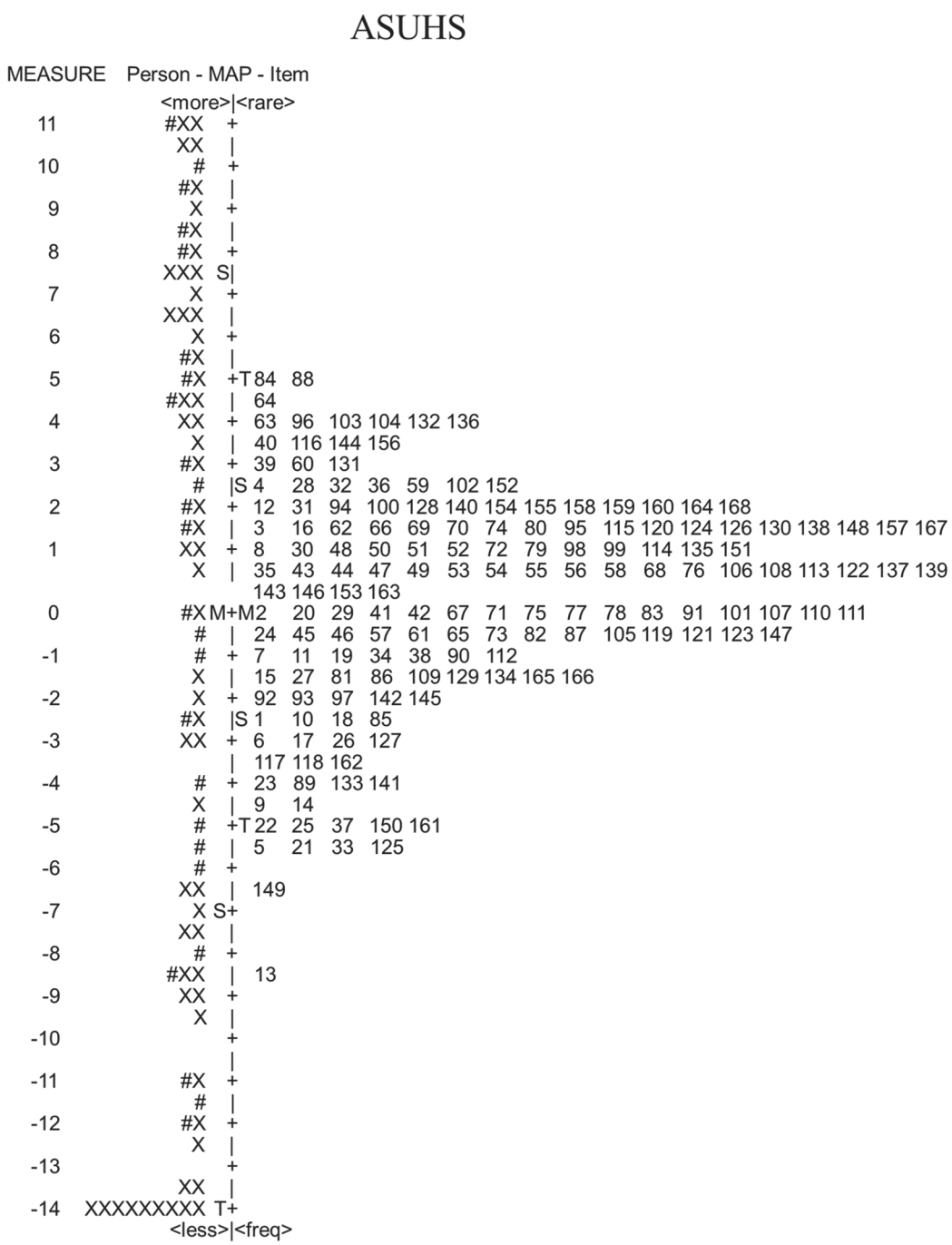

Fig. 3. Person–item map of ASUHS. Persons are to the left of the vertical "– + – +" line, and the item difficulty map is to the right of the line. Item numbers listed here correspond to the item numbers shown in the Appendix. X, two people; #, one person; S, one standard deviation from the mean; T, two standard deviations from the mean; M, mean.

ASUHS Items

In the Rasch analysis, 24 of 251 category C items that did not fit the Rasch model were excluded. Those excluded tended to be items with a very low difficulty, such as "Holding a cup on the table," "Holding a spoon," and "Holding a hair dryer," or items with a very high difficulty, such as "Picking up a 1.5-cm marble with chopsticks and carrying it to the mouth," "Writing your name on 10-mm graph paper," and "Hanging a bath towel on an overhead pole with both hands." According to systematic reviews, MAL is often used

to evaluate daily activities performed by the affected arm of patients with stroke.[7,9,10] MAL evaluates daily activities in 30 categories, whereas ASUHS evaluates daily activities in 42 categories. Although MAL evaluates the degree of performance of the daily activities themselves, therapists have difficulty in determining which process in the activities might be causing difficulty. ABILHAND indicates the difficulty of 23 daily activities by Rasch analysis and can compare the difficulties. In contrast, ASUHS divides each activity into four concrete processes and shows the difficulty of each process. With ASUHS, the concrete steps that are difficult for a patient when attempting an intended daily activity can be clarified, and therapists can identify the process that should be the next focus for training. Although ASUHS contains many items (with some not being performed, depending on the subject's ability), it took about 30–60 min to perform all items in ASUHS. Although it is acceptable to assess only subcategories of ASUHS, further research based on item response theory is required to enable estimation of the training content according to the patient's upper limb function and ability of activities of daily living even when selectively performing assessment items. We will conduct a future study in which the abilities of the subjects and the process of the daily activities that should be the next focus for training can be understood by performing a few selected items, rather than all items. ASUHS includes activities that differ depending on culture. For example, "holding a rice bowl in the air" is a typical task performed in Japan that may not generally be done elsewhere. Few items with such cultural specificity are evaluable with the existing scales. Therefore, one strength of ASUHS is that it includes items related to cultural differences that are difficult to evaluate with existing scales. However, differences in cultural behaviors limit the generalization of ASUHS to other cultures. Therefore, when using ASUHS, activities that are not performed in a certain culture should not be evaluated.

Item Difficulty and Person Ability

Rasch analysis places items and persons along the same linear continuum: if no items are located in the vicinity of the persons' level of ability or if important gaps exist between the items' difficulty levels, the ability of these patients cannot be estimated with precision.[22] Item difficulty level in ASUHS ranged from –8.71 to +5.18 logit, and no important gaps existed between the items' difficulty levels (**Fig. 3**). Therefore, the ability of patients can be estimated with precision using ASUHS. Furthermore, if the distribution ranges of an individual attribute and item difficulty are similar, item difficulty can be considered adequate.[37] **Figure 3** shows that the range of distribution of a person's ability level was wider than that of the item difficulty distribution; the reason for this was that subjects who could not move the affected arm at all and those with little paresis were both included. Ceiling effects and floor effects were therefore found in the present study. Consequently, in the future, the functional level of affected arms that are evaluable using ASUHS must be clarified by investigating the range of Fugl-Meyer scores of subjects evaluable by ASUHS.

Item Difficulty Hierarchies

In ASUHS, the most difficult item to perform with the dominant hand was "brushing the teeth," and the next most difficult item was "wiping the bottom with toilet paper." In contrast, the most difficult activities for the non-dominant hand were "washing the head" and then "washing the face with water held in both hands." Although there were differences in the activities performed between the dominant and non-dominant hands, items with a high level of difficulty were common in operations of the arm in the upper space higher than chest level and in movement using multiple joints. The items with the least difficulty were "holding a plastic bottle" followed by "holding a rice bowl on a table." Items with less difficulty were common to the behavior of grasping something and to movement performed on a desk or in a low position. Because upward elevation of the arm and separation movement accompanied by multi-joint movement appear later in the recovery process of motor paresis after stroke,[11] these actions have a high degree of difficulty. In the fingers, flexion movement often appears before extension movement, and all-finger flexion appears before separation movements of the individual fingers such as pinching.[12] Therefore, grasping something with all fingers flexed is considered to be an item with less difficulty. The above findings suggested that the range of item difficulties of ASUHS was appropriate. Subjects with severe cognitive impairment who could not follow directions were excluded, but subjects with mild and moderate cognitive impairments, such as inattention, aphasia, and apraxia, were not excluded. In addition to motor function, mild and moderate cognitive impairment, aphasia, and apraxia may affect the performance of the daily activities performed with the affected arm. Because these effects were not completely eliminated in this study, additional research is required.

The existing scales used to evaluate affected arm function in stroke patients have difficulty in indicating the process of a daily activity that should be targeted next. However, with

ASUHS, the specific process of a daily activity that should be able to be performed next is clarified for both patients and therapists because ASUHS clarifies the difficulty level of the daily activities performed by the affected arm. For example, if a patient performs "Lifting a plastic bottle without water in the air (–4.58 logit)," the next step should be to perform "Lifting a cup without water in the air (–4.58 logit)," with the same difficulty level or to begin training for the next goal at the next highest difficulty level, e.g., "Wetting hands with running water (–3.99 logit)" or "Holding the handle of a kettle (–3.92 logit)."

Clinical Implications of the ASUHS Scale

In rehabilitation, using an appropriate difficulty level is important when selecting a training program and setting goals.[13,14] However, it is difficult to determine which processes within daily activities should be the next focus for training because it is challenging for therapists to know the difficulty of the daily activities performed with an affected arm; consequently, practice programs are usually selected empirically. Moreover, it is difficult for patients to know what daily activities can be performed with the affected hand or what process they will be able to perform next. Consequently, these issues make shared decision making[38] between the therapist and the patient even more difficult. We therefore developed ASUHS, in which many daily activities are divided into small concrete steps, to objectively evaluate in detail how well these steps are performed with the affected arm. ASUHS has several advantages: (1) many daily activities and their specific processes can be evaluated in detail; (2) the difficulty levels of these activities are known, and it is therefore easy to determine which processes within daily activities should be the next focus for training; (3) even inexperienced therapists can recognize the functional level of the affected arm and the daily activities that can be performed with it; (4) patients can know the process they will be able to perform next; (5) sharing the results of ASUHS with patients encourages them to become conscious of using their hands in daily activities; and (6) patients are more motivated to perform rehabilitation because they know exactly which daily activities can be achieved. ASUHS allows the therapist to directly assess the patient's desired daily activities and can support decision making between the therapist and the patient regarding the program. In the next stage of ASUHS research, instead of reducing the items of ASUHS, we will develop a shortened version that will make it possible to estimate the items of the entire ASUHS so that it can be applied clinically.

Limitations

This study has a noteworthy limitation. Of the 512 patients evaluated for eligibility, only 145 participated. Although ASUHS can be applied to patients meeting the criteria of this study, it may be difficult to apply ASUHS to patients not meeting these criteria.

CONCLUSIONS

Few scales currently available to evaluate in detail the affected arm in stroke patients can be used both in performing many daily activities and to indicate the difficulty of the daily activities. We therefore developed ASUHS to objectively evaluate in detail the daily activities performable by an affected arm. The reliability and validity of ASUHS were preliminarily supported. ASUHS clarifies the difficulty level of the daily activities performed by the affected arm and indicates to therapists the specific processes of daily activities that the patient should be able to perform next. This study suggested that ASUHS may be a potentially useful clinical scale.

ACKNOWLEDGMENTS

We would like to thank Prof. Makoto Suzuki for providing us with thoughtful suggestions and ample support to complete this study. This study was supported by JSPS KAKENHI Grant Number JP18K17765 and a grant from Kitasato University School of Allied Health Sciences (Grant-in-Aid for Research Project, No. 2017-1061).

CONFLICTS OF INTEREST

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

APPENDIX. THE 168 ITEMS IN ASUHS-D AND THE 116 ITEMS IN ASUHS-ND

The 168 items (**Table A1, A2, A3**) are the items of ASUHS-D. The category B items indicated with an asterisk are excluded when the non-dominant hand is assessed. ASUHS-D, Activities Specific Upper-extremity Hemiparesis Scale-Dominant hand scale; ASUHS-ND, Activities Specific Upper-extremity Hemiparesis Scale-Non-Dominant hand scale; ADL, activities of daily living; IADL, instrumental activities of daily living.

REFERENCES

1. Wolf SL, Thompson PA, Winstein CJ, Miller JP, Blanton SR, Nichols-Larsen DS, Morris DM, Uswatte G, Taub E, Light KE, Sawaki L: The EXCITE stroke trial: comparing early and delayed constraint-induced movement therapy. Stroke 2010;41:2309–2315. DOI:10.1161/STROKEAHA.110.588723, PMID:20814005
2. Takahashi K, Domen K, Sakamoto T, Toshima M, Otaka Y, Seto M, Irie K, Haga B, Takebayashi T, Hachisuka K: Efficacy of upper extremity robotic therapy in subacute poststroke hemiplegia an exploratory randomized trial. Stroke 2016;47:1385–1388. DOI:10.1161/STROKEAHA.115.012520, PMID:27006452
3. Yavuzer G, Selles R, Sezer N, Sütbeyaz S, Bussmann JB, Köseoğlu F, Atay MB, Stam HJ: Mirror therapy improves hand function in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil 2008;89:393–398. DOI:10.1016/j.apmr.2007.08.162, PMID:18295613
4. Morris DM, Taub E, Mark VW: Constraint-induced movement therapy: characterizing the intervention protocol. Eura Medicophys 2006;42:257–268. PMID:17039224
5. Wade DT, Collin C: The Barthel ADL Index: a standard measure of physical disability? Int Disabil Stud 1988;10:64–67. DOI:10.3109/09638288809164105, PMID:3042746
6. Granger CV, Hamilton BB, Linacre JM, Heinemann AW, Wright BD: Performance profiles of the functional independence measure. Am J Phys Med Rehabil 1993;72:84–89. DOI:10.1097/00002060-199304000-00005, PMID:8476548
7. Ashford S, Slade M, Malaprade F, Turner-Stokes L: Evaluation of functional outcome measures for the hemiparetic upper limb: a systematic review. J Rehabil Med 2008;40:787–795. DOI:10.2340/16501977-0276, PMID:19242614
8. Bhakta BB, Cozens JA, Chamberlain MA, Bamford JM: Impact of botulinum toxin type A on disability and carer burden due to arm spasticity after stroke: a randomised double blind placebo controlled trial. J Neurol Neurosurg Psychiatry 2000;69:217–221. DOI:10.1136/jnnp.69.2.217, PMID:10896696
9. Taub E, Miller NE, Novack TA, Cook EW 3rd, Fleming WC, Nepomuceno CS, Connell JS, Crago JE: Technique to improve chronic motor deficit after stroke. Arch Phys Med Rehabil 1993;74:347–354. PMID:8466415
10. Penta M, Tesio L, Arnould C, Zancan A, Thonnard JL: The ABILHAND questionnaire as a measure of manual ability in chronic stroke patients: Rasch-based validation and relationship to upper limb impairment. Stroke 2001;32:1627–1634. DOI:10.1161/01.STR.32.7.1627, PMID:11441211
11. Fugl-Meyer AR, Jääskö L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. 1. A method for evaluation of physical performance. Scand J Rehabil Med 1975;7:13–31. PMID:1135616
12. Brunnstrom S: Movement Therapy in Hemiplegia. Harper and Row, New York, 1970.
13. Medical Advisory Secretariat, Health Quality Ontario: Constraint-induced movement therapy for rehabilitation of arm dysfunction after stroke in adults: an evidence-based analysis. Ont Health Technol Assess Ser 2011;11:1–58. www.hqontario.ca/en/mas/tech/pdfs/2011/rev_CIMT_November.pdf Accessed 18Nov2020 [Internet] PMID:23074418
14. Locke EA, Latham GP: The development of goal setting theory: a half century retrospective. Motiv Sci 2019;5:93–105. DOI:10.1037/mot0000127
15. Kooijman MK, Swinkels IC, Veenhof C, Spreeuwenberg P, Leemrijse CJ: Physiotherapists' compliance with ankle injury guidelines is different for patients with acute injuries and patients with functional instability: an observational study. J Physiother 2011;57:41–46. DOI:10.1016/S1836-9553(11)70006-6, PMID:21402329

16. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, de Vet HC: The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: an international Delphi study. Qual Life Res 2010;19:539–549. DOI:10.1007/s11136-010-9606-8, PMID:20169472
17. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, de Vet HC: COSMIN Checklist Manual. Executive Board of VU University Amsterdam, Amsterdam, 2010.
18. Suzuki M, Yamada S, Shimizu Y, Kono Y, Hirashiki A, Izawa H, Murohara T: Development of the participation scale for patients with congestive heart failure. Am J Phys Med Rehabil 2012;91:501–510. DOI:10.1097/PHM.0b013e31824ad653, PMID:22377827
19. Jackson A, Rogerson M, Le Grande M, Thompson D, Ski C, Alvarenga M, Amerena J, Higgins R, Raciti M, Murphy BM: Protocol for the development and validation of a measure of persistent psychological and emotional distress in cardiac patients: the Cardiac Distress Inventory. BMJ Open 2020;10:e034946. DOI:10.1136/bmjopen-2019-034946, PMID:32532770
20. Lawton MP, Brody EM: Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179–186. DOI:10.1093/geront/9.3_Part_1.179, PMID:5349366
21. Holbrook M, Skilbeck C: An activities index for use with stroke patients. Age Ageing 1983;12:166–170. DOI:10.1093/ageing/12.2.166, PMID:6869117
22. Forget NJ, Jerosch-Herold C, Shepstone L, Higgins J: Psychometric evaluation of the Disabilities of the Arm, Shoulder and Hand (DASH) with Dupuytren's contracture: validity evidence using Rasch modeling. BMC Musculoskelet Disord 2014;15:361–372. DOI:10.1186/1471-2474-15-361, PMID:25358527
23. Stroke – 1989. Recommendations on stroke prevention, diagnosis, and therapy. Report of the WHO Task Force on Stroke and other Cerebrovascular Disorders. Stroke 1989;20:1407–1431. DOI:10.1161/01.STR.20.10.1407, PMID:2799873
24. Vellas B, Gauthier S, Allain H, Andrieu S, Aquino JP, Berrut G, Berthel M, Blanchard F, Camus V, Dartigues JF, Dubois B, Forette F, Franco A, Gonthier R, Grand A, Hervy MP, Jeandel C, Joel ME, Jouanny P, Lebert F, Michot P, Montastruc JL, Nourhashemi F, Ousset PJ, Pariente J, Rigaud AS, Robert P, Ruault G, Strubel D, Touchon J, Verny M, Vetel JM: Consensus statement on dementia of Alzheimer type in the severe stage. J Nutr Health Aging 2005;9:330–338. PMID:16222399
25. Halligan PW, Cockburn J, Wilson BA: The behavioural assessment of visual neglect. Neuropsychol Rehabil 1991;1:5–32. DOI:10.1080/09602019108401377
26. Chang WC, Chan C: Rasch analysis for outcomes measures: some methodological considerations. Arch Phys Med Rehabil 1995;76:934–939. DOI:10.1016/S0003-9993(95)80070-0, PMID:7487434
27. Franchignoni F, Godi M, Guglielmetti S, Nardone A, Giordano A: Enhancing the usefulness of the Mini-BESTest for measuring dynamic balance: a Rasch validation study. Eur J Phys Rehabil Med 2015;51:429–437. PMID:25653078
28. Kielhofner G, Forsyth K, Kramer J, Iyenger A: Developing the Occupational Self Assessment: the use of Rasch analysis to assure internal validity, sensitivity and reliability. Br J Occup Ther 2009;72:94–104. DOI:10.1177/030802260907200302
29. Linacre JM: A User's Guide to Winsteps Ministep: Rasch-model Computer Programs. Winsteps, Chicago, 2009.
30. Yazdani K, Nedjat S, Karimlou M, Zeraati H, Mohammad K, Fotouhi A: Developing a Shortened Quality of Life Scale from Persian Version of the WHOQOL-100 using the Rasch analysis. Iran J Public Health 2015;44:522–534. PMID:26056671
31. Shen M, Hu M, Sun Z: Development and validation of brief scales to measure emotional and behavioural problems among Chinese adolescents. BMJ Open 2017;7:e012961. DOI:10.1136/bmjopen-2016-012961, PMID:28062469
32. Cohen JA: Coefficient of Agreement, a Psychological and Statistical Study Based upon the Block-design Tests. Macmillan, New York, 1923.
33. Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174. DOI:10.2307/2529310, PMID:843571

34. Ardolino EM, Hutchinson KJ, Pinto Zipp G, Clark M, Harkema SJ: The ABLE scale: the development and psychometric properties of an outcome measure for the spinal cord injury population. Phys Ther 2012;92:1046–1054. DOI:10.2522/ptj.20110257, PMID:22577065
35. See J, Dodakian L, Chou C, Chan V, McKenzie A, Reinkensmeyer DJ, Cramer SC: A standardized approach to the Fugl-Meyer assessment and its implications for clinical trials. Neurorehabil Neural Repair 2013;27:732–741. DOI:10.1177/1545968313491000, PMID:23774125
36. Platz T, Pinkowski C, van Wijck F, Kim IH, di Bella P, Johnson G: 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;19:404–411. DOI:10.1191/0269215505cr832oa, PMID:15929509
37. Park EY, Choi YI: Rasch analysis of the London Handicap Scale in stroke patients: a cross-sectional study. J Neuroeng Rehabil 2014;11:114. DOI:10.1186/1743-0003-11-114, PMID:25077991
38. Charles C, Gafni A, Whelan T: Shared decision-making in the medical encounter: What does it mean? (or it takes at least two to tango). Soc Sci Med 1997;44:681–692. DOI:10.1016/S0277-9536(96)00221-3, PMID:9032835

Table A1. The 168 Items in ASUHS-D and 116 Items in ASUHS-ND: Items 1–56

	Category A	Category B	Category C	Category A	Category B	Category C
ADL	Eating	Using a rice bowl	1. Holding a rice bowl on a table			32. Putting head through the shirt
			2. Lifting a rice bowl in the air		Taking off a pullover shirt	33. Taking off the sleeve on the affected side
			3. Holding a rice bowl at chest height			34. Taking off the sleeve on the non-affected side
			4. Carrying a rice bowl to the mouth			35. Grabbing the shirt from behind the neck
		Drinking water from a plastic bottle	5. Holding a plastic bottle			36. Pulling off the shirt over the head
			6. Lifting a plastic bottle without water in the air		Putting on pants	37. Raising pants to the knees with both hands
			7. Carrying a plastic bottle without water to the mouth			38. Raising pants to the waist with both hands (help with standing position is acceptable)
			8. Carrying a plastic bottle containing water to the mouth			
		Drinking water with a cup	9. Lifting a cup without water in the air			39. Inserting the affected foot into the hem area with both hands (help with posture maintenance is acceptable)
			10. Lifting a cup containing water in the air			
			11. Carrying a cup without water to the mouth			40. Inserting the non-affected foot into the hem area with both hands
			12. Carrying a cup containing water to the mouth		Taking off pants	41. Pulling down pants to the thigh with both hands (help with standing position is acceptable)
		*Using a spoon	13. Pretending to scoop food using a spoon			
			14. Scooping up a 1-cm block using a spoon			42. Pulling down pants to below the knee with both hands (help with standing position is acceptable)
			15. Carrying a spoon with 1-cm block to the mouth			
			16. Carrying a spoon with 1.5-cm marble to the mouth			43. Taking off pants over the non-affected foot with both hands

Table A1. (continued)

Category A	Category B	Category C	Category A	Category B	Category C
Dressing	Pulling up sleeve	17. Pulling up sleeve until just below the elbow			44. Taking off pants over the affected foot with both hands
		18. Returning the pulled-up sleeve from just below the elbow		Putting on socks	45. Pulling a sock to the non-affected heel with both hands
		19. Pulling up sleeve to the upper arm			46. Putting the non-affected toes into a sock with both hands
		20. Returning the pulled-up sleeve from the upper arm			47. Pulling a sock to the affected heel with both hands
	Putting on a front-opening shirt	21. Passing affected arm through the sleeve			48. Putting the affected toes into a sock with both hands
		22. Passing affected arm through the sleeve to the shoulder		Taking off socks	49. Taking a sock off the heel of the non-affected side with both hands
		23. Moving clothes to the non-affected side from the back			50. Taking a sock off the toes of the non-affected side with both hands
		24. Passing non-affected arm through the sleeve			51. Taking a sock off the heel of affected side with both hands (help with posture maintenance is acceptable)
	Taking off a front-opening shirt	25. Taking off the sleeve on the affected side			
		26. Pinching sleeve on the non-affected side with affected hand			52. Taking a sock off the toes of the affected side with both hands (help with posture maintenance is acceptable)
		27. Taking off the sleeve on the non-affected side			
		28. Moving clothes to the affected side from the back		Manipulating a zipper and buttons	53. Unzipping a jacket
	Putting on a pullover shirt	29. Putting the affected arm in the sleeve			54. Zipping up a jacket
		30. Putting the non-affected arm in the sleeve			55. Unbuttoning a shirt
		31. Pulling down the hem			56. Buttoning the shirt

Table A2. The 168 Items in ASUHS-D and 116 Items in ASUHS-ND: Items 57–117

Category A	Category B	Category C	Category A	Category B	Category C
Bathing	Tying a string	57. Tying a string lightly on a desk	Doing the laundry	*Brushing the teeth	88. Washing hands
		58. Tying a string tightly on a desk			89. Opening lid of toothpaste
		59. Tying a string into a bowknot on a desk			90. Squeezing toothpaste from the tube onto a toothbrush
		60. Tying a bowknot in a shoestring			91. Putting the toothbrush into the mouth
	Handling a shower nozzle	61. Taking a shower nozzle from the shower rack			92. Brushing the teeth
		62. Hanging the shower nozzle on the shower rack		Washing the face	93. Holding water in both hands
		63. Handling the shower nozzle and spraying the entire body			94. Wiping the face with a towel
		64. Handling the shower nozzle and spraying the entire head			95. Putting water on the face with both hands
	Wiping the body with a towel	65. Wiping both legs with a towel			96. Washing the face with water held in both hands
		66. Wiping the non-affected arm with a towel		*Doing the laundry	97. Holding a basket containing laundry
		67. Wiping the front of the trunk with a towel			98. Putting the laundry in the washing machine
		68. Wiping the back with a towel using both hands			99. Putting detergent into the washing machine after scooping the detergent with a measuring cup
	Washing the body	69. Rubbing both legs with a towel			
		70. Rubbing the non-affected arm with a towel			100. Taking the laundry out of the washing machine
		71. Rubbing the front of the trunk with a towel		*Ironing	101. Ironing out wrinkles in a handkerchief with an iron
		72. Rubbing the back with a towel using both hands			102. Placing clothes on the ironing board

Table A2. (continued)

Category A	Category B	Category C	Category A	Category B	Category C
	Washing and drying the hair	73. Squeezing the contents out of a shampoo bottle			103. Ironing out wrinkles in clothes with an iron
		74. Drying the hair with a hair dryer			104. Operating an iron's temperature control switch
		75. Wiping the entire head with a towel		Folding the laundry	105. Folding a towel
		76. Washing the entire head			106. Folding a pullover shirt
Toileting	Opening and closing a door	77. Pulling a hinged door			107. Folding pants
		78. Pushing a hinged door			108. Folding a front-opening shirt
		79. Pulling a sliding door		Hanging out the laundry	109. Hanging the laundry on a hanger
		80. Turning a key			110. Hanging laundry on a hanger on a pole at face height
	*Wiping the buttocks	81. Pulling out toilet paper			111. Pinning laundry with a clothespin at face height
		82. Tearing toilet paper			112. Hanging a bath towel on a pole at face height
		83. Folding up toilet paper	Communicating	*Operating a PC	113. Moving the mouse
		84. Wiping the buttocks (help in raising the buttocks is acceptable)			114. Clicking the mouse
Grooming	Washing hands	85. Wetting hands with running water			115. Pressing one character key
		86. Opening and closing a lever-type faucet			116. Entering your name
		87. Turning the faucet		*Calling	117. Picking up the handset

Table A3. The 168 Items in ASUHS-D and 116 Items in ASUHS-ND: Items 118–168

	Category A	Category B	Category C	Category A	Category B	Category C
			118. Pressing the buttons to enter a phone number		*Handling a kitchen knife	145. Moving a kitchen knife back and forth to imitate cutting
			119. Holding the handset to the ear			146. Cutting clay in two with a kitchen knife
			120. Talking while holding the handset to the ear			147. Cutting clay at 3-cm intervals with a kitchen knife
		Reading	121. Holding a book open on a desk			148. Cutting clay at 5-mm intervals with a kitchen knife
			122. Turning a page of a book on a desk	Shopping	Handling shopping baskets and carts	149. Holding a shopping cart handle with both hands
			123. Opening and holding a book with both hands in the air			150. Holding an empty shopping basket
			124. Turning a page while holding a book with both hands			151. Placing a shopping basket containing a 1-kg weight on a desk
		*Writing	125. Picking up a pen on a desk and holding it properly			152. Placing a shopping basket containing a 3-kg weight on a desk
			126. Drawing horizontal and vertical lines		*Dealing with money	153. Picking up coins and bills on a desk
			127. Drawing a circle			154. Putting coins and bills in and taking them out of a wallet
			128. Writing your name			155. Taking the change from a vending machine
	Cooking	*Opening and closing a lid	129. Opening and closing an opened jam bottle lid (5 cm in diameter)			156. Inserting coins into a vending machine
			130. Opening and closing an opened plastic bottle lid	Cleaning	Wiping things clean	157. Moving a cloth back and forth to wipe a desk
			131. Opening the seal of a freezer bag			158. Moving a cloth to the left and right to wipe a desk
			132. Peeling off the wrapping on a container			159. Wiping a window lower than the face

Table A3. (continued)

Category A	Category B	Category C	Category A	Category B	Category C
	Handling a pot	133. Holding an empty two-handed pot with both hands			160. Wiping a window higher than the face
		134. Holding a two-handed pot containing water with both hands		Putting things in and taking them out	161. Opening a drawer
		135. Holding a one-handed pot filled with water			162. Closing a drawer
		136. Pouring water from a one-handed pot into a dish			163. Taking a note out of a drawer
	Handling a kettle	137. Holding the handle of a kettle			164. Putting a book on a bookshelf
		138. Lifting the kettle		*Cleaning	165. Wiping the floor with a floor wiper
		139. Moving the kettle to the cup			166. Sweeping the floor with a broom
		140. Tilting the kettle over the cup to pour water			167. Handling a stick-type vacuum cleaner
	*Washing the dishes	141. Holding detergent container and applying detergent to the sponge			168. Handling a standard vacuum cleaner
		142. Washing dishes with a sponge			
		143. Rinsing the dishwashing detergent with water			
		144. Washing a pot and pan with a sponge			