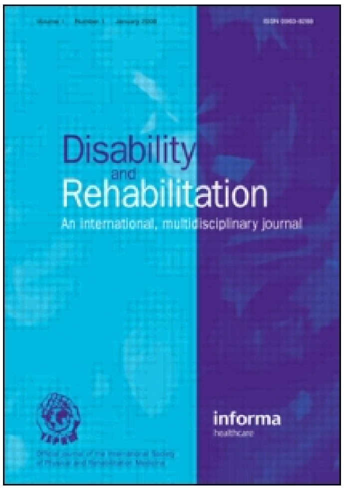


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# Arm and hand skills: Training preferences after stroke

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RESEARCH PAPER

# Arm and hand skills: Training preferences after stroke

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**Abstract**

*Purpose*. An increasing demand for training after stroke has brought about the need to develop rehabilitation technology. This article reports an inquiry into skill preferences of persons after stroke regarding arm–hand training and examines the relationship between the use of the affected arm and the patient's training preference.

*Method*. Data collection involved a semi-structured interview of 20 persons in the subacute and 20 persons in the chronic stage after stroke, based on an adaptation of the motor activity log.

*Results*. Subacute and chronic patients after stroke agreed on seven out of 10 most preferred training skills. Patient preferences related mostly to 'manipulation in combination with positioning' and 'manipulation'. Eight motivation aspects for skill training were identified as being important. A positive correlation was found between skill preference scores and use of the impaired arm ($r = 0.64$) ($p < 0.001$).

*Conclusions*. This study has resulted in an inventory of skills that persons after stroke prefer to train on. This list can be used for implementation of exercises in rehabilitation technology. Motivation for skill training pertains to optimising participation level, rather than function or activity level. This study suggests that client-centred assessment is advocated to set therapy goals that match patient training preferences.

**Keywords:** *Stroke, upper extremity, rehabilitation, technology, motivation*

## Introduction

Approximately 50% of stroke survivors experience considerable disability of arm and hand function after discharge from hospital or rehabilitation clinics, which may last for the rest of their lives [1–3]. Training after hospital or rehabilitation care can improve arm hand function further; even in chronic stages after stroke [4–11].

The expected increase of stroke events [12], and the knowledge that prolonged rehabilitation leads to improved arm and hand function in persons after stroke [4] has increased the demand for rehabilitation services. This is expected to increase pressure on the health system, considerably. The development of smart rehabilitation technology that can allow patients to train their arm (semi-) independent from a therapist is an opportunity if not a necessity for future stroke patient care [13].

Most robotic (actuator driven) [14] and sensor (movement/activity registration) systems [15], that are available nowadays for training arm and hand function in persons after stroke support training that involves practise of movements in single joints and along single movement planes. This approach may be effective in reducing motor impairment, but does not lead to corresponding benefits regarding every day life activities [16–18]. Arguably, impairment-oriented training is not a sound approach. Richards et al. [19] found that the more time is spent on

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training higher level skills in patients after stroke, the more successful the rehabilitation outcome will be. This was also confirmed by the literature review by Van Peppen et al. [20] who found that most evidence for influencing functional outcome after stroke exists for task-oriented training approaches. In the context of face to face contact between therapist and patient, it is not necessary to know *a priori* patient training preferences as exercises can be matched by the therapist to the needs of the patient [21].

However, task-oriented approaches are finding their way towards rehabilitation technology, although to date they are applied in few systems [22–26]. When developing rehabilitation technology it is essential to know in advance which skills are of interest to persons after stroke to ensure that technology will support these skills. Firstly, because training effects are context and task-specific and improvement after training a certain skill cannot be assumed to transfer to other functional activities [27,28]. Therefore, software (exercises, feedback on exercises) and training objects accompanying a robotic or sensor-based rehabilitation system should be as specific as possible for the skills that are trained. Secondly, it is important to allow patients to choose from skills that are close to what they want/need to train. Patient tailored rehabilitation allows patients to have an active role in their rehabilitation process, which stimulates motivation and treatment adherence [29–32].

This study aimed to assess (a) skill training preferences of subacute and chronic persons after stroke and (b) whether patients prefer to train on their most impaired functions (or not) and (c) which are their main motives for skill training preferences.

## Methods

### *Study design*

A cross-sectional survey involving a semi-structured interview of subacute and chronic patients after stroke was conducted. The Medical Ethics Committee of Stichting Revalidatie Limburg in Hoensbroek (the Netherlands) has approved this study.

### *Subjects*

Twenty subacute and 20 chronic patients after stroke were recruited from the Hoensbroek Rehabilitation Centre in Hoensbroek (NL) over a period of 5 months.

Inclusion criteria were: (1) a first ever supratentorial stroke, (2) age $\geq$18 years, (3) clinically diagnosed with central paresis of the arm/hand, (4) a post-stroke time of either 3–26 weeks (subacute group) or $>$12 months (chronic group), (5) a fair cognitive level, i.e. Mini-Mental State Examination (MMSE) score $\geq$26 [33], (6) ability to read and (7) understand the Dutch language.

Exclusion criteria were: (1) severe neglect in the near extra personal space [34], established by the letter cancellation test [35] and Bell's test (quantitative evaluation) [36] with a minimum omission score of 15% [37], (2) severe spasticity (Modified Ashworth Scale total arm, measuring spasticity of Shoulder adductors, Elbow Flexors and Wrist Flexor Musculature $>$4), (3) severe additional neurological, orthopedic or rheumatoid impairments before stroke that may interfere with task performance, (4) Broca aphasia, Wernicke aphasia, global aphasia: as determined by Akense Afasie Test (AAT) [38] and (5) severe apraxia as measured by apraxietest van Heugten [39].

### *Procedure*

The framework for the procedures used in the study was determined before conducting the study to avoid bias of the interviewer for data analysis and resulting conclusions. An overview of the procedures used is given in Figure 1.

A semi-structured interview was conducted, using an adapted version of Motor Activity Log (MAL), Dutch version [40,41]. The interviewer was not involved as a caregiver to participating patients.

The original MAL measures the use of the impaired arm in daily life. The adapted version has been designed to help patients towards a decision on skill preference. The original version was condensed to 17 (out of 26) items that are relevant for technology supported skill training.

After rating the 17 skills, patients were invited to suggest three skills outside the given list, which they would like to practise. This procedure resulted in a 20-item list of skills per subject.

For these 20 items, the MAL scoring system was applied. For each skill, a 0–10 score was thus obtained reflecting the amount of use ('How much did you use your impaired arm for this activity in the last week?') and quality of use ('How useful was your impaired arm when doing this activity in the last week?'). The sum score of 'amount of use' and 'quality of use' will further be specified as 'use' of the impaired arm.

To get information on which skills patients prefer to train on, patients were asked to indicate on which five activities out of the 20 they would like to train most. The 20-item list with skills was offered to each of the patients in a different randomised order to minimise the influence of order of presentation on choice of skill preference.

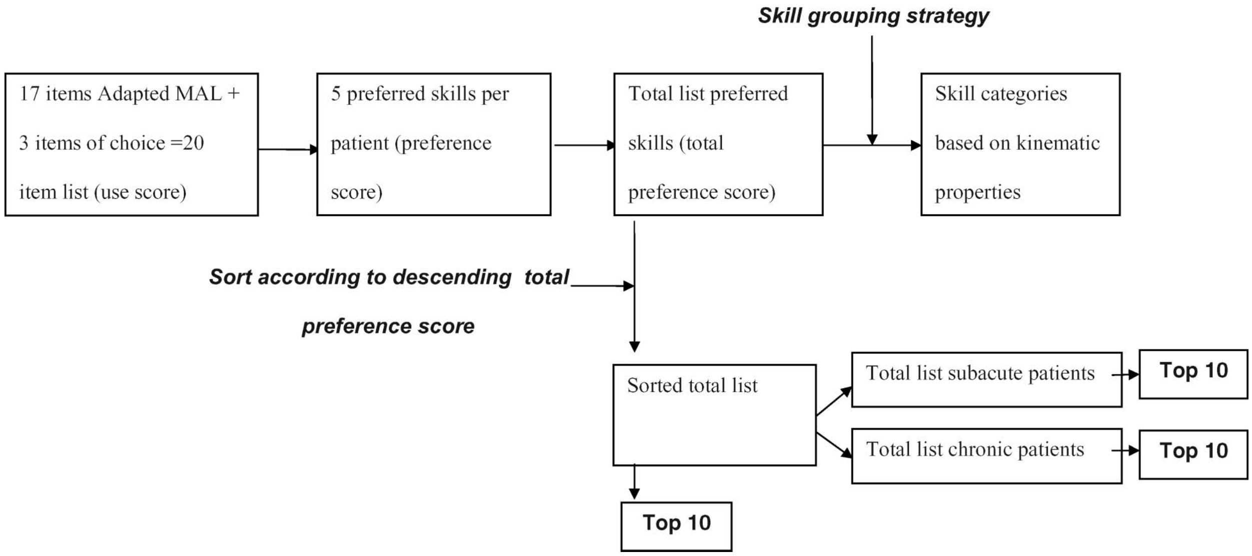


Figure 1. Schematic presentation of procedure (preference score = score given by a patient to the five skills that he/she prefers to train on; Total list = list of all skills that were mentioned by the total group of patients as preferred skills to train on; total preference score = sum of all the preferences scores that were attributed by the total group to a specific skill in the total list).



Subsequently, the interviewer wrote down these five preferred skills on separate cards. The patient was then asked to rank the skills according to descending preference level. Scores 1–5 were attributed (five for most preferred skill, one for least preferred skill), leading to a preference score.

The interviewer also asked the patients why they chose a certain activity to be their most preferred skill to train on (or why did they give a score of five to a specific skill)? This information was used to create an inventory of the reasons/motivations why skills were chosen as preferred skills to train on.

A total list was made containing all skills that were mentioned by the total group of patients as preferred skills to train on. For each skill in the total list, the preference scores attributed by patients for each skill were summed (=total preference score) and skills were ranked according to this total preference score (descending order). To identify any major differences regarding skill training preferences between persons in chronic and subacute stage after stroke, the 10 top rated skills for the two groups were compared (see also Figure 1). Note that the total preference score for a skill can outnumber the number of participants from the study, as each skill can be given a score of 1–5 by each of the participants (or 0 if it was not mentioned as a preferred skill to train on).

Next, a skill grouping strategy downsized the total list of preferred training skills by clustering items, based on kinematic similarity. This procedure was initiated, to detect where patients mentioned similar skills in different wording. The categories also give additional information about the skills that are mentioned by patients. It was not the purpose of this procedure to replace the skill information by its kinematic components.

Two independent movement scientists made an *a priori* grouping strategy. This resulted in the following skill categories: positioning the upper extremity, pointing to/indicate, grasp, manipulate, carry/tilt, push/pull, ‘other’. The movement scientists then evaluated the total list and mentioned for each skill the category name(s) that was/were applicable for that skill. Skills with similar movement components could now be clustered into categories. As skills could also contain components of several categories at the same time, combination categories were constructed.

There was 70% agreement between the experts. In the case of disagreement, a third expert evaluated the skill (not having seen the analysis of the other experts) to facilitate agreement on the differences between the coders.

It was analysed how skills from the total list were distributed across the categories (or combinations of categories) mentioned above. This was done to ascertain how frequent all categories of upper extremity activity were represented and whether categories of upper extremity skills were over- or underrepresented.

### *Data analysis*

A statistical analysis has been performed for following patient characteristics: age, MMSE and post-stroke time (SPSS).

The answers of the patients to the motivation question: ‘What was the reason for you to choose this skill as the most preferred skill to train on?’ were analysed qualitatively through open coding (one observer). To decide if motives where driven by a need to improve impairment level, activity level or participation level, the motives were matched to the following definitions. Impairment can be defined as 'problems in body functions or structure' [42]. Activity can be defined as 'the execution of a task by an individual' [42]. Participation can be defined as 'involvement of an individual in a life situation' [42].

Use scores and total preference scores were imported into Matlab 7.14 (The Mathworks Inc, Natick/Massachusetts). A Spearman correlation coefficient was calculated as a measure of association [43] between the total preference scores and the total use score (sum of use scores from all patients for a specific skill) related to the corresponding skill. This was done for total preference scores and use scores of the total list skills and of the categorised skills. As there were 10 participants with muscle power in the proximal upper extremity, but with a-functional hand function, it was interesting to see in how far 0 scores on the level of use influenced the association that was found. Therefore a Spearman correlation coefficient was calculated between arm use scores that are not equal to zero and their corresponding total skill preference scores.

## Results

### *Patient characteristics*

Forty persons after stroke participated in this study. Patient characteristics are displayed in Table I. No statistically significant differences can be found between subacute and chronic patients after stroke for age and MMSE. Only post-stroke time is significantly different for both groups ($p < 0.001$). No racial/ethnic-based differences were present.

### *Skill training preferences*

A list of the 10 most preferred skills, i.e. with the highest total preference scores is presented in Table II. In the list of the 10 most preferred training skills, seven out of 10 skills chosen were the same for subacute and chronic patients after stroke (Table II). These skills encompassed: 'eating with knife and fork', 'holding an object while walking', 'keyboard use', 'taking money from purse', 'opening/closing clothing', 'grooming' and 'handling broom, rake or spade'. Both in the subacute and chronic stroke group 'holding an object while walking' and 'eating with knife and fork' rated highest. In the subacute group, also the following skills were mentioned in the top 10 skill preferences: 'bringing cup to mouth', 'using telephone' and 'using a car's steering wheel'.

Table I. Overview of patient characteristics.

| | Subacute ($n=20$) | Chronic ($n=20$) | Total ($n=40$) |
|---|---|---|---|
| Gender | | | |
| Male | 11 | 13 | 24 |
| Female | 9 | 7 | 16 |
| Post-stroke time | | | |
| Average months (SD) | 3.12 (1.21)* | 24.22 (19.65)* | 13.67 (17.4) |
| Age | | | |
| Average years (SD) | 61.9 (12.2) (NS) | 59.71 (10.1) (NS) | 60.78 (11.1) |
| Total range | 28–79 | 41–77 | 28–79 |
| Dominant side | | | |
| Left | 3 | 1 | 4 |
| Right | 17 | 19 | 36 |
| Impaired side | | | |
| Left | 11 | 10 | 21 |
| Right | 9 | 10 | 19 |
| MMSE | | | |
| Average score (SD) | 28.35 (1.38) (NS) | 28.05 (1.31) (NS) | 28.2 (1.34) |

(NS), non-significant.
*$p < 0.001$.

Table II. Ranking of skills according to the 10 highest total preference scores from the total patient group ($n=40$), the patients in subacute stage after stroke ($n=20$) and the patients in chronic stage after stroke ($n=20$).

| Skills as named by patient | Total group *R* (tps) | Subacute stroke patients *R* (tps) | Chronic stroke patients *R* (tps) |
|---|---|---|---|
| Eating with knife/fork | 1 (61) | 1 (35) | 2 (26) |
| Holding object while walking | 2 (52) | 2 (25) | 1 (27) |
| Keyboard work | 3 (42) | 3 (22) | 4 (20) |
| Taking money from purse | 4 (37) | 4 (21) | 7 (16) |
| Open/close clothing | 5 (36) | 5 (19) | 6 (17) |
| Grooming | 6 (33) | 7 (14) | 5 (19) |
| Writing | 7 (28) | | 3 (25) |
| Holding rake/broom/spade | 8 (26) | 8 (13) | 9 (13) |
| Cup to mouth | 9 (18) | 6 (15) | |
| Arm in sleeve/reach high/sewing | 10 (17) | | 10 (×/×/(12)) |
| Wash and dry body | | | 8 (14) |
| Handling telephone and steering wheel car | | 9 and 10 (10/10) | |

*R*, ranking of skills; tps, total preference score.

In the chronic group, participants mentioned 'writing', 'washing/drying body' and 'sewing'.

The sum of total preference scores of the 10 most preferred skills were comparable for the subacute and chronic patient group, i.e. 184 and 189, respectively. This indicates that both groups give equal importance to these skills.

After the skills had been clustered skills in skill categories, the categories were examined to establish whether preferred skills were spread equally over the categories. The number of skills that were attributed per skill category was calculated. Almost all categories contained multiple skills.

Skill preference scores per category were calculated by adding up all the total preference scores of the skills belonging to a specific skill category (Figure 2).

Skills that patients preferred to train on are spread along the skill categories. Most skills belonged to combination categories ('position-grasp', 'position-manipulate', 'grasp-carry/lift'). It can be concluded that 'manipulation in combination with positioning' and 'manipulation' per se were the skills that are most preferred by patients to train on (Figure 2). This is followed by 'grasp in combination with positioning' and by 'carry/lift' (Figure 2). The above mentioned categories were all represented by multiple skills.

### *Motives for choosing preferred training skills*

From the total inventory of motives that patients mentioned for choosing certain skills as their most preferred skill to train on; eight motives could be identified. The motives were: hope on transfer to other activities, avoid frustration, avoid embarrassment in public, independence, not to be a burden to others, pride, joy, back to work. It seemed that patients were mostly driven to improve their participation level, rather than their impairment and activity levels.

Motives that relate to participation are: avoiding embarrassment in public ('I want to be able to hold a cup/glass or use cutlery properly when eating with friends', 'I don't want to spill food/drinks when eating with others'), avoiding frustration ('It is frustrating when I have a queue of people waiting behind me while I try to take money out of my purse'), independence ('I don't want home-care to help with washing/dressing', 'I don't want to ask help for taking money out of my purse'), not to be a burden to others ('I want to do my share in the household, otherwise I feel a burden to spouse/children'), pride ('I want to look good when I go out of the house'), joy ('I really enjoy cycling', 'I want to caress my grandchildren'), back to work ('I have my own company and I want to fulfil my role'). Improving the activity level is related to the motive: hope on transfer to other activities ('If I can drink from a cup, I will be able to do many more activities'). Improving impairment was never mentioned by patients as a motive for choosing a skill as a preferred skill to train on.

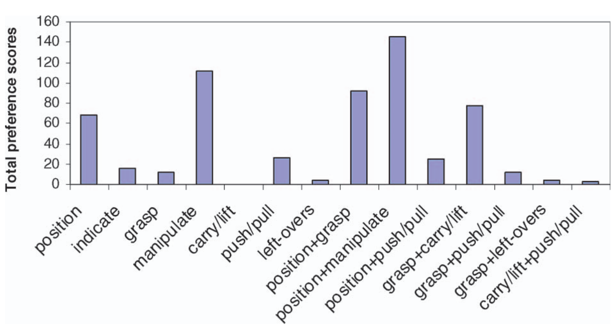


Figure 2. Total preference scores per skill category.

All skills from the total list were chosen to improve participation level. Bringing cup to mouth, hold fish line and operating a PC-keyboard were also chosen for improving activity level (hope on transfer to other activities).

### *Relationship between actual arm use and arm skill training preferences as perceived by persons after subacute and chronic stroke*

The use score (MAL score) reflected the frequency of use; as well as the quality of involvement of the affected extremity for a certain skill. The higher the use scores for a skill, the less the upper limb was impaired for that skill.

Figure 3 presents the relationship between arm use scores for a certain skill and the corresponding total skill preference score. A positive Spearman Correlation Coefficient between skill preference totals and use totals was found ($r = 0.64$, $p < 0.001$).

The correlation between arm use totals that are not $= 0$ and their corresponding skill preference totals was also positive (Spearman $r = 0.62$, $p < 0.001$).

This relationship is even more pronounced when total skill preference sore and use scores are summed per category (Figure 4). The correlation between categorised skill preferences and categorised skill level of use equals 0.8664 ($p < 0.001$).

## Discussion

As the awareness is growing in the field of rehabilitation technology, that training of real-world activities is to be included in future technological developments [13–16], the question remains for which functional tasks to offer upper extremity training. This is an important issue, as training opportunities should be personally meaningful and challenging to support motor learning processes and brain plasticity [44–46].

The first aim of this study was to identify skill training preferences of persons in a subacute and chronic phase after stroke. The skills that patients prefer to train on are very much related to fine motor skills: manipulation and grasp. This was to be

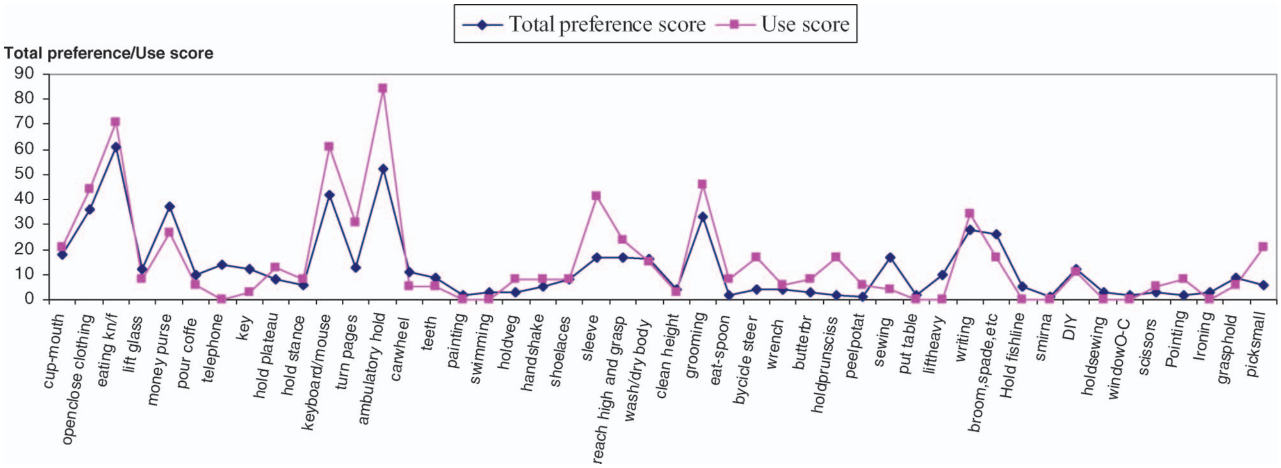


Figure 3. Association between total preference and total arm use scores for total stroke group.

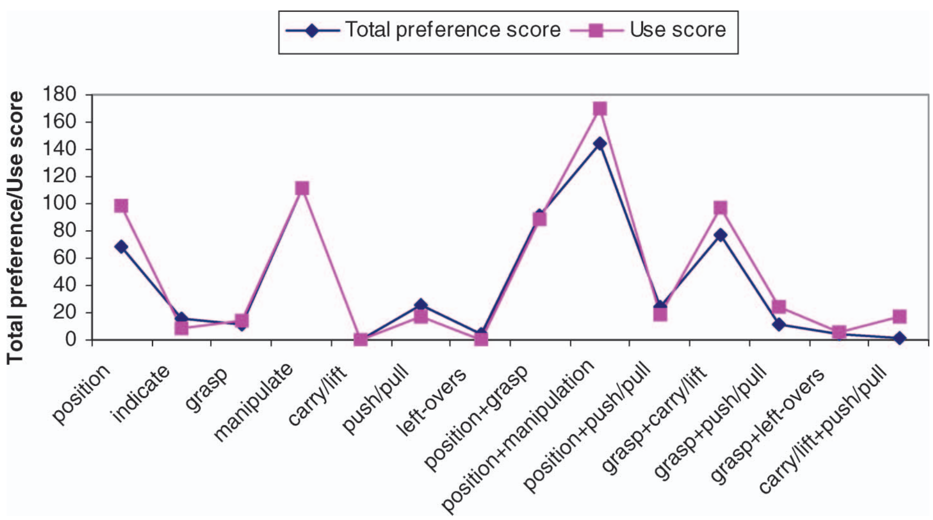


Figure 4. Association between total skill preference score and arm use scores per cluster (total stroke group).



expected as arm movement is to a large extent in function of the hand. Gross motor arm function was also mentioned in the category 'positioning'.

No major differences were found between skill preferences of subacute and chronic patients after stroke, as seven out of the top 10 mentioned skills were the same for both patient groups. The two most preferred skills to train on were the same for subacute and chronic patients, namely: 'hold an object while walking' and 'eating with knife and fork'. This indicates that for technology development, no separate applications are needed for subacute and chronic patients after stroke. To our knowledge, no similar studies exist that provide this information.

The second aim for this study was to find out which are motives for skill training preferences. Motives were found not to be driven by impairment and activity levels, but more by the need of patients to participate in society.

A third aim of this study was to study the relationship between use of the impaired arm for a certain skill and the level of preference that patients showed for training the same skill. The results of this study indicate that patients prefer to train on skills for which they have already achieved a certain level of use and proficiency, rather than to train on their most impaired skills. A positive correlation between use and skill preference scores was found ($r = 0.64$, $p < 0.001$), which was higher if skills are considered in categories that reflect functional entities ($r = 0.86$, $p < 0.001$). This implies that patient training preferences are unlikely to match therapist-defined treatment goal priorities after outcome assessment. It is known that therapists tend to influence goal setting towards physical independence and mobility, and that therapist set goals are driven by economic factors [47]. It has already been indicated by spinal cord patients that rehabilitation is often not sufficiently patient-centred and is not always perceived to address enough the individual needs [48]. The result of the present study suggests that the same might hold for persons after stroke. Currently, therapists tend to set evidence based treatment goals that are mostly based on the outcome of non client-centred assessment tools [43,49,50]. These tools identify the body structures/functions and activities that are at risk, as well as quality of life of the person that is assessed. The results of the present study urge therapists, who are not limited in the treatment intervention they can offer, to set treatment goals not only for, but also with the patients. Client-centred instruments should be seen as a necessary part of patient assessment.

It has been indicated that the use of a client-centred instrument, as e.g. the Canadian Occupational Performance Measure, leads to patients having an active role in the rehabilitation process and a meaningful treatment outcome in terms of self-management [21].

### *Limitation of the study and future research*

It was not within the scope of this article to assess the use of the impaired arm for all skills that were assessed per patient. It would have been interesting to compare the average impaired arm use for skills that were not chosen as preference skills to the average use for the preference skills. This would give a more complete picture of the association between skill preference and arm use.

This study has investigated the association between skill training preferences and total use scores of the affected upper limb for that skill. A cause–effect relationship cannot be concluded. It would be interesting to know if patients have higher levels of use for skills they prefer to train on, because motivation to try has led to less learned non-use of the affected arm for these skills. Or is the relation the other way around? Because use of the affected limb for a certain skill is higher, patients may feel they will reach more arm hand function if they can optimise function that is already there. A third explanation could be that patients face more their limitations in skills they are attempting (because they like or need to do them), and therefore mention them as preferred skills to train on.

Another limitation of the study is that 10 patients (five subacute and five chronic) out of the forty participating had muscle activity in their upper extremity, but had no hand function. The association between arm use for a certain skill and preference scores was analysed without the results of these patients to examine if their data affected the association. The association measure was only slightly lower ($r = 0.621$, $p < 0.001$), which can be attributed to a reduced number of data in the calculation of the correlation coefficient.

This study has not revealed any clear differences in skill training preferences between patients in subacute and chronic stage after stroke. This might be because of the fact that the post-stroke time of the subacute group (0–6 months) was not different enough from post-stroke time of the chronic group (more than 1 year after stroke) who participated in this study. Many of the persons in a subacute stage after stroke were already discharged from staying in the rehabilitation centre (outpatient treatment only) and therefore were facing similar restrictions to patients in a chronic stage after stroke. More pronounced differences between the two groups (e.g. subacute group 0–3 months post stroke *versus* chronic more than one year post-stroke) might have revealed more differences in skill training preferences. This must be taken into account when using the presented list of skill preferences for e.g. implementation in technology for patients in the subacute stage after stroke that are still staying in rehabilitation centres. Another weakness of this study is the absence of arm–hand function assessment on impairment level and participation level as well as activity level that is measured by MAL. Results on the different outcome measures might have been stronger predictors for the choice of skill training preferences than the post-stroke time.

Finally, it must be kept in mind that the results of this study fit a very specific group of persons after stroke. Inclusion criteria for the study were set to target that part of the stroke population, which could benefit from a therapist independent technology-supported task-oriented training program.

It would be interesting to also study skill preferences of patients after stroke with a lower functional level than the ones included in this study.

## Conclusion

Patients in subacute and chronic stages after stroke share their interest in training arm–hand function skills relating to manipulation of objects and grasp. An inventory of skills that patients after stroke prefer to train on is presented. Although this list is limited in its number, the inventory is a useful starting point for implementing exercises in technology supported training systems.

A positive correlation was found between the use of the arm for a certain skill and the preference score that is attributed to the skill. Motivation for skill training preferences seems to be associated with optimising participation level, rather than function or activity level. This information supports the use of client-centred instruments in arm and hand function assessment to formulate therapy goals that match the motivations of persons after stroke.

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