Home Exercise Programs for Adults With Neurological Injuries: A Survey

Rachel Proffitt

MeSH TERMS

- exercise therapy
- health care surveys
- home care services
- nervous system diseases
- occupational therapy

OBJECTIVE. The purpose of this study was to describe current occupational therapy practices in the usage and prescription of and clinical reasoning process supporting home exercise programs (HEPs) for clients with neurological injuries (CWNIs).

METHOD. A survey was distributed via mail to 2,000 members of the American Occupational Therapy Association. The survey questions concerned basic demographics, current HEP practices, and attitudes toward using HEPs with CWNIs.

RESULTS. In the 360 returned surveys, occupational therapists reported numerous benefits of using HEPs and were able to clearly articulate their clinical reasoning. Commonly reported HEP activities were preparatory in nature, and the most frequently prescribed dosage was 16–30 min daily. Most therapists relied on the same clinical reasoning process but varied in implementation methods.

CONCLUSION. This study's results highlight the gaps between evidence and practice. The active ingredients in HEPs for CWNIs need to be more clearly defined and described.

Proffitt, R. (2016). Home exercise programs for adults with neurological injuries: A survey. *American Journal of Occupational Therapy*, 70, 7003290020. <http://dx.doi.org/10.5014/ajot.2016.019729>

Rachel Proffitt, OTD, OTR/L, is Assistant Professor, Department of Occupational Therapy, University of Missouri, Columbia; proffittm@health.missouri.edu

Neurological conditions and injuries, such as stroke, traumatic brain injury, spinal cord injury, and Parkinson's disease, present a global burden. Of 10 disorders in the three highest disability classes, 8 are neurologically related (Menken, Munsat, & Toole, 2000). In adults, neurological conditions can lead to significant functional impairments, including hemiparesis and mobility limitations (Mozaffarian et al., 2015). The economic cost of treating and managing clients with neurological injuries (CWNIs) is large and includes not only the cost of treatment but also lost productivity on the part of the CWNi as well as the caregiver or family members (Gustavsson et al., 2011).

Rehabilitation for neurological conditions has been shown to improve recovery outcomes and decrease functional limitations (Cifu & Stewart, 1999). To date, the evidence supporting the effectiveness of home exercise programs (HEPs) in improving patient outcomes has been equivocal. One scientifically evaluated HEP is the family-mediated exercise intervention. Family members are trained in individualized exercises that they help the adult with stroke complete (Galvin, Cusack, O'Grady, Murphy, & Stokes, 2011). Use of family-mediated exercise for 3 mo has resulted in increased active range of motion and mobility, improved community reintegration, and decreased caregiver burden, but only mobility gains were significant at 3-mo follow-up (Galvin et al., 2011). Greater adherence to an HEP among patients with neurological injuries leads to increased functional recovery, improved patient outcomes, and greater patient satisfaction (Duncan et al., 2002; Reker et al., 2002). Unfortunately, adherence to routinely prescribed HEPs in the stroke population is low, with many patients participating for only a short period of time (Jurkiewicz, Marzolini, & Oh, 2011).

In addition to studying the effectiveness of HEPs, many researchers have compared experimental home-based interventions with usual and customary care, but clear, unified, evidence-based clinical guidelines and recommendations for standard or usual HEPs are lacking. As an example, U.S. guidelines on rehabilitation for people with stroke include the American Heart Association/American Stroke Association–endorsed guidelines (Duncan et al., 2005) and the *VA/DoD Clinical Practice Guideline for the Management of Stroke Rehabilitation* (U.S. Department of Veterans Affairs, U.S. Department of Defense, & American Heart Association/American Stroke Association, 2010). These guidelines include statements on using community rehabilitation programs if necessary but do not offer any recommendations for HEPs or clearly define the components of an HEP or provide standard procedures.

The equivocal evidence supporting the effectiveness of HEPs and the vague clinical guidelines highlight the gap in evidence and in the scientific process. To provide occupational therapists with sound evidence supporting the effectiveness of HEPs, the first step is to understand current practice. Therefore, the purpose of this study was to describe current occupational therapy practices in the usage, prescription, and clinical reasoning process supporting HEPs for CWNIs.

Method

Participants and Procedure

This study involved a survey approach and was approved by the University of Southern California's institutional review board. The names and addresses of 22,150 members of the American Occupational Therapy Association (AOTA) were purchased from AOTA's list rental service following the organization's guidelines (members may opt out). Surveys were mailed to 2,000 occupational therapists who were selected via computer-generated randomization of every fifth name of occupational therapist members. Surveys were distributed via mail, and respondents had the option of returning the paper survey via the enclosed stamped envelope or completing the online version of the survey. The criteria for selection were based on a Boolean search of the following list rental categories:

- Special Interest Sections: *gerontology* OR *physical disabilities* OR *home & community health* OR *technology* OR *work & industry*
- Work settings: *free standing outpatient* OR *home health* OR *hospital (non-mental health)* OR *private practice* OR *rehabilitation hospital/center* OR *sub-acute facility/unit* OR *work/industry/ergonomics* OR *community-based*

(e.g. *Easter Seal, homeless shelter*) OR *skilled nursing/long-term care*

- Practice areas: *geriatrics* OR *hand therapy* OR *home/community modification* OR *physical disabilities (adult)* OR *prevention/health promotion* OR *private practice* OR *visual impairment* OR *work/ergonomics*.

Instrument

The survey was developed from semistructured interviews and focus groups conducted by the author. The initial survey was distributed to 5 occupational therapists to determine readability and appropriateness of questions. Recommended changes were made to this initial survey, resulting in the refined final version that was distributed in the mailing. Six questions related to demographics: years of experience, specialties or certifications held, practice setting, diagnoses treated, days per week treating clients, and length of occupational therapy treatment sessions. Six open-ended questions were related to HEP treatment dosage, the type of HEP activities, and methods of education that occupational therapists used in HEP. Fifteen questions were Likert-scale questions designed to ascertain occupational therapists' opinions on the use and value of HEPs for CWNIs (Figure 1). Three open-ended questions asked occupational therapists about the clinical reasoning underlying the prescription and progression (e.g., grading or updating) of HEPs for CWNIs:

1. What do you feel is beneficial about prescribing HEPs for CWNIs?
2. What guides your clinical reasoning when prescribing an HEP for CWNIs?
3. What guides your clinical reasoning when progressing an HEP for CWNIs?

Occupational therapists who did not use HEPs in practice had the option of selecting "I do not prescribe HEPs" and providing an open-ended response.

Data Analysis

Data were entered into a REDCap database (Harvard Catalyst, Boston), validated for accuracy, and checked for missing data. Data were exported to Excel (Microsoft Corp., Redmond, WA), and surveys returned from occupational therapists who were no longer practicing or who held administrative or management positions were analyzed separately. All check box and Likert-scale questions were analyzed using descriptive statistics and frequencies. Post hoc correlations were calculated to identify potential relationships between survey respondent demographics and questionnaire responses.

The open-ended question about HEP dosage was coded separately by the author and one other researcher, and the answers were grouped into categories for descriptive

Questions Related to HEP Activities, Education, and Dosage

- What exercises and/or activities do you include in HEPs?
- What type(s) of modalities do you use for HEPs?
- What other treatments do you include in HEPs?
- What is a typical dose for an HEP? How many minutes per day? How many days per week?
- How do you involve caregivers in HEPs?
- To educate my client on an HEP, I typically:

Likert-Scale Questions

Categories: *strongly agree, agree, neutral, disagree, strongly disagree*

Question Phrasing: Choose the option for each statement that best fits your opinion. There are no right or wrong answers.

- I prescribe HEPs because I want to give my clients with neurological conditions the best opportunity to start getting better.
- I prescribe HEPs for all of my clients with neurological conditions, regardless of diagnosis.
- I prescribe HEPs because consistency is important.
- I usually prescribe an HEP on the day of evaluation or during the second treatment session.
- I prescribe HEPs because it helps clients meet goals that cannot be met with the limited amount of one-on-one therapy allotted.
- HEPs reinforce carryover into the client's environment.
- HEPs allow for a more rapid and effective return of function.
- I have clients complete a check box list of exercises to track their adherence.
- Caregiver feedback is a source of monitoring HEP adherence.
- Verbal statements from the client is how I track HEP adherence.
- I progress a client's HEP based on observed functional changes in treatment sessions.
- I progress a client's HEP based on client self-report of functional changes.
- Proactive clients are more likely to be compliant with HEPs.
- A client's insight, memory, and attention affect their compliance with an HEP.
- After discharge, most clients do not continue their HEP.

Figure 1. Survey questions on HEP activities, methods of client and caregiver education, and opinions and attitudes toward using HEPs with CWNIs.

Note. CWNIs = clients with neurological injuries; HEP = home exercise program.

statistics analysis. The other open-ended questions—those related to HEP prescription and progression—were coded by the same two researchers, and themes were allowed to emerge from the data. Occupational therapists who indicated that they did not prescribe HEPs were grouped, and their data were analyzed separately using the same methods.

Results

Of the 2,000 surveys sent out, 384 were returned (19.2% response rate). Of this total, 24 surveys were unusable because they were marked *return to sender* ($n = 9$) or the occupational therapist indicated that he or she was retired, no longer practicing, or working in an academic setting ($n = 4$). Additionally, 11 respondents indicated that they do not prescribe HEPs because (1) they do not work regularly or with subpopulations appropriate for the prescription of HEPs ($n = 1$), (2) clients are unable to perform HEPs because of the treatment setting or

diagnosis ($n = 4$), (3) HEPs are not the main focus of treatment ($n = 2$), (4) there are issues with client or caregiver compliance and follow-through ($n = 2$), (5) safety reasons preclude the prescription of HEPs ($n = 1$), and (6) they prescribe other exercise programs ($n = 1$). The results described in the sections that follow are based on the 360 usable responses.

Demographics and General Clinical Practice

Respondent characteristics are presented in Table 1. The majority of occupational therapists worked in hospital-based settings and treated a diverse range of neurological conditions. The most frequently treated condition was cerebrovascular accident ($n = 307$). No statistically significant correlations were found between demographic variables and HEP content, dosage, and client or caregiver education.

Home Exercise Program Content, Dosage, and Client and Caregiver Education

The majority of occupational therapists (94%) reported prescribing an HEP for CWNIs. The content of these HEPs varied greatly across occupational therapists (Figure 2A). The most commonly prescribed activities—each selected by more than 250 occupational therapists—were fine motor activities, active range of motion, active assistive range of motion, and whole or partial activity of daily living (ADL) tasks. Occupational therapists were able to state how many days per week they prescribed an HEP for a CWNI, and the most common dosage was 16–30 min daily. Some felt that prescribing anything >30 min/day was burdensome to clients and thus reduced adherence rates.

Methods used to educate CWNIs about an HEP included providing paper copies of the exercises ($n = 307$; 85.3%), demonstrating exercises ($n = 320$; 88.9%), asking the CWNI to demonstrate the exercise ($n = 309$; 85.8%), providing a handout with text and pictures ($n = 290$; 80.6%), asking the CWNI to practice in front of a mirror ($n = 128$; 35.6%), and videotaping ($n = 29$; 8.1%) or photographing ($n = 41$; 11.4%) the CWNI for his or her own review later. Similarly, methods used to educate caregivers included providing handouts with text and pictures ($n = 316$; 87.8%), answering questions ($n = 306$; 85.0%), demonstrating exercises ($n = 312$; 86.7%), providing hands-on learning ($n = 218$; 60.6%), providing hands-on learning with return demonstration ($n = 287$; 79.7%), and allowing caregivers to take pictures or videos for later review ($n = 72$; 20.0%). Although many occupational therapists reported providing CWNIs and their caregivers with paper handouts, only 17% had CWNIs

Table 1. Respondent Characteristics

Characteristic	<i>n</i> ^a	% ^b
Years in practice		
0–5	79	21.9
6–10	43	11.9
11–15	45	12.5
16–20	56	15.6
≥20	137	38.1
Specialties or certifications held		
Neurodevelopmental Treatment	36	10.0
Certified Brain Injury Specialist	13	3.6
Physical Agent Modalities	46	12.8
Proprioceptive Neurological Facilitation	4	1.1
Certified Driving Rehabilitation Specialist	6	1.7
Certified Strengthening and Conditioning	5	1.4
Certified Hand Therapist	15	4.2
None	182	50.6
Other	107	29.7
Client populations treated		
Acquired brain injury	179	49.7
Traumatic brain injury	244	67.8
Cerebrovascular accident	307	85.3
Spinal cord injury	171	47.5
Tumors	170	47.2
Neurodegenerative conditions (MS, ALS)	259	71.9
Neurological vision deficits	159	44.2
Other	129	35.8
Primary treatment setting		
Acute hospital	67	19.1
Subacute or inpatient rehabilitation hospital	62	17.7
Outpatient rehabilitation	60	17.2
Hand clinic	7	2.0
Transitional care	3	0.8
Long-term care	10	2.9
Skilled nursing facility	39	11.1
Home health	57	16.4
Community based	13	3.7
Other	32	9.1

Note. ALS = amyotrophic lateral sclerosis; MS = multiple sclerosis.

^aFrequencies are based on the number of participants reporting for each question. ^bPercentages may add to more than 100% because survey respondents were able to select multiple options for some survey questions.

complete a paper checklist to track adherence. The majority (71%) relied on verbal statements from the CWNI or their caregiver to track adherence.

Clinical Reasoning

Occupational therapists reported several factors that guided their clinical reasoning for prescribing HEPs for CWNIs. Client priorities and goals were a primary factor. As 1 occupational therapist stated, “It’s based on what *they* want to achieve.” As expected, the client’s deficits and functional abilities guided the choice of exercises and the dosage and progression of an HEP over time. Many occupational therapists noted that cognitive deficits played a large role in their choice of activities and

timing when prescribing an HEP. More than 90% of occupational therapists agreed or strongly agreed with the following statements: “Proactive clients are more likely to be compliant with HEPs” and “[Clients’] insight, memory, and attention affect their compliance with HEPs.”

Occupational therapists were less in agreement with regard to the practices used to implement and progress (e.g., update or modify) an HEP (Figure 2B). For instance, the point during treatment at which the HEP was implemented varied across occupational therapists. Some prescribed an HEP for CWNIs during the first or second session of treatment because, as 1 occupational therapist stated, “Since the client is the one who will live with [the] deficits, early engagement and ownership is essential.” The methods and clinical reasoning skills used to progress an HEP also varied across occupational therapists. Many relied on observed functional changes in treatment sessions, and others based their decisions on client or caregiver report. Some occupational therapists reported that they used a variety of strategies, such as “clinical progression seen in therapy sessions as well as info[r]mation gleaned from [the] patient and/or caregiver.”

Perceived Benefits of Home Exercise Programs

Prescribing HEPs for CWNIs had many reported benefits. The major theme that emerged from qualitative analysis was that the “client is an active part of rehabilitation/recovery.” A majority of occupational therapists reported that carryover or generalization of an HEP was a benefit because “[it allows for] continuation of services at home when they may not otherwise be available and gives [the] client control over recovery.” More than 95% of occupational therapists agreed or strongly agreed with the statement “HEPs reinforce carryover into the client’s environment.” Occupational therapists also described the formation of an HEP routine by the client as a benefit. For example, occupational therapists felt that an HEP “is a good opportunity to give patients and their family a chance to improve their well-being on their own and create good health habits in their lives.” Nearly 90% of occupational therapists agreed that the amount of one-to-one occupational therapist services that insurance covered was insufficient to meet client goals and was thus a primary reason for prescribing an HEP.

The client factor–related benefits of an HEP included a reduction in deficits, prevention of decline, and allowing for neuroplasticity to occur. Several occupational therapists made comments specifically related to the link between the amount of therapy and the physiological and neurological changes after a neurological

Figure 2. HEP activities as reported by (A) survey respondents and (B) occupational therapist responses to Likert-scale questions on implementation and progression of an HEP.

Note. AAROM = active assistive range of motion; ADL = activity of daily living; AROM = active range of motion; fx = functional; HEP = home exercise program; IADL = instrumental activity of daily living; PROM = passive range of motion; tx = therapy.

injury: “HEPs reinforce brain-to-body connections. Regular opportunities to engage in motor planning and motor control activities are beneficial to overall brain/neurotransmitter functioning.”

Discussion

The purpose of this study was to describe current occupational therapy practices in the usage and prescription of and clinical reasoning process underlying HEPs for CWNIs. Much was gleaned from analysis of the survey results, resulting in three areas of discussion. First, the HEP dosage prescribed by most occupational therapists did not align with their statements regarding motor learning and neuroplasticity. Second, the activities prescribed focused heavily on preparatory activities. Third, although most occupational therapists were in agreement on the rationale

behind an HEP, there was less agreement on the methods of implementation.

In response to the open-ended questions regarding the clinical reasoning supporting an HEP, many occupational therapists specifically mentioned the terms *neuroplasticity* and *repetitions*. Recent studies exploring interventions such as high-intensity task-oriented training (Outermans, van Peppen, Wittink, Takken, & Kwakkel, 2010; Yang, Wang, Lin, Chu, & Chan, 2006), constraint-induced movement therapy (Taub et al., 2006; Wolf et al., 2006), and task-specific training (Bayona, Bitensky, Salter, & Teasell, 2005; Hubbard, Parsons, Neilson, & Carey, 2009) have been founded, in part, on concepts demonstrated in animal models: The more repetitions and practice achieved, the higher likelihood of changes in both the brain (neuroplasticity) and associated functional outcomes

(Nudo, Plautz, & Frost, 2001). The exact number of repetitions, length of time per session, and length of time required for the intervention to produce lasting changes are unknown in humans (Kleim, Barbay, & Nudo, 1998; Nudo & Milliken, 1996; Nudo et al., 2001). A closer look at clinical practice reveals low intensity of in-clinic treatment sessions (Lang et al., 2009). On the basis of this study's findings, a program lasting only 16–30 min is likely insufficient to produce the outcomes described by occupational therapists (i.e., neuroplastic changes), even as an adjunct to one-on-one therapy or other daily activities. Engagement in daily activities (such as bathing, cooking, or shopping) was mentioned by many occupational therapists, but most described needing to prescribe a specific HEP. Further research on the dosage and intensity of HEPs for CWNIs will help build an evidence base for occupational therapists.

The content of HEPs described by occupational therapists heavily comprised preparatory activities such as stretching, active range of motion, and fine motor activities. Contextual practice of ADLs and instrumental activities of daily living (IADLs) is critical to recovery; the home and community environments should be used to provide CWNIs with opportunities to improve their abilities (Radomski & Trombly Latham, 2014). HEP tasks should relate to client goals and not be solely focused on building functional capacities. For example, Lang and Birkenmeier (2014) provided guidelines for an HEP as part of their Upper-Extremity Task-Specific Training Program that include client identification of intrinsically important tasks in order to increase adherence. Occupational therapists should also seek to explain clearly to their CWNIs the relationship between preparatory activities and achievement of goals.

The variety of methods described by occupational therapists to translate theories and evidence into practice may reflect the true client-centered nature of care (Cott, 2004). Many occupational therapists used the term *evidence* or *evidence-based practice* in their open-ended responses, but few cited specific studies. The fault for this shortcoming in practice may lie with the practicing occupational therapist. Many lack sufficient means, time, and knowledge to access up-to-date literature. However, AOTA's *Occupational Therapy Practice Guidelines for Adults With Stroke* (Wolf & Nilsen, 2015) also had few references to HEPs: "Discharge recommendations may also include . . . home programs designed to help the survivor carry out needed therapeutic activities or exercises" (p. 19). The lack of clear program descriptions limits the ability of both researchers and occupational therapists to clearly describe the translation from theory

and evidence to an HEP to be used in practice or a trial. Future research should focus on identifying the active ingredients in an HEP prescription and the mechanism of action. This identification will not only allow for reproducibility across clinicians and studies (Dijkers, 2015) but also help occupational therapists to better describe the rationale for an HEP to the CWNI and caregivers.

This study has several limitations. First, participants were randomly selected from several AOTA list rental categories and may not be representative of all occupational therapists who treat CWNIs. Second, the response rate was lower than the current response rate for mixed-method survey studies (60%), which also suggests that this study may not be representative of the practices and opinions of all occupational therapists who treat CWNIs. Third, the diversity in diagnoses, ages, and time since injury of CWNIs makes it difficult to provide evidence and suggestions for a single client population. Follow-up studies with subgroups (e.g., people with Parkinson's disease or stroke) are currently planned, and some are in progress. Fourth, the use of Likert-scale questions leaves the responses open to bias. The person completing a survey may interpret the phrasing or anchors on the scale differently than the researchers.

Implications for Occupational Therapy Practice

Current occupational therapist practices with respect to HEPs for CWNIs include a prescription for at least 16–30 min of daily practice per day, a mix of preparatory and ADL- and IADL-based tasks, and a clinical reasoning process grounded in evidence and theory to support recovery. The implications for occupational therapy practice are as follows:

- Client goals guide treatment planning, strategies, and choice of activities to ensure true client-centered care in the provision of an HEP.
- Occupational therapy practice guidelines are a resource for implementing evidence-based practice but include few guidelines or recommendations for HEPs to guide occupational therapy decision making.

Conclusion

Although HEPs are frequently prescribed by occupational therapists in clinical practice, little is known about the content, dosage, and clinical reasoning processes for use with CWNIs. Clinical practice guidelines contain limited evidence to support the use of HEPs and are frequently vague in their descriptions. The purpose of this study was

to describe current use of and clinical reasoning processes underlying HEPs for CWNIs through a survey. Survey respondents were able to clearly describe the benefits and clinical reasoning supporting HEPs for CWNIs. However, the respondents varied in their prescriptions and included preparatory activities and programs that are not in accordance with current literature on motor relearning and neuroplasticity. Future research on the dosing of HEPs and the connection between theory and clinical implementation is necessary to improve evidence-based practice. ▲

Acknowledgments

This study was supported by the Telemedicine and Advanced Technology Research Center at the U.S. Army Medical Research and Materiel Command (W911NF-04-D-0005; principal investigator: Belinda Lange), a National Institutes of Health (NIH) T32 Institutional Postdoctoral Training Grant, TREET: Training in Rehabilitation Efficacy and Effectiveness Trials (5T32HD064578-02; principal investigator: Florence Clark), and an NIH K12 Rehabilitation Research Career Development Award (K12 HD055929; principal investigator: Kenneth Ottenbacher). The author thanks Justin Proffitt for his help with data entry and Ssu-Ting Yeh for her help with data analysis.

References

- Bayona, N. A., Bitensky, J., Salter, K., & Teasell, R. (2005). The role of task-specific training in rehabilitation therapies. *Topics in Stroke Rehabilitation*, 12, 58–65. <http://dx.doi.org/10.1310/BQM5-6YGB-MVJ5-WVCR>
- Cifu, D. X., & Stewart, D. G. (1999). Factors affecting functional outcome after stroke: A critical review of rehabilitation interventions. *Archives of Physical Medicine and Rehabilitation*, 80(Suppl. 1), S35–S39. [http://dx.doi.org/10.1016/S0003-9993\(99\)90101-6](http://dx.doi.org/10.1016/S0003-9993(99)90101-6)
- Cott, C. A. (2004). Client-centred rehabilitation: Client perspectives. *Disability and Rehabilitation*, 26, 1411–1422. <http://dx.doi.org/10.1080/09638280400000237>
- Dijkers, M. P. (2015). Reporting on interventions: Issues and guidelines for rehabilitation researchers. *Archives of Physical Medicine and Rehabilitation*, 96, 1170–1180. <http://dx.doi.org/10.1016/j.apmr.2015.01.017>
- Duncan, P. W., Horner, R. D., Reker, D. M., Samsa, G. P., Hoenig, H., Hamilton, B., . . . Dudley, T. K. (2002). Adherence to postacute rehabilitation guidelines is associated with functional recovery in stroke. *Stroke*, 33, 167–178. <http://dx.doi.org/10.1161/hs0102.101014>
- Duncan, P. W., Zorowitz, R., Bates, B., Choi, J. Y., Glasberg, J. J., Graham, G. D., . . . Reker, D. (2005). Management of adult stroke rehabilitation care: A clinical practice guideline. *Stroke*, 36, e100–e143. <http://dx.doi.org/10.1161/01.STR.0000180861.54180.FF>
- Galvin, R., Cusack, T., O'Grady, E., Murphy, T. B., & Stokes, E. (2011). Family-mediated exercise intervention (FAME): Evaluation of a novel form of exercise delivery after stroke. *Stroke*, 42, 681–686. <http://dx.doi.org/10.1161/STROKEAHA.110.594689>
- Gustavsson, A., Svensson, M., Jacobi, F., Allgulander, C., Alonso, J., Beghi, E., . . . Olesen, J.; CDBE2010 Study Group. (2011). Cost of disorders of the brain in Europe 2010. *European Neuropsychopharmacology*, 21, 718–779. <http://dx.doi.org/10.1016/j.euroneuro.2011.08.008>
- Hubbard, I. J., Parsons, M. W., Neilson, C., & Carey, L. M. (2009). Task-specific training: Evidence for and translation to clinical practice. *Occupational Therapy International*, 16, 175–189. <http://dx.doi.org/10.1002/oti.275>
- Jurkiewicz, M. T., Marzolini, S., & Oh, P. (2011). Adherence to a home-based exercise program for individuals after stroke. *Topics in Stroke Rehabilitation*, 18, 277–284. <http://dx.doi.org/10.1310/tsr1803-277>
- Kleim, J. A., Barbay, S., & Nudo, R. J. (1998). Functional reorganization of the rat motor cortex following motor skill learning. *Journal of Neurophysiology*, 80, 3321–3325.
- Lang, C. E., & Birkenmeier, R. L. (2014). *Upper-extremity task-specific training after stroke or disability: A manual for occupational therapy and physical therapy*. Bethesda, MD: AOTA Press.
- Lang, C. E., Macdonald, J. R., Reisman, D. S., Boyd, L., Jacobson Kimberley, T., Schindler-Ivens, S. M., . . . Scheets, P. L. (2009). Observation of amounts of movement practice provided during stroke rehabilitation. *Archives of Physical Medicine and Rehabilitation*, 90, 1692–1698. <http://dx.doi.org/10.1016/j.apmr.2009.04.005>
- Menken, M., Munsat, T. L., & Toole, J. F. (2000). The global burden of disease study: Implications for neurology. *Archives of Neurology*, 57, 418–420. <http://dx.doi.org/10.1001/archneur.57.3.418>
- Mozaffarian, D., Benjamin, E. J., Go, A. S., Arnett, D. K., Blaha, M. J., Cushman, M., . . . Turner, M. B.; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. (2015). Heart disease and stroke statistics—2015 update: A report from the American Heart Association. *Circulation*, 131, e29–e322. <http://dx.doi.org/10.1161/CIR.0000000000000152>
- Nudo, R. J., & Milliken, G. W. (1996). Reorganization of movement representations in primary motor cortex following focal ischemic infarcts in adult squirrel monkeys. *Journal of Neurophysiology*, 75, 2144–2149.
- Nudo, R. J., Plautz, E. J., & Frost, S. B. (2001). Role of adaptive plasticity in recovery of function after damage to motor cortex. *Muscle and Nerve*, 24, 1000–1019. <http://dx.doi.org/10.1002/mus.1104>
- Outermans, J. C., van Peppen, R. P., Wittink, H., Takken, T., & Kwakkel, G. (2010). Effects of a high-intensity task-oriented training on gait performance early after stroke: A pilot study. *Clinical Rehabilitation*, 24, 979–987. <http://dx.doi.org/10.1177/0269215509360647>
- Radomski, M. V., & Trombly Latham, C. A. (Eds.). (2014). *Occupational therapy for physical dysfunction* (7th ed.). Philadelphia: Lippincott Williams & Wilkins.

- Reker, D. M., Duncan, P. W., Horner, R. D., Hoenig, H., Samsa, G. P., Hamilton, B. B., & Dudley, T. K. (2002). Postacute stroke guideline compliance is associated with greater patient satisfaction. *Archives of Physical Medicine and Rehabilitation*, 83, 750–756. <http://dx.doi.org/10.1053/apmr.2002.99736>
- Taub, E., Uswatte, G., King, D. K., Morris, D., Crago, J. E., & Chatterjee, A. (2006). A placebo-controlled trial of constraint-induced movement therapy for upper extremity after stroke. *Stroke*, 37, 1045–1049. <http://dx.doi.org/10.1161/01.STR.0000206463.66461.97>
- U.S. Department of Veterans Affairs, U.S. Department of Defense, & American Heart Association/American Stroke Association. (2010). *Va/DoD clinical practice guideline for the management of stroke rehabilitation*. Washington, DC: Office of Quality and Performance, Department of Veterans Affairs, and Quality Management Division, U.S. Army MEDCOM.
- Wolf, S. L., Winstein, C. J., Miller, J. P., Taub, E., Uswatte, G., Morris, D., . . . Nichols-Larsen, D.; EXCITE Investigators. (2006). Effect of constraint-induced movement therapy on upper extremity function 3 to 9 months after stroke: The EXCITE randomized clinical trial. *JAMA*, 296, 2095–2104. <http://dx.doi.org/10.1001/jama.296.17.2095>
- Wolf, T. J., & Nilsen, D. M. (2015). *Occupational therapy practice guidelines for adults with stroke*. Bethesda, MD: AOTA Press.
- Yang, Y. R., Wang, R. Y., Lin, K. H., Chu, M. Y., & Chan, R. C. (2006). Task-oriented progressive resistance strength training improves muscle strength and functional performance in individuals with stroke. *Clinical Rehabilitation*, 20, 860–870. <http://dx.doi.org/10.1177/0269215506070701>