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Observation of Amounts of Movement Practice Provided during Stroke Rehabilitation

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Observation of amounts of movement practice provided during stroke rehabilitation

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Abstract

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Objective

To investigate how much movement practice occurred during stroke rehabilitation, and what factors might influence doses of practice provided.

Design

Observational survey of stroke therapy sessions.

Setting

7 inpatient and outpatient rehabilitation sites.

Participants

We observed a convenience sample of 312 physical and occupational therapy sessions for people with stroke.

Intervention

NA

Main Outcome Measures

We recorded numbers of repetitions in specific movement categories and data on potential modifying factors (patient age, side affected, time since stroke, Functional Independence Measure item scores, and years of therapist experience). Descriptive statistics were used to characterize amounts of practice. Correlation and regression analyses were used to determine if potential factors were related to the amount of practice in the two important categories of upper extremity functional movements and gait steps.

Results

Practice of task-specific, functional upper extremity movements occurred in 51% of the sessions that addressed upper limb rehabilitation and the average number of repetitions/session was 32 (95% CI = 20–44). Practice of gait occurred in 84% of sessions that addressed lower limb rehabilitation and the average number of gait steps/session was 357 (95% CI = 296–418). None of the potential factors listed above accounted for significant variance in the amount of practice in either of these two categories.

Conclusions

The amount of practice provided during post-stroke rehabilitation is small compared to animal models. It is possible that current doses of task-specific practice during rehabilitation are not adequate to drive the neural reorganization needed to optimally promote function post stroke.

Keywords: Intensity, Rehabilitation, Stroke, Motor, Physical Therapy, Occupational Therapy

INTRODUCTION

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Research performed over the past 15 years has improved our understanding about the adaptive capacity of the nervous system and captured the interest of the stroke rehabilitation community. Paradigms designed to investigate neural adaptive capacity (i.e. plasticity) in animal models require the animals to engage in hundreds of repetitions of movement practice daily. Practiced tasks are functional movements, such as reach and retrieval of food pellets. For example, healthy rats and monkey perform 400–600 repetitions/session of upper limb tasks in studies investigating how motor skill learning alters cortical representation [1, 2]. Similarly, in stroke models, monkeys performed 600 repetitions of a pellet retrieval task per day to reverse the detrimental changes due to a cortical lesion [3]. Even in behavioral studies of human motor learning, neurologically-intact control subjects [4] and stroke subjects [5] are required to perform hundreds of repetitions of the specific upper extremity movement task to be learned. For the lower extremity, little attention has been paid to the number of steps necessary to induce neuroplastic changes and promote optimal ambulatory function. In animal models of spinal cord injury, approximately 1000–2000 steps are performed during daily, 30 minute treadmill sessions [6, 7] to improve hindlimb stepping. More recent data suggests that higher stepping doses following experimental spinalization improves stepping quality [8]. Currently, definitive numbers of repetitions needed for optimal learning is unknown [9, 10]; future definitive numbers will likely be both task- and species-specific. Nonetheless, these paradigms suggest that large doses of practice, on the order of hundreds of daily repetitions of upper extremity practice and thousands of daily repetitions of gait, may be required to produce lasting neural changes and optimize motor learning.

These findings led us to question the current dosage of practice provided to people during stroke rehabilitation. This is a particularly relevant issue given that the high dosage treatment, constraint-induced movement therapy, has recently been shown to more effective than a minimal dose treatment [11]. Studies of stroke rehabilitation dosage have typically measured the duration and/or frequency of therapy services [12–18]. Duration and frequency measures provide information about the amount of minutes and/or days per week of therapy service provided, but do not provide information about the amount of movement practice that occurred during those minutes or days. Only a few studies have looked at what happens during therapy [19–21]. Ada and colleagues found that only 34% of the therapy minutes was spent in task-specific practice [21]. In a small pilot project (sample size = 36 observations), we recently found that the amount of functional, task-specific practice of upper and lower limb movements was, in general, an order of magnitude lower than that experienced by animal models [22]. While intriguing, our pilot data represented only a quick snapshot of the extent of therapeutic activities provided at a single, outpatient rehabilitation facility. Additionally, these data did not permit exploration of any factors that may influence the amount of practice because data on potential factors were not collected.

The primary purpose of the current study was to characterize the amount and type of movement practice provided during stroke rehabilitation in a larger sample. A secondary purpose was to determine if various patient and therapist factors influence the amount of practice provided. We collected observational data on the number of repetitions in specific movement categories, and descriptive data on potential modifying factors from patients (e.g. age, chronicity of symptoms) and therapists (e.g. years of experience) from 7 sites across the United States and Canada. As suggested from the animal literature, we were most interested in the number of repetitions of functional upper extremity movements and the number of repetitions of gait because practice of these two categories of movement are most likely to result in functional improvements that are important to patients and their families [23–25]. Consistent with our preliminary data, we hypothesized that the total number of repetitions of specific upper and lower limb activities would be small as compared to the practice provided in animal or human motor learning studies.

METHODS

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Observed sessions

We recorded the number of repetitions of all movement activities during 312 physical (PT) and occupational therapy (OT) sessions from 7 sites around the United States and Canada (Table 1). Sites were selected based on convenience and are not a random sample of rehabilitation sites in North America. Data was collected between the time period from May 1, 2007 to June 30, 2008. PT and OT sessions were observed since both disciplines address movement rehabilitation. Research assistants were trained to observe and collect data at each site. To ensure fidelity of the data, detailed procedures for training and data collection were provided on paper and in electronic materials. Videos of simulated therapy sessions were used to test the observers for consistency and reliability of data collection. Activities and repetitions used in the test videos were from sessions we had observed previously[22] with actors playing the roles of patients and therapists in order to safeguard confidentiality. Consistent with recent rehabilitation trials [26, 27], each observer had to be within 90% agreement on test videos prior to collecting data. On average, observers attain 94% agreement.

Table 1

Top: Observation sites; Bottom: site-specific data on the number of repetitions observed in the category "transfers".

Treatment sessions were observed if they met the following criteria. Inclusion criteria for sessions were: 1) the therapist providing the treatment session was a licensed physical therapist, physical therapy assistant, occupational therapist, or certified occupational therapy assistant; 2) the patient participating in the treatment session had hemiparesis due to stroke; and 3) the treatment session addressed motor problems related to the stroke. Exclusion criteria for sessions were: 1) the individual providing treatment was an aide or technician; 2) the treatment session was an initial or discharge evaluation; 3) the treatment session addressed non-motor (e.g. cognitive or attention) problems; 4) the treatment session addressed equipment fitting (e.g. wheelchair, splints, orthotics); or 5) the patient was unable to provide informed consent. Treatment sessions provided by aides or technicians were excluded because this treatment time is typically not considered billable, skilled therapy in the United States. Individual patients were observed during 1–3 therapy sessions and individual therapists were observed multiple times (see last column table 1 for number of therapists observed/site).

The study was approved by the Washington University Human Research Protection Office and by institutional review boards at each participating site. Informed consent was obtained from the therapist and patient prior to observing a treatment session. In the consent process, therapists and patients were told that we were gathering data on the way rehabilitation was delivered but were blinded to the specific purposes of the study.

Observation protocol

The primary data collected were the number of repetitions of movement. Repetitions were counted in defined categories because the repertoire of potential activities that could be observed during PT and OT sessions is enormous. Activities were divided into six categories according to definitions based on published lists of activities that patients perform in rehabilitation [28, 29] and developed during earlier pilot work [22]. The categories were: upper extremity movements, lower extremity movements, gait, stair climbing, transfers, and balance activities. The categories of upper and lower extremity movements were further divided into the following subcategories: active exercise, passive exercise, functional, and sensory. Definitions of movements and units of repetition were used to record the observations. This information is provided in Table 2 along with examples of activities in each category. Within each category and subcategory, the numbers of observed repetitions of individual movements were summed to obtain the total number in that category or subcategory within that session.

Table 2

Definitions of movements, units of repetition, and examples for categories and subcategories.

At times we observed the therapist working on two skills at one time with the patient. In these instances, repetitions in both activities were recorded. An example of this is when the therapist asked the patient to sit unsupported on the edge of the mat to address balance but then also asked them to practice buttoning with both hands in his/her lap to address upper extremity function. The observer would record repetitions for the sitting balance activities and record repetitions for the upper extremity functional movements.

For all categories and subcategories of movement, repetitions were only counted if the movement or activity was considered therapeutic, i.e. instructed or performed for the purpose of therapy. Repetitions were not counted when the movement was performed with the sole intent to position the patient to be ready to perform the next activity (e.g. "lie down and get ready to do your exercises while I go get the weights"). If the observer was unclear whether or not the activity was therapeutic, they were instructed to count it. Thus, our data may be considered a slight overestimation of the amount of practice experienced.

Data on potential factors that might modify the number of repetitions were collected from each session. Potential factors included: age, side affected, time since stroke, independence level as measured by individual items on the Functional Independence Measure

(FIM [30]; obtained from medical record), level of therapist licensure (therapist vs. therapy assistant), and years of therapist experience. The individual FIM item scores reflected general functional abilities in activities such as walking, feeding, dressing, etc., but not overall stroke severity. FIM item scores range from 1–7 where a score of 1 indicated complete dependence on that activity and a score of 7 indicates independence in performing that activity. An estimate of overall stroke severity (e.g. National Institutes of Health Stroke Scale) was not collected because it was not routinely used at 6 of the 7 facilities and it is not widely used by physical and occupational therapists in making treatment decisions. Additional data collected at each session included: type of therapy (PT, OT), type of clinical setting (inpatient, outpatient), duration of the session, and frequency (sessions/day and days/week) of therapy.

Selection of which treatment sessions to be observed was done by convenience, i.e. the session was observed when observers were available and when the scheduled patient met the criteria. For each treatment session, observers positioned themselves in locations where they could adequately see and hear, and where they were least distracting. Observers made tally marks on the data recording sheet for each activity observed. A mechanical counter was used for gait steps and other activities where the count was anticipated to be in the hundreds or thousands. Therapists were instructed not to offer rationales or explanations to the observer during the treatment session. Likewise, observers were instructed not to participate in any way during the session.

Data Analyses

Statistical analyses were done with SPSS v. 13. Repetition data in each category and subcategory were normally distributed as determined by Kolmogorov-Smirnov tests. A two-way ANOVA with main factors of site and category/subcategory was used to test for differences across sites. Instead of determining observed frequencies across all sessions, frequencies were calculated as the number of sessions in which the category or subcategory was observed divided by the number of sessions in which rehabilitation focused on that part of the body. For example, the frequency of upper extremity active exercise was calculated as the number of sessions in which upper extremity active exercise was observed divided by the number of sessions in which any upper extremity activities were observed. Denominators for frequency calculations were as follows: Upper extremity subcategories n = 162; Lower extremity subcategories, gait and stairs n = 230; transfers and balance n = 312. Means, 95% confidence intervals, and standard deviations for the number of repetitions were calculated for each category and subcategory.

We considered the two most important observed categories to be upper extremity functional movements and gait steps because practice in these categories is most likely to improve functional capabilities [23–25]. For these two categories, t tests were used to determine if numbers of repetitions differed across settings (inpatient and outpatient) and by therapy discipline (PT and OT). Correlation (parametric and non-parametric) and regression analyses were used to explore how patient and/or therapist factors might be related to the number of repetitions observed. For these analyses, a subset of 187 inpatient observations was used because one potential factor, FIM scores, was consistently collected only during inpatient rehabilitation and was frequently not available during outpatient rehabilitation.

RESULTS

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Repetitions were counted during 312 observed physical and occupational therapy sessions at 7 sites (Table 1, top). The sites were inpatient and outpatient settings (see 2nd column of Table 1). None were skilled nursing facilities. Inpatient settings typically saw patients 5 days/week, 1–2 times per day, while outpatient settings typically saw patients 2–3 days/week, 1time per day. Average session duration was 36 ± 14 minutes (range = 16–104 minutes). Time was recorded from the point where therapeutic intervention began to when it ended, excluding rest breaks longer than 5 minutes. Thus, this average value is not a representation of the time scheduled per patient nor is it necessarily a representation of the full time spent with the patient. We report this value because it provides a context in which to appreciate the number of repetitions observed. Characteristics of the patients and therapists are provided in Table 3.

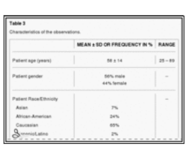

Table 3
Characteristics of the observations.

Using a two-way ANOVA, we found no differences in the number of repetitions across sites ($p < 0.05$) and no interaction between site and category ($p < 0.05$). As an example, the average number of repetitions and ranges from each site in the category of transfers are provided in the bottom of Table 1. There was considerable variability in the number of repetitions observed within each site. Repetition data from all sites were pooled for subsequent analyses.

Activities and numbers of repetitions during stroke rehabilitation are provided in Table 4. Note that the descriptive statistics on numbers of repetitions are from totals observed per session in a particular category or subcategory, and are not meant to represent the number of repetitions of any single activity (e.g. a session could have 54 total repetitions of active exercise from 10–11 repetitions of 4 different exercises).

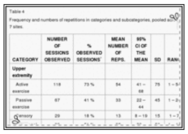

Table 4

Frequency and numbers of repetitions in categories and subcategories, pooled across all 7 sites.

Upper extremity movements in any subcategory were observed in 162 sessions. Active exercise repetitions were observed most frequently and sensory activities were observed least frequently. Functional movements were observed in half of the 162 sessions that provided therapy to the upper extremity. The average number of functional upper extremity repetitions in those sessions was 32; this total number of repetitions was typically split between 2–4 different activities. Functional upper extremity repetitions showed a trend toward being smaller in the inpatient (mean ± SE, 23 ± 5) vs. outpatient setting (45 ± 13; $p = 0.08$). A larger number of functional upper extremity repetitions were performed during OT (41 ± 8) sessions than during PT sessions (12 ± 3; $p = 0.002$).

Lower extremity, gait, and stair repetitions were observed in 230 sessions. Gait was the category most frequently observed. Lower extremity functional movement repetitions were rarely observed (e.g. practice donning and doffing a shoe), which was expected since gait is the primary functional movement of the lower extremities and was counted separately. The observed frequency of lower extremity active exercise was similar to that observed for the upper extremity. The average number of gait steps was 357 and these steps were completed in an average of 6 gait episodes (6 times getting up to walk during the session). As anticipated, a larger number of gait steps were performed in the outpatient (501 ± 64) vs. the inpatient setting (249 ± 20, $p < 0.001$) and a larger number of gait steps were performed during PT sessions (370 ± 32) vs. during OT sessions (121 ± 38).

Correlation and regression analyses were done on the subset of inpatient data ($n = 187$, see Methods) to evaluate if and how patient or therapist factors may influence the number of repetitions experienced in 2 categories. For upper extremity functional movements, correlations between the number of repetitions and the factors of patient age, side affected, time since stroke, FIM upper extremity item scores, level of therapist licensure, and years of therapist experience ranged from −0.16 to 0.20 (p values > 0.05). Regression analyses for functional upper extremity movements indicated that, when entered together, the factors predicted little variance in the number of repetitions ($R^2 = 0.16$, $p = 0.70$). For gait steps, small but significant correlations ($p < 0.05$) were found with time since stroke ($r = 0.34$) and years of therapist experience ($r = −0.27$). The correlation with years of experience was negative, suggesting that there was a small association between higher gait steps and therapists with fewer years of experience. Correlations with the other factors of patient age, side affected, FIM walking score, and level of therapist licensure ranged from −0.05 to 0.09 and were not significant ($p > 0.05$). Regression analyses for gait steps indicated that, when entered together, the factors predicted minimal variance in the number of steps ($R^2 = 0.13$, $p = 0.12$).

DISCUSSION

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We investigated the amount of practice, in numbers of repetitions, currently occurring in stroke rehabilitation. In each category, there was considerable variability in the amount of practice (Table 4, last column). Practice of functional upper extremity movements occurred in only half of the sessions that addressed upper limb rehabilitation and the average number of repetitions in those sessions was low. Practice of gait occurred much more often in sessions that addressed lower limb rehabilitation and the average number of gait steps was in the hundreds. While we found several expected differences in the amount of practice in inpatient vs. outpatient settings and between OT and PT disciplines, the individual patient (e.g. age, functional ability level) or therapist (e.g. experience) factors did not account for a significant portion of the variance in the amount of practice in either of these two categories.

Our results indicate that doses of movement practice currently provided during stroke rehabilitation are substantially smaller than doses used in animal models investigating the adaptive capacity of the nervous system and human motor learning studies (see Introduction), and in recently tested therapies [11]. Results from this larger sample are generally consistent with our earlier pilot findings at a single site [22]. The amount of practice described from these 7 sites is likely representative of what is experienced during stroke rehabilitation across North America. Although types and amounts of activities were similar across sites, we cannot rule out the possibility that the amount of practice may be different at other, unobserved facilities. Our data may now be used to help define dose and types of activities for “standard care” control groups in future rehabilitation clinical trials.

We were most interested in the number of repetitions of functional upper extremity movements and the number of repetitions of gait because practice of these two categories of movement are most likely to result in functional improvements that are important to patients and their families [23–25]. It is intuitive that practice of specific tasks results in improved performance on those tasks. Indeed, repeated practice of challenging movement tasks results in larger brain representations of the practiced movement [2]. This finding and others from the neuroscience literature (for review see [9, 31]) suggest that extended, task-specific practice is critical for producing lasting changes in motor system networks, motor learning, and motor function. The minimal critical threshold required to drive these same results in humans with stroke has not been established, nor do we fully understand the challenges the stroke survivor must overcome to endure sustained repeated task practice.

For both upper limb and lower limb rehabilitation, a large number of repetitions were devoted to active exercise. This is in contrast to a previous finding that active exercise made up only 8% of the therapy minutes in two Australian rehabilitation facilities[21]. We speculate that one reason for small amounts of practice in upper extremity functional movement and gait steps may be that patients in our study spent time performing more traditional exercises instead. While there has been a long-held clinical belief in the value of active exercise, current stroke rehabilitation trials suggest that beneficial effects of non-task related exercise do not consistently transfer to improved daily function (for reviews see [32, 33, 34]). Other potential reasons for the small number of repetitions observed might include patient fatigue or perception of patient fatigue, patient and therapist motivation, cardiopulmonary function, a need to address multiple areas and functions during rehabilitation sessions (e.g. lower extremity, gait, balance, and transfers), inefficient use of therapy time, and lack of therapy time.

The amount of practice of upper extremity functional movements and gait were not related to patients' ability to perform functional activities, as determined by the near-zero correlations between numbers of repetitions and FIM item scores. This finding is contrary to the common intuition that patients who have better functional capabilities receive more task-specific practice during rehabilitation. The lack of a relationship ($r = 0.06$) between FIM walking scores and number of gait steps during inpatient rehabilitation conflicts with a previous report showing that FIM walking scores were related to the number of minutes of gait training [35]. We did find a small, inverse correlation between therapists' years of experience and the number of gait steps. This suggests that the gradual translation of basic science regarding the adaptive plasticity of the nervous system is being incorporated into the curriculums of therapy educational programs and is manifesting itself as increased practice provided by those therapists who have graduated most recently. We were surprised that none of the tested factors explained any significant portions of the variance in the number of repetitions in these two important categories. These results bring up the question of what is guiding therapist and patient decisions regarding amounts of practice. This critical question needs to be addressed in future studies.

Limitations

Several limitations should be considered when interpreting our results. First, the study was observational. Observers counted therapeutic repetitions (see Methods). If the observer was unclear whether or not the activity was therapeutic, they were instructed to count it. Thus, our data may be considered a slight overestimation of the amount of practice experienced. We did our best to assign observed movements to specific categories, but were not privy to the therapists' thought processes as to why the activity was chosen or why that number of repetitions occurred. Investigations of the reasons will require further study with qualitative research techniques. Second, we cannot rule out the possibility that simply being observed in some way influenced the delivery of treatment. Our assumption is that observation might influence the delivery to make it better (not worse), thus the data in this report would be representative of sessions that were providing better treatment than might normally be provided. Third, we recorded the number of repetitions of activities but did not record other issues that might affect skilled motor learning. The number of repetitions may be only one piece that determines the success of motor learning and rehabilitation. Additional important pieces could include the frequency, duration and spacing of sessions, the engaging nature of the content, whether or not the content (movement activity) is appropriately challenging to the patient, and whether or not the activity is aimed at relearning a motor skill or providing compensatory function. Addressing these issues was beyond the scope of the current study. And last, other factors that were not evaluated might influence the amount of practice in post-stroke rehabilitation. In the design of this study, we selected those factors that we considered were most likely to be important and could be obtained within our limited budget. For example, we used FIM item scores as measures of functional abilities. While the FIM has been an important tool to measure inpatient rehabilitation outcomes over the past few decades, we cannot rule out the possibility that individual item scores may not have been sensitive enough to detect real relationships between movement ability and amounts of practice. In hindsight, other measures that assess limb motor ability, such as the Motricity Index [36] or the Fugl-Meyer Motor Scale [37], might have shown some relationships with amounts of practice.

Conclusions and Implications

In summary, we found that the amount of task-specific practice currently provided during stroke rehabilitation is small compared to animal models and human motor learning studies. Given that patients post stroke spend large portions of their day relatively inactive [17, 38], the dose of practice provided during therapy is of utmost importance. Our results open up *the possibility* that current doses of task-specific practice may not be adequate to drive the neural changes needed to optimally promote function post stroke.

While optimal doses of daily repetitions have not been determined from animal models or human studies [9], we *speculate* that required doses to facilitate neural reorganization associated with improved functional recovery are probably much higher than the numbers reported here. If future studies substantiate the number of repetitions currently delivered to animal models of stroke, then rehabilitation for people with stroke will have to change. Based on the upper limits of the observed ranges (Table 4, last column), it appears possible to provide hundreds of daily repetitions of upper extremity functional movement and thousands of daily repetitions of gait during rehabilitation. A small pilot study is now underway in one of our labs to evaluate the feasibility of high repetition doses of task-specific practice for upper extremity rehabilitation in people with chronic stroke.

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Footnotes

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