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Assessment Criteria and Capability Scores for Upper Extremity Functions from Inclusive Design Perspectives

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Abstract

Inclusive design is increasingly gaining attention, as some people find using products difficult after becoming physically impaired, despite daily use. However, making inclusive products is a challenge for designers or companies, as a lack of knowledge and tools stems their low involvement in it. Developing inclusive design tools is thus needed. This study developed criteria to assess upper extremity capabilities corresponding to specific daily activities. A questionnaire survey was conducted among 58 physiatrists and orthopedists. Non-parametric statistics were employed and medians were adopted as representative scores in the assessment criteria based on normality and reliability test results, non-normal data, and strong reliability of respondents in ranking. Consequently, an assessment tool was developed with 14 criteria (divided into range of motion and strength) and capability scores between 0 and 100, which discerned the moderately impaired from the severely disabled and fully capable. Since the doctors agreed to adopt the criteria but assign numeric values, especially for mild impairments, their capability assessment perception was likely influenced by dichotomy. To compensate for these deficits, qualitative or ergonomic approaches are considered simultaneously.

Key words: Body Function Assessment Criteria, Inclusive Design, Physical Impairment, Upper Extremity

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1. Introduction

People complete various tasks every day using the countless products and facilities found in their surroundings. However, individuals who have even mild, temporary functional impairments from accidents, diseases, or simply aging may find these products useless or face difficulties using them in their daily lives. This is because most products are generally optimized for people without any physical impairments. This suggests that people with functional impairments or disabilities have been ignored by designers or companies in social negligence. Intentionally or unintentionally, this situation has caused design exclusion. To construct an environment that reflects the needs of the physically vulnerable, more consideration, that is more investment, is required. However, this does not guarantee more profits. Hence, design approaches that consider the vulnerable, such as Inclusive Design, which is aligned with Universal Design or Barrier-free Design, are considered ethical rather than profitable. Therefore, these approaches have been recognized as alternative or optional rather than essential.

In the current “Risk Society,” as Beck (2014) referred to it, the likelihood that people experience impairments or disabilities resulting from accidents or diseases has increased. Additionally, there has been an aging trend in advanced Western nations, as well as Japan, South Korea and even China. As the number of the elderly increases and their life spans expand, the aged will soon emerge as a sizable market. and the health care industry is obtaining more interest (Hong et al., 2011). This requires more consideration with regard to the problems people with impairments face in using products. While these the societal changes have led to increasing support for design approaches for the physically vulnerable, companies still face a burden in developing inclusive products (Goodman et al., 2006). The most common reason for designers or companies not to participate in inclusive design is unawareness with lack of knowledge and tools. If they are aware of inclusive design, then their lack of participation comes from the belief that “inclusive design is too hard to implement” (McAdams and Kostovich, 2011). This reveals that to encourage designers’ and companies’ involvement in inclusive design, it is necessary to develop more accessible tools to them.

When employing an inclusive design approach, the current referential tools, such as HADRIAN, Exclusion Calculator, and various assessment tools to diagnose or evaluate body functions are inclined toward heavy medical perspectives. HADRIAN and Exclusion Calculator respectively evaluate interaction difficulties based on an estimate of the number of people included as users of a particular product (Johnson et al., 2010). Medical assessment tools have been used by medical professionals to diagnose, measure, or assess body functions. Nevertheless, the evaluation results from HADRIAN, an automated product analysis system, can be affected by users’ capability levels. The number of people calculated by the Exclusion Calculator, the population estimator, can be changed depending on the definition of capability extents. As they are suited for severe function losses like dementia, Alzheimer’s disease, physical disabilities, and others, various medical assessment tools do not target people who experience relatively mild losses, like the elderly. These tools tend to ignore these problems in people who do not have any health problems. In addition, the tools are designed for medical professionals such as clinicians, nurses, occupation therapists and others familiar with technical jargon, which hinders others with ordinary medical knowledge from using them.

Taking these deficits into consideration, efforts to build more suitable assessment tools are required. As a part of the efforts to boost inclusive design, it is necessary to build baseline assessment criteria for body functions accessible to designers, not medical professionals. Hence, this study aimed to create assessment criteria for body capabilities which would allow people to surmise the extent of capabilities and to have an intuitive understanding of use; provide compatibility with existing assessment tools in other domains; and cover a full range of capability levels from severe to mild loss. Due to the limit of study period and cost, despite the inter-connected organic relationship between body functions, this study concentrated on stretch and reach functions of the upper extremities (except hands) to use products

2. Functions and Assessment tools of Upper Extremities

2.1. Functions of the Upper Extremities in Using Products

As previously mentioned in this study, the upper extremities specifically referred to the forearms, elbows, arms, shoulders, and axillae except the hands. The upper extremities are engaged in the movement such as reaching, stretching out, and carrying, all of which are required for interacting with products and surroundings to perform daily routine tasks. Usually, ahead of manipulating them with hand functions, it is necessary for one or both of the upper extremities to reach out from the trunk. Examples would include turning lights on and off, putting a hat on the head, or opening the door. In each case, it is necessary to stretch the upper extremity out toward the switch, the closet shelf where the hat is, or the door respectively. To use a heavy electric tool, in addition to reaching out, it is necessary to bear its weight while carrying it from the shelf to the site. Completion of these activities primarily depends on movement range and muscle strength of the upper extremities.

In the range of motion (ROM) of the upper extremities, the main joints (shoulder joints, elbow joints, wrist joints) are crucial to complete the movements smoothly. This involves creating various gestures with the upper extremities. The movement directions for each joint are horizontal from left to right and reversed; vertical from the bottom to the top and reversed; and horizontal from the rear to the front and reversed (Fig. 1).

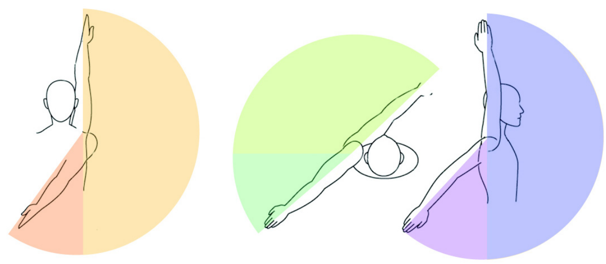

Fig. 1. Range of Motion of the Upper Extremities

As a result of a combination of the movements of each joint, various gestures to interact with products are created. For muscle strength, from the wrist to the shoulder, there are as many as 37 muscles involved in generating upper extremity gestures. Based on their appropriate strength, it becomes possible to bear the weight of products carried for a longer period of time. Meanwhile, bearing weight for long and repeating the same movement are more related to muscle endurance. Even though muscle strength and muscle endurance are different functions with regard to actual movements, applying a strain to a certain body part and maintaining strength are interconnected and occur simultaneously. At this point, they are considered together especially when attempting a contextual approach.

The movements of the upper extremities are affected by internal or external factors. As external factors, product location and weight are considered, i.e. physical distance and angle from the trunk to the product. Reaching and stretching become more difficult as the arms and forearms move further away from the rest position. Maintaining muscle strength becomes more difficult as the weight of products lifted or carried by the arms and forearms increases. The movements of the upper extremities are also restricted when the joints become stiff and muscles lose their tension and strength due to diseases, accidents, or aging, all of which are internal factors. Aging occurs to everyone. Thus, age-related functional impairments should be thought as one of the main issues in designing products used by anyone. In terms of motor functions, physical attributes of the elderly are weakness of muscular strength and limited range of motion (Bae and Lee, as cited in Ha et al., 2014). As people age, their range of motion diminishes (Grimston et al., 1993) and, in particular, their flexion, extension, and flexion-extension ranges are limited (Sullivan et al., 1994). Among the three main joints of the upper extremities, problems are frequently seen in the shoulder joint due to degenerative arthritis and adhesive capsulitis (The Korean Academy of Clinical Geriatrics, 2011). Around the age of 50, muscle mass begins to decrease and after the age of 60, this loss accelerates. The attack rate of Sarcopenia (natural physiological changes) associated with aging, not pathologic symptoms (Song and Hong, 2011) in the elderly over 65 is more than 25%, and over 80 is about 50% (Iannuzzi et al., 2002).

2.2. Existing Assessment Tools

In Korea, assessment tools of upper extremity functions can be categorized into two groups: specific approaches emphasizing a certain body part (or function), and umbrella approaches based on Activities of Daily Living (ADL) or Instrumental Activities of Daily Living (IADL). One group has detailed assessment criteria by body functions (or body parts) focusing on medical diagnosis and evaluations. As representative examples of this group, there are the Korean Disability Grading System, McBride Disability Evaluation Principles, A.M.A Guide, and others. Based on medical accuracy emphasizing specific problematic parts or functions, these tools have been used as standards to determine grades of the disabilities or levels of accident insurance benefits. The other group provides umbrella assessment criteria to evaluate general basic abilities to perform daily activities. Hence, their criteria consist of multiple body function factors. They were primarily devised to see the deterioration extents in physical and cognitive functions resulting from dementia or stroke. In this group, there are Barthel Index, OECD Long-term Disability Questionnaires, Functional Independence Measure (FIM), and others.

The other hand, the specific approaches provide relatively clear determination in evaluating severe function loss with specific evidence but still have difficulties in grading the functions. Their criteria to evaluate function levels are expressed with technical terms in medical domains. Therefore, this group of tools is hard to use and to understand without proper knowledge. For example, the Korean Disability Grading System refers to “a person whose range of motion has decreased more than 75% in their three major joints in one of their upper extremities” as the type 1 of grade 2 of upper extremity joint dysfunction. Based on the criteria, it is difficult to understand how capable the person is intuitively, i.e., what the person can do in his/her daily life with the loss.

Although the umbrella approaches focus on severe loss excluding mild loss as well, criteria of the umbrella approaches are composed of different function evaluators such as seeing, hearing, mobility, and others. Each criterion focuses on different body functions not overlapped with each other and not focusing a certain function. Thus, as a group, criteria of the approaches review the conditions of the entire body functions needed for daily life. The approaches also adopt a descriptive expression manner for daily activities almost everyone performs. The activities are necessary for daily life but each function requires low capability levels. For example, in OECD Long-term Disability Questionnaires, one of the questions asked is “Is your eyesight good enough to read ordinary newspaper print (with glasses if usually worn)?” Upon hearing the question, the context and significance of the question are instantly understood. However, as the questions demonstrate, these approaches also focus on severe loss impacting independent living. In this regard, the umbrella approaches are limited in that they exclude those who are functionally impaired but not disabled.

Table 1. Korean Disability Grading System for Extremity Joint Dysfunction

Grade	Type	Description (A person whose ROM decreased more than~)
1	1	- 75% in each of the three major joints in each upper extremity
2	1	- 75% in each of the three major joints in the upper extremity OR 75% in two out of the three major joints in each upper extremity
	2	- 50% up to 75% in each of the three major joints in each upper extremity
	3	- 75% overall in each of the fingers in each hand
3	1	- 50% up to 75% in two out of the three major joints in each upper extremity OR 25% up to 50% in the three major joints in each upper extremity
	2	- 75% in each of the first and second fingers in each hand
	3	- 75% overall in each joint of the finger in the hand
	4	- 75% in two out of the three major joints in the upper extremity OR 75% in all of the three major joints in the upper extremity
4	1	- 75% in one of the three major joints in the upper extremity
	2	- 75% overall in the first fingers in each hand
	3	- 75% overall in the three fingers including the first or second finger in the hand
	4	- 50% up to 75% overall in the four fingers including first or second finger in the hand
5	1	- 50% up to 75% in two out of the three major joints in the upper extremity OR 25% up to 50% in each of the three major joints in the upper extremity
	2	- 50% up to 75% overall in the first fingers in each hand
	3	- 75% overall in the first finger in the hand
	4	- 50% up to 75% overall in each of the first and second fingers in a hand
	5	- 50% up to 75% overall in each of the three fingers including the first or second finger in the hand
6	1	- 50% in the shoulder, elbow, or wrist joint in the upper extremity OR 50% up to 75% overall in the first finger in the hand
	2	- 75% overall in the two fingers including the second finger in the hand
	3	- 50% up to 75% overall in the two fingers including the first finger in the hand
	4	- 75% overall in each of the third, forth, and fifth fingers in the hand

Table 2. OECD Long-term Disability Questionnaires (McDowell, 2006)

Question No.	Criteria
	Note: The ten questions with an asterisk are included in the abbreviated version.
1	Is your eyesight good enough to read ordinary newspaper print? (with glasses if usually worn)
2	Is your eyesight good enough to see the face of someone from 4 metres? (with glasses if usually worn)
3	Can you hear what is said in a normal conversation with 3 or 4 other persons? (with hearing aid if you usually wear one)
4	Can you hear what is said in a normal conversation with one other person? (with hearing aid if you usually wear one)
5	Can you speak without difficulty?
6	Can you carry an object of 5 kilos for 10 metres?
7	Could you run 100 metres?
8	Can you walk 400 metres without resting?
9	Can you walk up and down one flight of stairs without resting?
10	Can you move between rooms?
11	Can you get in and out of bed?
12	Can you dress and undress?
13	Can you cut your toenails?
14	Can you (when standing), bend down and pick up a shoe from the floor?
15	Can you cut your own food? (such as meat, fruit, etc.)

Contrasting the two types of assessment approaches discussed so far, although it has not been widely used yet in Korea, an inclusive approach from Keates and Clarkson (2004) should be considered. This approach discerns mild impairments from severe impairments and disabilities instead of treating them as perfectly normal. Thus, it covers from the full capability levels not suffering any problems to the almost zero capability level where behavior cannot be performed. Its criteria adopt easy words to describe capability extents in daily activities, similar to the umbrella approaches. Its descriptive criteria contribute to grasping the meaning related to capability levels by using a numerical severity score. However, this approach's criteria only focuses on evaluating range of motion (ROM), and excludes other factors to help upper extremity movements such as muscular strength and muscular endurance. Despite full ROM in the front, behind back, above, if either arm is unable to maintain appropriate muscle strength during the time necessary to complete the movement, the movement cannot be made.

Table 3. Keates and Clarkson's Reach & Stretch Capability (2004)

Level	Question	Severity Score
R1	Cannot hold out either arm in front to shake hands	9.5
R2	Cannot put either arm up to head to put a hat on	9.0
R3	Cannot put either hand behind back to put jacket on or tuck shirt in	8.0
R4	Cannot raise either arm above head to reach for something	7.0
R5	Has difficulty holding either arm in front to shake hands with someone	6.5
R6	Has difficulty putting either arm up to head to put a hat on	5.5
R7	Has difficulty putting either hand behind back to put jacket on or tuck shirt in	4.5
R8	Has difficulty raising either arm above head to reach for something	3.5
R9	Cannot hold one arm out in front or up to head (but can with other arm)	2.5
R10	Cannot put one arm behind back to put on jacket or tuck shirt in (but can with other arm). Has difficulty putting one arm behind back to put jacket on or tuck shirt in, or putting one arm out in front or up to head (but no difficulty with other arm)	1.0
R11	Full reach & stretch ability	

In sum, all of the specific, umbrella, and inclusive approaches fail to evaluate some of the upper extremity functions. The specific and umbrella approaches have limited coverage focusing on severe function loss. In addition, the specific approaches that focus on a certain function, like Korean Disability Grading System, require special knowledge to understand the technical jargons. The umbrella approaches based on (I)ADL also have some limitations in assessing the upper extremity functions in that they concentrate on overall function loss rather than particular damage levels of each body function. Meanwhile, the inclusive approach ranges from severe function loss to mild loss and consists of intuitively understandable criteria with numerical severity scores. Regrettably, it has some deficits due to its emphasis on ROM and is not widely used. Therefore, compensating for the deficits found, the guidelines for a new set of criteria to assess upper extremity functions are as follows: providing a full range assessment from mild loss to severe loss; allowing ordinary people to intuitively understand the criteria meaning through descriptive statements stating common daily activities; enabling people to surmise capability extents with numerical values that indicate capacity extents by capacity levels; providing compatibility with existing assessment tools to lead to wider use and thus expand inclusive design by reflecting the numerical estimates of medical specialists.

3. Method

3.1. Study Population and Survey Administration

The population of this study was Korean physiatrists and orthopedists working either in private practice or in a hospital where they met with patients with temporary or permanent motor function impairments. Out of the total population of 5,797 specialists (Jung et al., 2011), 58 eligible participants were recruited between April and November 2014 from the Seoul metropolitan region, including the Gyeonggi province and the Daegu Gyeongbuk region. Initially, these participants were recruited through the author's personal network as contact was effortless. The initial participants were then requested to share the survey with their colleagues via their personal networks. They were informed about the survey purpose, the data confidentiality, and an incentive in the form of a gift worth fifty thousand won offered for participating in the study. Complete responses were obtained primarily through email or visiting their workplaces. The recruiting methods in this study may have produced a sample with some bias relative to the entire medical professional population in that it focused solely on physiatrists and orthopedists.

3.2. Development of the Questionnaire and Content Validity

An expert survey was conducted to identify numeric values for each question that indicated the extent of upper extremity capability. Three steps were employed to develop criteria to be used as questions in the questionnaire to evaluate upper extremity capability. First, to identify critical issues in evaluating capability, a discussion with medical experts, nurses and physiatrists was conducted. Second, existing assessment tools for upper extremity functions were reviewed. Third, paper-based interviews with five physiatrists were conducted with regard to 28 preliminary criteria (11 criteria for ROM, 17 criteria for strength); these were developed from discussion findings and literature reviews. The objective of the paper-based interview was primarily to identify the content validity of the questionnaire consisting of 28 criteria, to uncover possible problems in running the full study, and to explore respondents' comprehension of specific questions. The questionnaire was judged by interviewees (five physiatrists) to be relevant to the assessment of upper extremities. Identifying solid content validity, two revision directions were cited to maintain a separation between strength and ROM, and to widen the differences in capability extents between questions. Consequently, based on the findings, the questionnaire was developed that consists of two seven-questions (totally fourteen questions) describing daily activities in strength and ROM of the upper extremities.

3.3. Statistical Analysis

Incomplete questionnaires were excluded and complete questionnaires were analyzed. In the survey, participants were required to submit perceptual estimations of the upper extremity capabilities corresponding to the activities stated in contextual questions. More specifically, they were requested to provide each question with a numeric score that ranged from 0 to 100(representing fully disable to fully able). 0 was assigned if neither arm could be moved in any direction, while 100 was assigned if both arms could be moved any direction. This meant that theoretically infinite choices were presented between 0 and 100. Nevertheless, response scores provided by respondents were shown in multiples of 5 or 10 and sorted into seven to ten groups. Due to the relatively small sample size resulting from limited access to medical experts within a specific specialty, two tests for the normality of data, the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test, were conducted. The test values below 0.05 indicated that the data significantly deviated from a normal distribution. Since no claim for normal distribution could be made, nonparametric statistics were employed. Therefore, as a reliability test, Kendall's Coefficient of Concordance for rank (W) was calculated to measure the agreement among several rankers (respondents) assessing a given set of questions. For Kendall's Coefficient of Concordance test, the Ws were >.9, thus indicating that respondents strong agreed in the question rankings ($p<0.0001$). Based on the test results of normality and reliability, medians were more appropriate as representative values. All analyses were conducted using the Statistical Package for Social Sciences (SPSS, Inc., Chicago Ⅲ), version 20.0.

Table 4. Kendall's Coefficient of Concordance Test (N=56)

Category	Criteria	Mean Rank
ROM	Can move either arm in front to shake hands	1.0
	Can lift either arm up to reach a plate on an eye-level shelf	2.1
	Can move either arm in front, behind, up, down to point to something	3.2
	Can move either arm in front, behind, up, down to put on a jacket or shirt	3.8
	can move both arms in any directions with no problems	5.0
	W^a=.939, χ^2= 210.438, df= 4, Asymp. Sig.=	.000
Strength	Can use either arm to lift up or carry a mug cup without any liquid (300-500g)	1.1
	Can use either arm to lift up or carry a bottle of milk (1L, 1.05kg)	2.0
	Can use either arm to lift up or carry a pack of sugar (2.7kg)	3.0
	Can use either arm to lift up or carry a pack of rice (10kg)	4.0
	Can use each arm to lift up or carry a pack of rice (10kg)	5.0
	W^a=.953, χ^2= 213.535, df= 4, Asymp. Sig.=	.000

a. Kendall's coefficient

4. Result

4.1. Characteristics of Respondents

Out of a total of 58 questionnaires, 56 questionnaires were used for this analysis. Table 5 summarizes the characteristics of the participants.

Table 5. Characteristics of Survey Participants

Specialty	Sex		Total (%)	Region		Total (%)
	Male	Female		Seoul · Metropolitan	Daegu · Gyeongbuk	
Physiatrist	39	12	51 (87.9)	36	15	51 (87.9)
Orthopedist	7	0	7 (12.1)	4	3	7 (12.1)
Total	46	12	58 (100)	40	18	58 (100)

4.2. Response Results for Upper Extremity Capacity in ROM

Table 6 shows the descriptive data for ROM questions in the survey. For the purpose of assessment, two questions and their scores were given as such that "cannot move either arm in any directions" was rated 0, and "can move both arms in any directions with no problems" was rated 100. Corresponding to "can move either arm in front to shake hands," the representative value of capability extents were accounted for mean, mode, and median of 22.1, 10.0, and 20.0 respectively. As representative values of "can lift either arm up to reach a plate on an eye-level shelf," mean, mode, and median were 39.0, 40.0, and 40.0 respectively. As representative values, corresponding to "can move either arm in front, behind, up, down to point to something," mean, mode, and median were 55.1, 50.0, and 50.0 respectively. As representative values corresponding to "can move either arm in front, behind, up, down to put on a jacket or shirt," mean, mode, and median were 64.6, 70.0, and 70.0 respectively. As representative values corresponding to "can move both arms in front, behind, up, down to put on a jacket or shirt," mean, mode, and median were 86.9, 90.0, and 90.0 respectively.

Table 6. Descriptive Data in ROM Questions (N=56)

Criteria	Mean	SD	Min.	Max.	IQR			Mode (%)
					Q1	Q2	Q3	
Cannot move either arm in any directions	Given 0, thus not applicable							
Can move either arm in front to shake hands	22.1	13.5	10	60	10	20	30	10 (35.7)
Can lift either arm up to reach a plate on an eye-level shelf	39.0	14.1	20	70	30	40	40	40 (31.6)
Can move either arm in front, behind, up, down to point to something	55.1	12.3	30	80	50	50	70	50 (38.6)
Can move either arm in front, behind, up, down to put on a jacket or shirt	64.6	13.4	30	90	52	70	70	70 (36.8)
Can move both arms in front, behind, up, down to put on a jacket or shirt	86.9	8.7	60	100	80	90	90	90 (57.9)
Can move both arms in any directions with no problems	Given 100, thus not applicable							

4.3. Response Results to Upper Extremity Capacity in Strength

Table 7 shows the descriptive data for each strength question in the survey when "cannot use either arm to lift up or carry anything with strength" is given 0 and "can use each arm to lift up or carry something with no problems" is given 100. As representative values of "can use either arm to lift up or carry a ceramic mug cup without any liquid (300-500g)," mean, mode, and median were 23.0, 10, and 20 respectively. As representative values corresponding to "can use either arm to lift up or carry a bottle of milk (1L, 1050g)." mean, mode, and median were 36.5, 30, and 30 respectively. As representative values corresponding to "can use either arm to lift up or carry a pack of sugar (2.7kg)," mean, mode, and median were 50.1, 50, and 50 respectively. As representative values corresponding to "can use either arm to lift up or carry a pack of rice (10kg)," mean, mode, and median were 65.0, 60, and 60 respectively. As representative values corresponding to "can use each arm to lift up or carry a pack of rice (10kg)," mean, mode, and median were 87.6, 90, and 90 respectively.

Table 7. Descriptive Data in Strength Questions (N=56)

Criteria	Mean	SD	Min.	Max.	IQR			Mode (%)
					Q1	Q2	Q3	
Cannot use either arm to lift up or carry anything with strength	Given 0, thus not applicable							
Can use either arm to lift up or carry a mug cup without any liquid (300-500g)	23.0	14.1	10	60	10	20	30	10 (38.6)
Can use either arm to lift up or carry a bottle of milk (1L, 1.05kg)	36.5	13.0	20	75	30	30	40	30 (33.3)
Can use either arm to lift up or carry a pack of sugar (2.7kg)	50.1	12.7	30	80	40	50	60	50 (33.3)
Can use either arm to lift up or carry a pack of rice (10kg)	65.0	12.8	40	90	60	60	70	60 (35.1)
Can use each arm to lift up or carry a pack of rice (10kg)	87.6	10.3	50	100	90	90	90	90 (56.1)
Can use each arm to lift up or carry something with no problems	Given 100, thus not applicable							

4.4. Assessment Criteria and Capability Scores of Upper Extremity

Based on the non-normality of data and reliability of respondents with regard to ranking, the questions and the median values in the survey were used as the assessment criteria and capacity scores to represent the capability extents respectively. The resultant product is shown in Table 8. With regard to ROM and strength, questions with capability scores of 0, and 100 were listed in levels 1 and 7 respectively. Two five-question groups in the survey were listed in levels 2 through 6 and divided into ROM and strength in increasing order.

Table 8. Assessment Criteria and Capacity Scores for Upper Extremity Functions

Category	Level	Criteria	Score
ROM	1	Cannot move either arm in any direction	0
	2	Can move either arm in front to shake hands	20
	3	Can lift either arm up to reach a plate on an eye-level shelf	40
	4	Can move either arm in front, behind, up, down to point to something	50
	5	Can move either arm in front, behind, up, down to put on a jacket or shirt	70
	6	Can move both arms in front, behind, up, down to put on a jacket or shirt	90
	7	Can move both arms in any directions with no problems	100
Strength	1	Cannot use either arm to lift up or carry anything with strength	0
	2	Can use either arm to lift up or carry a mug cup without any liquid (300-500g)	20
	3	Can use either arm to lift up or carry a bottle of milk (1L, 1.05kg)	30
	4	Can use either arm to lift up or carry a pack of sugar (2.7kg)	50
	5	Can use either arm to lift up or carry a pack of rice (10kg)	60
	6	Can use each arm to lift up or carry a pack of rice (10kg)	90
	7	Can use each arm to lift up or carry something with no problems	100

5. Discussion

Compared with a series of tools similar to (I)ADL (Katz et al., 1963) that concentrated on severe function loss, the assessment criteria developed in this study included relatively mild impairments impacting daily activities. In contrast to the Korean Disability Grading System using technical terms that pose a barrier to users' intuitive understanding, the newly developed criteria would release their difficulties by using descriptive criteria from daily activities. In differentiating from Keates and Clarkson (2004) that provided hierarchy among criteria and severity scores, this study departmentalized construct factors, ROM and strength, assigning them hierarchy and capability scores. This separation of the factors allowed exacter assessment by removing intervention of factors in different groups and consequent misjudgment.

In the meantime, this research determined that medical specialists showed strong agreements in ranking criteria, but weak consensus in assigning specific scores to them. This indicated that subdividing the ranks with specific scores was hindered by conceptual and instrumental deficits: dichotomous classifications in medicine and lack of referential data. Specifically, as noted, during the expert interview, the interviewees' difficulties in interpreting differences among the 28 preliminary criteria as numerical values led to decreasing the number of criteria (from 28 to 14 criteria). This problem would be originally from dichotomous perspectives between pathologic and non-pathologic, disability and normality. The medical field has been interested in pathologic severe impairments to cure patients while ignoring comparatively mild impairments. The situation in the medical field means that there are no resources to consider other options that could consolidate the medical dichotomy in medicine. This dichotomy treats non pathologic impairments as normal conditions without problems and eliminates the opportunity to consider non-pathologic impairments that create problems in daily lives. This conceptual deficiency can affect or be affected by the shortage of assessment tools. In contrast to the various tools for severe impairments, the lack of referential evaluation criteria for those who are not severely impaired would partially demonstrate the link between conceptual and instrumental deficiencies.

This study has limitations. As estimated, the sample size of 58 medical doctors from a certain specialty, and a non-parametric approach are reasons to be guarded against overconfidence in generalizing the findings. Even though theoretically it had large enough sample size (>30) to guarantee normality, this study could not survey the entire study population of physiatrists and orthopedists. This study could not compare the findings (criteria with capability scores obtained from the survey), to outcomes through qualitative expert opinion-based analyses (i.e., Delphi, Analytic Hierarchy Process, AHP), or ergonomic analyses (i.e., Rapid Upper Limb Assessment, RULA, Rapid Entire Body Assessment, REBA). The comparison is currently absent because sufficient information about outcomes from other approaches is lacking.

6. Conclusion

In an effort to bolster inclusive design, this study developed criteria and capability scores to assess upper extremity capabilities as a more accessible tool for designers. The accessibility of this tool was obtained through descriptive criteria having numeric values. Content validity and reliability of the criteria were verified by physiatrists and Kendall's W test respectively. Meanwhile, it was found that medical doctors specialized in motor functions were in accord with criterion ranking, but had difficulties in assigning specific scores to each criterion. Their difficulties were increased especially in mild impairments. From the results, it can be inferred that the medical specialists' perceptions to assess capability extents were influenced by dichotomy between disability and non-disability. Their perceptions led to difficulties in allocating numeric values for the grey area between disability and non-disability. Therefore, this study suggested that in order to offset for this deficit and confirm the result, outcomes from ergonomic approaches might also be considered.

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