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reSearch

A collection of research reviews on rehabilitation topics from NARIC and other information resources.

Telerehabilitation

In this edition of *reSearch* we explore the topic of telerehabilitation. *reSearch* was originally created as a vehicle to further explore disability related topics presented by patrons through our information service via phone, mail, email, and our chat-based reference service. In December, NARIC received a chat request for information regarding telephone follow-up post-rehabilitation:

Do you have any resources related to post-discharge rehab follow up phone calls? (12/29/08)

Information specialists directed the patron toward information and resources related to telerehabilitation.

“Telerehabilitation is the delivery of rehabilitation services over telecommunication networks and the internet.” Telerehabilitation. (2009, March 6). In *Wikipedia, The Free Encyclopedia*. Retrieved 20:29, March 6, 2009, from <http://en.wikipedia.org/w/index.php?title=Telerehabilitation&oldid=271812739>.

As the word implies, telerehabilitation is a blending of telecommunication and rehabilitation. Similarly, telehealth and telemedicine involve the use of telecommunication resources to provide information and medical clinical practice from a distance. Telerehabilitation serves two purposes: clinical assessment and application of clinical therapy from a distance. This is especially useful for providing services to people with limited access the healthcare, including people with disabilities or individuals living in remote rural areas. Citations included in this research brief cover the various types of telerehabilitation technologies, which include but are not limited to: 1) telephones and videophones, 2) video-conferencing, 3) virtual reality, web-based and Internet-based approaches, 4) wireless technolo-

gies, and 5) personal digital appliances or PDAs. Telerehabilitation. (2009, March 6). In *Wikipedia, The Free Encyclopedia*. Retrieved 20:29, March 6, 2009, from <http://en.wikipedia.org/w/index.php?title=Telerehabilitation&oldid=271812739>.

The research presented in this issue provides a “snapshot” of telerehabilitation over a 10-year time period. Combined search terms included: telerehabilitation, telehealth, telemedicine, and remote service delivery. A listing of approximately 70 additional descriptor terms between the NARIC, AHRQ, Cochrane, and PubMed databases can be found at the end of this document. A search of the REHABDATA database resulted in 45 documents published between 1999 and 2007. A search of Cochrane and AHRQ resulted in 14 documents between 2002 and 2008 and 2 documents between 2005 and 2006, respectively. Finally, a search of PubMed resulted in 39 documents published in 1999 and 2009. The complete citations are included in this research brief.

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NIDRR Funded Projects Related to Telerehabilitation

In addition to document searches, we searched our NIDRR Program Database to locate grantees/projects related to telerehabilitation. The search resulted in 19 NIDRR funded projects — 10 currently funded and 9 which have completed their research activities. Project information and their publications are offered as additional resources for our patrons.

Combining Technologies to Maximize Outcomes: Telemedicine and Online Training Program for Parents of Children with Autism.

Project Number: H133G060238
www.jgcp.ku.edu

Effectiveness of a Teleconference Fatigue Management Program for People with Multiple Sclerosis.

Project Number: H133G070006
Phone: 312/996-4603

Mayo Clinic Traumatic Brain Injury Model System.

Project Number: H133A070013
www.mayo.edu/model-system

Rehabilitation Engineering Research Center on Telerehabilitation.

Project Number: H133E040012
www.rerctr.pitt.edu

Rehabilitation Research and Training Center on Disability in Rural Communities.

Project Number: H133B030501
rtc.ruralinstitute.umd.edu

Rehabilitation Robotics and Telemanipulation Machines Assisting Recovery from Stroke Rehabilitation Engineering Research Center (MARS-RERC).

Project Number: H133E070013
www.mars-lerc.org

Sensorimotor Training and Assessment in Adults with Hemiplegic Cerebral Palsy: The ULTrA Program.

Project Number: H133G050151
www.motorcontrol.umich.edu/ultra

Telephone and In-Person Cognitive Behavioral Therapy for Depression After Traumatic Brain Injury.

Project Number: H133G070016
Phone: 206/685-4280

Television Assisted Promotion (TAP): Enhancing Rehabilitation Outcomes with Familiar Technology.

Project Number: H133S080077
Phone: 541/915-8472

Treatment Components and Active Ingredients in a Scheduled Telephone Intervention for Traumatic Brain Injury.

Project Number: H133G070143
www.einstein.edu/facilities/mossrehab/index.html

The following projects have completed their research activities:

The Consortium for Children and Youth with Disabilities and Special Health Care Needs.

Project Number: H133B001200
Phone: 202/687-8742

Creating Permanent Behavioral Health Access for Rural Missourians with TBI: Teleconferencing Application for Improved Services.

Project Number: H133G80033
www.telerehab.net

Home-Based Tracking Training to Stimulate Neuroplasticity and Improve Function in Stroke.

Project Number: H133G020145
Phone: 612/626-2746

Optimizing Assistive Technology Service with Video Teleconferencing.

Project Number: H133G990087
Phone: 650/237-9222

Rehabilitation Engineering Research Center on Telerehabilitation.

Project Number: H133E980025
Phone: 202/319-5891

Rehabilitation Research and Training Center on Secondary Conditions of Spinal Cord Injury: Promoting General Health, Well-Being, and Community Integration Through Home-Based, Self-Directed Care.

Project Number: H133B980016
Phone: 205/934-3283

Telemedicine and Neuropsychological Services: Improving Access to Care for Rural Residents with Brain Injury.

Project Number: H133F70010
Phone: 573/882-1561

Telerehabilitation to Support Assistive Technology.

Project Number: H133G990133
Phone: 404/350-7595

Web-Based Telerehabilitation for Home Assessment and Monitoring.

Project Number: H133S020046
www.anthrotronix.com



Documents from NARIC's REHABDATA search listed are listed below:

2007

Bendixen, Roxanna, M., Horn, Kathleen, & Levy, Charles. (2007). **Using telerehabilitation to support elders with chronic illness in their homes.** *Topics in Geriatric Rehabilitation, 23*(1), 47-51.

NARIC Accession Number: J52098

ABSTRACT: Telerehabilitation is an emerging practice that uses communications technology for the remote delivery of rehabilitative services. The Low ADL Monitoring Project (LAMP) is an example of a telerehabilitation program designed to deliver home-based rehabilitation services through the provision of assistive technology and adaptive equipment, communications technology, and care coordination. The LAMP model uses a combination of traditional and advanced technologies to conduct daily remote monitoring of health status that is important for promoting functional independence, self-care, and self-management in older adults.

Girard, Philip. (2007). **Military and VA telemedicine systems for patients with traumatic brain injury.** *Journal of Rehabilitation Research and Development (JRRD), 44*(7), 1017-1026.

NARIC Accession Number: J54571

ABSTRACT: Article discusses the military and Department of Veterans Affairs (VA) telemedicine capabilities that are supporting the care of service members and veterans with traumatic brain injury (TBI). These capabilities include new technologies that enhance the identification of TBI, management of symptoms in theater, and application of proven technologies (interactive video, Internet, and World Wide Web) to improve overall care coordination throughout military and VA systems. The impact of distance learning, teleconsultation, telerehabilitation, and home telehealth programs is also described within this context.

Hamza, Heba, Kim, JongBae, Wang, Yan, & Yue, Jing. (2007). **The virtual reality telerehabilitation system for accessibility of the built environment: Feasibility test of multimedia decision supporting system, IP camera, and coded targets.** *30th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O17016

ABSTRACT: Study evaluated the feasibility of new technologies developed to enhance a virtual reality telerehabilitation system that enables clients to assess the wheelchair accessibility of building environments. Specifically, the study examined whether the use of a Web-based multi-media decision supporting system could enhance the communication between clinicians and clients; whether high quality pictures could be taken via the Internet using the D-Link@ IP camera; and whether the efficiency of three-dimensional reconstruction could be enhanced through Coded Targets detected and processed by the Photomodeler Pro 5 software. Results indicate that the multimedia decision supporting system allows all participating project members to share their information and data via the Internet. The IP camera and coded targets provide more choice during construction of the 3D model of the real house environment. Additionally, the Coded Target module can speed the processing and enhance the efficiency and accuracy of building 3D construction models. This paper was presented at the 2007 Annual Conference of the Rehabilitation Engineering & Assistive Technology Society of North America and is available on CD-ROM.

Kim, Jongbae, & Fuhrman, Ya'aqov. (2007). **Comparison of web-based videoconferencing systems for telerehabilitation applications.** *30th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16961

ABSTRACT: Study evaluated and compared seven instant messenger (IM) systems and remote communication techniques for telerehabilitation use: (1) AIM, (2) Conference XP, (3) CU-See-Me, (4) ICQ, (5) MSN Messenger, (6) Skype, and (7) Yahoo Messenger. The IM systems were evaluated in terms of the following characteristics: (1) ease of use, (2) ease of set-up, (3) video resolution and frame rate, (4) audio clarity, (5) video-audio synchronization, and (6) connection reliability. Results were recorded using a five-point Likert scale. Of the seven systems evaluated, three demonstrated superior qualities. Results from this study and evaluation will be used to recommend the Skype, MSN, and ICQ IM systems for telerehabilitation purposes. This paper was presented at the 2007 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Mann, William, C. (Ed.). (2007). **Smart technology.** *Topics in Geriatric Rehabilitation, 23*(1), 1-93.

NARIC Accession Number: R08825

ABSTRACT: This journal issue focuses on smart home technology. Topics include: a home monitoring system for use in the homes of people with cognitive impairment; monitoring the well-being of older people; use of currently available smart home technology by frail elders; older adults' perceptions and use of personal digital assistants, home automation systems, and home health monitoring systems; using telerehabilitation to support elders with chronic illness in their homes; user needs and usage analysis in a smart environment for people requiring assistance; consumer feedback on smart home applications; pilot live-in trial at the GatorTech smart house; and quality of life technologies for people with dementia. Articles are available for document delivery under accession numbers J52094 through J52102.

Schein, Richard M., & Schmeler, Mark. (2007). **Telerehabilitation: A proposed innovative approach for rural wheelchair service delivery.** *30th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O17011

ABSTRACT: Paper outlines a study underway to examine the effectiveness and accuracy of using telerehabilitation (TR) for procuring appropriate wheeled mobility and seating devices for individuals with mobility impairments. TR is the application of telecommunication technology that provides distant support, assessment, and intervention to people with disabilities. A repeated measure study design will be used to assess the effectiveness of wheeled mobility and seating interventions provided in a remote location by a generalist occupational and/or physical therapy practitioner in consultation with an expert practitioner via interactive secure videoconferencing. Effectiveness will be measured by the change in function as scored by the Functioning Everyday with a Wheelchair instrument before and after provision of the device. Equipment included the use of a personal computer, Logitech webcam with a built-in microphone for video and audio, and videoconferencing software. This paper was presented at the 2007 Annual Conference of the Rehabilitation Engineering & Assistive Technology Society of North America and is available on CD-ROM.

2006

(2006). **National Telerehabilitation Service System: Helping rural under-served communities and individuals with disabilities.** *Exceptional Parent, 36*(4), 47-49.

NARIC Accession Number: J50722

ABSTRACT: The National Telerehabilitation Service System (NTSS) was created to provide access to quality rehabilitation services by researching new or existing telecommunications and computing technologies and modifying them to meet the needs of people with disabilities. This article describes the facilities and their utilization, activities, and future events, and research of the NTSS.

Brienza, David, M., & Kim, Jongbae. (2006). **A virtual reality telerehabilitation system for analyzing accessibility of the built environment: A field evaluation.** *29th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16676

ABSTRACT: Article describes the evaluation of a virtual reality telerehabilitation system (VRTS) that enables clinicians to assess the wheelchair accessibility of users' built environments from a remote location. This system uses commercial software to construct three-dimensional (3-D) virtualized environments from photographs. The software and hardware components were analyzed by assessing the accuracy of dimensional measurements in a virtual environment and a comparison of dimensional measurements from 3-D models created with four cameras/settings. Based on these analyses, a consumer-grade digital camera and the PhotoModeler software were specified for the system. A feasibility analysis of the system in an actual environment resulted in an accurate assessment of the accessibility of the wheelchair user's environment. A field evaluation was performed to test whether this new system is comparable to the traditional method of accessibility assessment. The results of field trials showed high a level of agreement between the two assessment methods. The findings also provided the evidence that a VRTS can be an alternative, cost-effective solution to conventional rehabilitation services. This paper was presented at the 2006 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Brienza, David, Nnaji, Bart, Parmanto, Bambang, Saptono, Andi, & Sugiantara, Wayan. (2006). **Information technology infrastructure for supporting telerehabilitation.** *29th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16661

ABSTRACT: Paper describes the design and development of an information technology (IT) infrastructure that can support various project tasks within the

Rehabilitation Engineering Research Center (RERC) on Telerehabilitation. Researchers applied systematic steps to identify and evaluate components of the IT infrastructure required to support telerehabilitation. The model and methods used in this project are applicable to IT infrastructure development in other RERCs. This paper was presented at the 2006 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Brisben, Amy, J., Cohn, Ellen, R., Lathan, Corinna, E., Parmanto, Bambang, & Yaruss, J. Scott. (2006). **Development of telemonitoring architecture for children's communication skills.** *29th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16667

ABSTRACT: Paper describes a proposed teletherapy architecture for speech/language therapy, discusses the current state of the architecture, and describes future efforts in development and evaluation. Virtual CosmoBot is a motivating, computer-based character designed to enhance children's communication skills and stimulate verbal interaction during the remediation of speech and language disorders via telerehabilitation. The proposed architecture provides two types of telemonitoring: (a) simultaneous monitoring, where the therapist monitors the child "live" and the child and therapist are communicating via telemedicine technology, and (b) store-and-forward monitoring, where the therapist monitors the child after the child has completed a therapy session. This paper was presented at the 2006 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Carignan, Craig, R., & Krebs, Hermano, I. (2006). **Telerehabilitation robotics: Bright lights, big future?** *Journal of Rehabilitation Research and Development (JRRD)*, 43(5), 695-710.

NARIC Accession Number: J51746

ABSTRACT: Article examines the future of using robotic technology to provide rehabilitation services over the Internet. Current trends in telerehabilitation systems are reviewed, the technical challenges still facing researchers are described, and some promising results are presented for a new bilateral system in which both the patient and the therapist use robots to interact with each other over the Internet. The future directions and

commercial outlook for rehabilitation robots over the next 15 years are discussed.

Chase, Susan, L., Danilko, Nick, Demuth, Barb, McCue, Michael, Pramuka, Michael, & van Roosmalen, Linda. (2006). **Telerehabilitation and vocational rehabilitation: Supported self-employment using web-based applications.** *29th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16664

ABSTRACT: Study evaluated the provision of remote support for the development of a self-employment feasibility plan to five individuals with disabilities in rural locations. The protocol was delivered using telerehabilitation technology including web-based teleconferencing with application sharing, phone, email contact, and traditional mail. The final product was a user friendly feasibility assessment delivered to each participant and their state vocational rehabilitation counselor. Results indicated that remote coaching made the most use of emails and phone contact and that a complete feasibility plan could be completed successfully in one to three months. Participants successfully identified either a self-employment goal or an alternative employment goal through the telerehabilitation support process. Participant surveys indicated positive experiences overall with the process. Suggestions are offered for future efforts at using telerehabilitation to support self-employment. This paper was presented at the 2006 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Fatula, Amy, Kim, Jongbae, Kim, Kyoung, Y., Regulski, Angela, Schein, Richard, & Schmeler, Mark. (2006). **Proposed protocol for remote wheelchair consultation using telerehabilitation.** *29th Annual RESNA Conference Proceedings.*

NARIC Accession Number: O16722

ABSTRACT: This paper presents the protocol for a study investigating the feasibility of procuring wheeled mobility and seating devices for individuals with mobility impairments through the use of telerehabilitation consultations. Telerehabilitation refers to the use of telecommunications technology to provide rehabilitation and long-term support to people with disabilities in geographically remote regions. This paper was presented at the 2006 annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and is available on CD-ROM.

Hardin, Philip, Lum, Peter, S., Mark, Victor, W., Taub, Edward, & Uswatte, Gittendra. (2006). **A telerehabilitation approach to delivery of constraint-induced movement therapy.** *Journal of Rehabilitation Research and Development (JRRD)*, 43(3), 391-400.

NARIC Accession Number: J51495

ABSTRACT: Article focuses on the design and development of the Automated Constraint-Induced Therapy Extension (AutoCITE), which was created to automate the intensive training component of constraint-induced movement therapy (CIMT). The general premise behind CIMT is that it has been proven to yield an increase in the amount of use of the more affected upper limb among rehabilitation clients with chronic stroke and mild to moderate motor impairment by restraining the less affected limb, thus forcing the client to use the more affected limb. AutoCITE was created to automate the training portion of CIMT in order to reduce the amount of therapist effort and to overcome obstacles to therapy such as transportation issues in rural areas and treatment cost. AutoCITE uses a computer and eight tasks devices that are placed in a cabinet on four work surfaces. The computer provides simple one-step instructions on a monitor that guides the client through the entire treatment process. Completion of each treatment activity is verified by sensors that are built into the device. The AutoCITE tasks are discussed in detail, as initial trials with the device have proven to be promising.

2005

Anson, Denis (Ed.). (2005). **RESNA 28th international annual conference: Technology and disability: Research, design, practice and policy: June 23 to June 27, 2005: Atlanta, Georgia.**

NARIC Accession Number: O16150

ABSTRACT: Proceedings of the annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America, includes over 200 presentations on all facets of assistive technology (AT) through workshop sessions, scientific platform sessions, interactive poster presentations, integrated demonstrations, and a clinical practicum on seating & mobility. The program has three conference tracks: practice, research, and public policy. Within each track, the scientific papers are grouped according to the following categories: (1) computer applications and communica-

tions; (2) job and environmental accommodations, including ergonomics; (3) outcomes and quantitative measurement; (4) seating and wheeled mobility; (5) technology for cognitive and sensory impairments; (6) public policy; and (7) other, including technology transfer, rural rehabilitation, robotics, and telerehabilitation. The winning papers for the Student Scientific Paper and Student Design competitions are also included. The papers presented at this conference are available on CD-ROM and are included separately in the NARIC collection under accession numbers O16151 through O16213.

2004

Anson, Denis (Ed.). (2004). **RESNA 27th international annual conference: Technology and disability: Research, design, practice and policy: June 18 to June 22, 2004: Orlando, Florida.**

NARIC Accession Number: O15728

ABSTRACT: Proceedings of the annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America, includes over 200 presentations on all facets of assistive technology (AT) through workshop sessions, scientific platform sessions, interactive poster presentations, integrated demonstrations, and a symposium on AT outcomes. The program has three conference tracks: practice, research, and public policy. Within each track, the scientific papers are grouped according to the following categories: (1) computer applications and communications; (2) job and environmental accommodations, including ergonomics; (3) outcomes and quantitative measurement; (4) seating and wheeled mobility; (5) technology for cognitive and sensory impairments; (6) public policy; and (7) other, including: technology transfer, rural rehabilitation, robotics, and telerehabilitation. The winning papers for the Student Scientific Paper and Student Design competitions are also included. The papers presented at this conference are available on CD-ROM.

Butterfield, Tina, Daviou, Pat, Grogg, Kevin, Jones, Michael, & Sanford, Jon, A. (2004). **Using telerehabilitation to identify home modification needs.** *Assistive Technology*, 16(1), 43-53.

NARIC Accession Number: J48234

ABSTRACT: Article describes the use of video conferencing technology to provide remote assessment for home modification services. The feasibility of the

remote assessment process was evaluated by validating it against an in-home assessment by a home modifications specialist. The results were compared for agreement in identification of specific accessibility problems in and quantitative measurements of the home. The remote assessment correctly identified a total of 51 of the 59 problems (86 percent) identified by the in-home assessment. In addition, 54 of 60 (90 percent) of the quantitative measurements from the remote assessment matched those from the in-home assessment. Findings suggest that remote telerehabilitation assessments have the potential to identify accessibility problems in the home.

Ellsworth, Christopher, Feng, Xin, Johnson, Laura, & Winters, Jack, M. (2004). **Unitherapy: Software design and hardware tools of teletherapy.** In D. Anson (Ed.), *Proceedings of the RESNA 27th International Conference: Technology and Disability: Research, Design, Practice and Policy*. Arlington, VA: RESNA Press.

NARIC Accession Number: O15769

ABSTRACT: Paper discusses the development of software for a computer-assisted home-based telerehabilitation program for motor recovery in the upper limbs. The program utilizes force-reflecting joysticks and other input devices to provide interactive assessment and therapy. This paper was presented at the 2004 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America and is available on CD-ROM.

Palsbo, Susan, E. (2004). **Medicaid payment for telerehabilitation.** *Archives of Physical Medicine and Rehabilitation*, 85(7), 1188-1191.

NARIC Accession Number: J48130

ABSTRACT: Article describes payment practices for telemedicine and telerehabilitation in state Medicaid programs. Telerehabilitation helps Medicaid programs deliver specialized care to locations with provider shortages. All 50 states and the District of Columbia were contacted during the summer of 2002; 35 programs completed the survey. Half of the responding programs reimbursed at least some telemedicine services in 2002. The most frequent categories reimbursed were consultation and evaluation and management services. Seven states reimbursed telepsychology, and four states reported reimbursing for telespeech and language pathology, physical therapy, or occupational therapy.

2003

Bonilla, Jacqueline, M., Branneck, Roberta, Diamond, Bruce, J., Johnston, Mark, V., Morodan, Jennifer, & Shreve, Gregory, M. (2003). **Telerehabilitation, cognition and user-accessibility.** *NeuroRehabilitation*, 18(2), 171-177.

NARIC Accession Number: J51357

ABSTRACT: Article presents a study conducted to: (1) build an Internet-based virtual rehabilitation center (VRC) that provides rehabilitation, education, and support to individuals with traumatic brain injury; and (2) determine the relationships between the nature and severity of the participants' cognitive impairments and their ability to use the VRC. All eight participants were administered the Neurobehavioral Cognitive Status Exam (NBCSE) to assess their level of consciousness, orientation, and intellectual functioning. The VRC modules consisted of reaction time, functional modules, and communication capabilities. All participants learned how to use the VRC although learning rates varied. Those requiring more trials to acquisition showed greater cognitive impairment in the construction, reasoning, calculation and language subtests of the NBCSE than those requiring fewer trials. One case study demonstrates how learning on the VRC was generalized to the community.

Borstad, Alexandra, Conroy, Brendan, Lauderdale, Donal, Savard, Lynda, & Tkachuck, Joy. (2003). **Telerehabilitation consultants for clients with neurologic diagnoses: Cases from rural Minnesota and American Samoa.** *NeuroRehabilitation*, 18(2), 93-102.

NARIC Accession Number: J51355

ABSTRACT: Article describes two clinical programs that use videoconferencing to provide rehabilitation consultations to patients living in remote areas with limited access to specialists. The Minnesota Telerehabilitation Initiative serves patients and clinicians in rural Minnesota and the Pacific Rim Initiative serves patients and clinicians on the island of American Samoa. A total of 117 telerehabilitation encounters were completed with 75 patients. Each consultation included the patient, the local caregivers, and specialists for each program interacting via videoconferencing. All consultations resulted in changes to the plan of care. Thirty-eight of those consultations were with individuals with neurological diagnoses. Of those, 25 visits were for initial assessments and 13 were follow-up visits.

Brienza, David, M., & Kim, Jonbae. (2003). **The virtual reality telerehabilitation system for analyzing accessibility of the physical environment: A comparison of camera systems.** In R. Simpson (Ed.), *Proceedings of the RESNA 26th International Conference: Technology and Disability: Research, Design, Practice and Policy*. Arlington, VA: RESNA Press.

NARIC Accession Number: O15577

ABSTRACT: Study compared four types of cameras for use in a virtual reality telerehabilitation system that enables clinicians to evaluate the wheelchair accessibility of users' homes from a remote location. The 4 camera types are: a disposable film camera, an inexpensive consumer level digital camera, a high-resolution digital camera, and the same high-resolution digital camera with a wide-angle lens. Images from each camera were used to create four 3-dimensional models of the same bathroom. Measurements of selected dimensions within each bathroom model were compared to a manual tape measure measurement to assess accuracy. Results showed that although the high-resolution digital camera with the wide-angle lens produced the most accurate results, all of the cameras produced satisfactory results. This paper was presented at the 2003 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America and is available on CD-ROM.

Frnka, Jacquelyn, Gaddis, William, Garber, Susan, L., Henson, Helene, K., Itani, Kamal, M.F., Krouskop, Thomas, A., Matamoros, Rebeca, Monga, Trilok, N., Rintala, Diana, H., & Wright, John, V. (2003). **Telerehabilitation for veterans with a lower-limb amputation or ulcer: Technical acceptability of data.** *Journal of Rehabilitation Research and Development (JRRD)*, 40(5), 481-490.

NARIC Accession Number: J54471

ABSTRACT: Study evaluated the technical acceptability of information obtained using a computer-based telerehabilitation system regarding patients with lower-limb ulcers or recent lower-limb amputations. Three experienced raters evaluated a total of 57 wounds in 54 veterans by means of still photographs and skin temperature data sent through ordinary telephone lines. Intra-rater agreements and McNemar tests were assessed between decisions made after by the same rater after telerehabilitation sessions and in-person session. Inter-rater agreements were assessed between 2 raters for both telerehabilitation and in-person session. The intra-

rater agreement on 57 wounds for the primary rater was 93 percent, and the McNemar test indicated no significant difference in the ratings. Inter-rater agreement on 18 wounds was 78 percent for the telerehabilitation sessions and 89 percent for the in-person sessions. Most qualitative comments by three clinicians on picture quality and temperature data were favorable (good to excellent). The information yielded from this study provides evidence that the telerehabilitation system has the potential to present sufficient information to experienced clinicians so they can make informed decisions regarding wound management.

2002

Abraham-Fuchs, Klaus, DeLuca, John, Garay, Edward, Germain, Anneliese, Ricker, Joseph, H., Rosenthal, Mitchell, & Schmidt, Kai-Uwe. (2002). **Telerehabilitation needs: A survey of persons with acquired brain injury.** *Journal of Head Trauma Rehabilitation*, 17(3), 242-250

NARIC Accession Number: J44797

ABSTRACT: Reports findings from a survey conducted to assess the interest in, access to, and familiarity with telerehabilitation technologies among individuals with acquired brain injury. Respondents indicated great interest in accessing telerehabilitative services. Specifically, strong interest was expressed in services that could assist with problems in memory, attention, problem solving, and activities of daily living.

Appel, Philip, R., Bleiberg, Joseph, & Noiseux, John. (2002). **An exploration of behavioral telehealth interventions for pain management and consumer satisfaction.** In M. J. Rosen and D. E. Lauderdale (Eds.) *Proceedings of the State of Science Conference on Telerehabilitation and Applications of Virtual Reality* (pp. 23-30). Washington, DC: NRH Press.

NARIC Accession Number: O14719

ABSTRACT: Paper describes the use of telerehabilitation for providing behavioral interventions designed to teach self-regulation skills to patients with chronic pain. Participants were randomly assigned to one of three treatment conditions: (1) traditional face-to-face interaction, (2) closed-circuit television, or (3) speakerphone. Analysis of outcome measures indicated that all of the interventions were effective and no differences between methods of delivery were found. Consumer satisfaction was relatively high in each of the treatment groups.

Baron, C., Brennan, D., & Georgeadis, A. (2002). **Telerehabilitation tools for the provision of remote speech-language treatment.** *Topics in Stroke Rehabilitation, 8*(4), 71-78.

NARIC Accession Number: J44148

ABSTRACT: Paper provides an overview of telerehabilitation (telerehab) and the tools required to provide remote speech-language diagnosis and treatment for patients after stroke. Telerehab is the method of using communication technologies to provide rehabilitation services from a distance. Many speech-language pathology services are well suited for telerehab and can be conducted using existing technology, such as videoconferencing. Implications for stroke rehabilitation and future research are discussed.

Boninger, Michael, Cohen, Laura, Cooper, Rory, A., Cooper, Rosemarie, Fitzgerald, Shirley, & Shapcott, Nigel. (2002). **Using telerehabilitation to aid in selecting a wheelchair.** In R. Simpson (Ed.), *Proceedings of the RESNA 25th International Conference: Technology and Disability: Research, Design, Practice and Policy* (pp. 327-329). Arlington, VA: RESNA Press.

NARIC Accession Number: O14559

ABSTRACT: Study examines the relationship between the type of wheelchair the person actually uses and the type of wheelchair recommended via telerehabilitation and during mobility assessments. Results show that therapists using telerehabilitation demonstrated a high level of agreement in recommending the same type of wheelchair that subjects already owned. There was also a high level of agreement between telerehabilitation assessments and in-person assessments. This paper was presented at the 2002 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

Hauber, Roxanne, P., & Jones, Michael, L. (2002). **Telerehabilitation support for families at home caring for individuals in prolonged states of reduced consciousness.** *Journal of Head Trauma Rehabilitation, 17*(6), 535-541

NARIC Accession Number: J44808

ABSTRACT: Reports results from the evaluation of a program that used telerehabilitation to support families caring at home for individuals in prolonged states of reduced consciousness after severe traumatic brain injury (TBI). Participants in the telerehabilitation group received weekly follow-up visits by a certified neuro-

science registered nurse via videophone equipment. The comparison group received no follow-up except for responses to caregiver-initiated phone calls. Follow-up telephone interviews were conducted with all participants to determine the patients' present living status, number of emergency room visits and hospital admissions since discharge, the caregivers' perceptions of functional status and care needs, and perceived family needs as measured by the Family Needs Questionnaire. The videoconference group had more patients still living at home and having returned to rehabilitation than the comparison group. The comparison group had fewer readmissions and visits to the emergency room. Families in the videoconferencing group reported more of their needs being met than families in the comparison group.

Hayes, Olga E. (Ed.). (2002). **Research update: Spring 2002.**

NARIC Accession Number: O14650

ABSTRACT: Newsletter presents news of research and projects of the National Rehabilitation Hospital Center for Health and Disability Research (NRH-CHDR). In this issue: (1) the NRH Neuroscience Research Center, (2) NRH selected as site for Lokomat robotic treadmill, (3) applied neuromuscular biomechanics lab established, (4) study to evaluate telerehabilitation technology for wound management, (5) profile of researcher Justin Carter, (6) enhancements expand uses of cognitive assessment tool, (7) new research internship focuses on emergent disabilities, (8) neuroscience research grant to support NRH's participation in international stroke outcome study, and (9) experts urge rapid development of telerehabilitation and related technologies.

Lauderdale, Donal, E., & Rosen, Michael, J. (Eds.). (2002). **Proceedings of the state of science conference on telerehabilitation and applications of virtual reality: Washington, DC: October 12-13, 2001.**

NARIC Accession Number: O14713

Available in full-text at www.naric.com/research/rehab/download.cfm?ID=95644.

ABSTRACT: Contains the formal papers presented at the conference on telerehabilitation and rehabilitation-focused virtual reality. They are organized by subject matter: (1) applications of telerehabilitation related to health, mobility, and activities of daily living; (2) applications of telerehabilitation related to cognition, communication, and emotion; (3) virtual environments and

advanced human interface technologies; and (4) telerehabilitation technologies. A brief overview of the theme of each session precedes its associated papers. The papers are included separately in the NARIC collection under accession numbers O14714 through O14736.

Lauderdale, Donal, E., Rosen, Michael, J., & Winters, Jack, M. (2002). **Telerehabilitation**. In J. M. Winters, C. Robinson, R. Simpson, and G. Vanderheiden, (Eds.), *Emerging and Accessible Telecommunications, Information and Healthcare Technologies*, (pp. 95-111). RESNA Press: Arlington, VA , Pgs. 220-245.

NARIC Accession Number: O15117

ABSTRACT: Chapter summarizes the contents of the six sessions of the State of the Science Conference on Telerehabilitation and Applications of Virtual Reality in Rehabilitation. Topics for the sessions included clinical applications of telerehabilitation research, research applications of virtual reality and telerehabilitation technologies, and outcomes and policy issues. Brief summaries of the various presentations are provided along with summaries of the evolving discussions and comments.

Scheideman-Miller, Cynthia. (2002). **INTEGRIS rural telemedicine project: Telerehab TM**. In M. J. Rosen and D. E. Lauderdale (Eds.) *Proceedings of the State of Science Conference on Telerehabilitation and Applications of Virtual Reality* (pp. 18-20). Washington, DC: NRH Press.

NARIC Accession Number: O14805

ABSTRACT: Article describes a telemedicine program that delivers rehabilitation services to rural communities in Oklahoma. The telerehabilitation program was initiated when a rural hospital participating in the INTEGRIS Rural Telemedicine Project began using telemedicine to provide speech therapy to local schools. Success of the pilot programs in speech therapy and later, physical therapy, evolved into the INTEGRIS Telerehabilitation Program, TeleRehabTM. The program also incorporates occupational therapy, neuropsychology, pharmacy, vocational counseling, audio/verbal therapy, and physiatry as telemedicine specialties.

Shapcott, Nigel. (2002). **Using telerehab for providing assistive technology**. In J. M. Winters, C. Robinson, R. Simpson, and G. Vanderheiden, (Eds.), *Emerging and Accessible Telecommunications, In-*

formation and Healthcare Technologies, (pp. 95-111). RESNA Press: Arlington, VA , Pgs. 112-118.

NARIC Accession Number: O15111

ABSTRACT: Chapter describes research the examined the efficacy of using telerehabilitation for the prescription of wheelchairs. The study used video conferencing to evaluate individuals for their seating and mobility needs and compared results to their clinical-based prescription to determine if services were delivered at the appropriate level. Significant problems were found with the methods for obtaining measurements for both the in-person and telerehabilitation evaluations and further research is recommended.

2001

Boninger, M., Cohen, L., Cooper, R., Cooper, R.A., Shapcott, N., & Thorman, T. (2001). **Development of a tool to be used during telerehabilitation evaluation and recommendation process**. In R. Simpson (Ed.), *Proceedings of the RESNA 2001 Annual Conference: The AT Odyssey Continues* (pp. 254-256). Arlington, VA: RESNA Press.

NARIC Accession Number: O14212

ABSTRACT: Paper on the development of a form suitable for telerehabilitation assessment of seating and mobility in rural and remote areas. This paper was presented at the 2001 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

Boninger, M., Cohen, L., Cooper, Rory, Cooper, Rosi, Fitzgerald, S., & Shapcott, N. (2001). **Determining the efficacy of POTS based telerehabilitation for wheelchair prescription**. In R. Simpson (Ed.), *Proceedings of the RESNA 2001 Annual Conference: The AT Odyssey Continues* (pp. 169-171). Arlington, VA: RESNA Press.

NARIC Accession Number: O14184

ABSTRACT: Paper on remote delivery of rehabilitation services, including wheelchair prescription, using video conferencing via "plain old telephone system" (POTS) lines. The paper summarizes a protocol for mobility assessment using TeleRehab, and describes a project to assess the efficacy of the video conferencing method. This paper was presented at the 2001 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

2000

Burns, R., Hauber, R., & Vesmarovich, S. (2000). **Telerehabilitation: Continuing cases and new applications.** In J. Winters (Ed.), *Proceedings of the RESNA 2000 Annual Conference: Technology for the New Millennium* (pp. 258-260). Arlington, VA: RESNA Press.

NARIC Accession Number: O13674

ABSTRACT: Paper using three case studies to describe processes for designing, installing, and delivering assistive technology services via telerehabilitation. The case studies include training in two computer access systems (EZ Keys and speech recognition), and remote evaluation for home modification. This paper was presented at the 2000 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

Cirwithen, S., Cole, E., Gustafson, C., Wu, Y., Yonker, V., & Ziegmann, M. (2000). **Use of "therapist-friendly" tools in cognitive assistive technology and telerehabilitation.** In J. Winters (Ed.), *Proceedings of the RESNA 2000 Annual Conference: Technology for the New Millennium* (pp. 31-33). Arlington, VA: RESNA Press.

NARIC Accession Number: O13609

ABSTRACT: Paper describing computer-based telerehabilitation services for a male age 41 with traumatic brain injury, in which therapists working at a distance were able to customize assistive software and conduct other interventions to support the client in activities of daily living. Results are described in the areas of conveying information to physicians, scheduling rides from transportation services, and communicating with friends. This paper was presented at the 2000 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

Lauderdale, D.E., & Winters, J.M. (2000). **Evaluation of nine IP teleconferencing products.** In J. Winters (Ed.), *Proceedings of the RESNA 2000 Annual Conference: Technology for the New Millennium* (pp. 113-115). Arlington, VA: RESNA Press.

NARIC Accession Number: O13632

ABSTRACT: Paper analyzing nine Internet Protocol software systems marketed for teleconferencing over the Internet, with a focus on their possible application to telerehabilitation. Features discussed include: compliance with International Telecommunications Union

standards (H.323 v.2); interoperability; applications collaboration; and multipoint capability. This paper was presented at the 2000 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

O'Brien, A.J., & Winters, J.M. (2000). **Intelligent systems: Terminology, tools, and applications for rehabilitation/telerehabilitation.** In J. Winters (Ed.), *Proceedings of the RESNA 2000 Annual Conference: Technology for the New Millennium* (pp. 307-309). Arlington, VA: RESNA Press.

NARIC Accession Number: O13690

ABSTRACT: Paper on intelligent systems terminology and software, and its application to rehabilitation and telerehabilitation. Terms defined include intelligent systems, expert systems, fuzzy systems, neural networks, and neurofuzzy systems. URLs for intelligent systems tools are listed. A neurofuzzy expert system application for muscle force estimation is described. This paper was presented at the 2000 annual conference of RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America.

1999

Hauber, R.P., Jones, M.L., Phillips, V.L., Temkin, A.J., & Vesmarovich, S. (1999). **Extending the continuum of care after spinal cord injury through telerehabilitation.** *Topics in Spinal Cord Injury Rehabilitation*, 5(3), 11-20.

NARIC Accession Number: J38440

Abstract: Article describing Shepherd Center's development of telerehabilitation as a means of providing support and continued rehabilitation to patients and families after discharge. Topics include: uses of telerehabilitation; lessons learned in the Shepherd center program; unresolved issues; and future plans.

Hopper, A., & Peifer, J. (1999). **A review of current and future technology for telerehabilitation.** *Topics in Spinal Cord Injury Rehabilitation*, 5(3), 1-10.

NARIC Accession Number: J38439

ABSTRACT: Article reviewing telecommunications technologies used to support independent living and rehabilitation services. Topics include: videoconferencing; digital communication technology; bandwidth; connection types; network versus point-to-point communication; the Next Generation Internet initiative; remote monitoring; and information appliances.

Kinsella, A. (1999). **Disabled populations and telerehabilitation: New approaches.** *Caring*, 18(8), 20-27.

NARIC Accession Number: J37584

ABSTRACT: Article on telerehabilitation, the delivery of rehabilitation services to persons with disabilities via telecommunications (such as telephones, television set-top boxes, or home computers). Describes the work of the Rehabilitation Engineering Research Center on Telerehabilitation, including projects to provide telerehab assistance to caregivers of older adults with stroke, and teletherapy to children with severe disabilities.

Puskin, D.S., & Urka, M.A. (1999). **A policy maker's glimpse of the road ahead: Telerehabilitation in the 21st century.** *Topics in Spinal Cord Injury Rehabilitation*, 5(3), 70-74.

NARIC Accession Number: J38444

ABSTRACT: Article about the future of home-based telerehabilitation, especially in underserved rural areas. One of the authors is director the Office for Telehealth in the U.S. Department of Health and Human Services (HHS), and the other is an HHS consultant.

Rosen, Michael. (1999). **Telerehabilitation.** *NeuroRehabilitation*, 12(1), 11-26.

NARIC Accession Number: J51009

ABSTRACT: Article provides an overview and examples of telerehabilitation and tele-enhancement of independent living for individuals with neurological and other disabilities. Telerehabilitation is defined as the delivery of medical rehabilitation services at a distance using electronic information and communication technologies. The modes of, rational for, and reimbursement and cost effectiveness of telerehabilitation practice are discussed.

Rosen, M.J., & Trepagnier, C. (1999). **Research and development in telerehabilitation.** In C. Buhler & H. Knops (Eds.), *AAATE 1999 conference proceedings: Assistive Technology on the Threshold of the New Millennium* (pp. 102-105). Amsterdam: IOS Press.

NARIC Accession Number: O13473

ABSTRACT: Paper providing an overview of the research and development projects of the Rehabilitation Engineering Research Center on Telerehabilitation, including projects on telerehabilitation in the home, vocational telerehabilitation, tele-assessment of skin health,

behavioral and mental health telehealth, use of virtual reality to assess gaze attention in persons with autism and right hemisphere stroke, teleplay for children with motor disabilities, and integrating telerehabilitation into the health care marketplace. This paper was a contribution to the 5th biennial European Conference for the Advancement of Assistive Technology in Europe (the 1999 conference of the Association for the Advancement of Assistive Technology in Europe [AAATE]). The modes of, rational for, and reimbursement and cost effectiveness of telerehabilitation practice are discussed.

Rosen, M.J., & Trepagnier, C. (1999). **Research and development in telerehabilitation.** In C. Buhler & H. Knops (Eds.), *AAATE 1999 conference proceedings: Assistive Technology on the Threshold of the New Millennium* (pp. 102-105). Amsterdam: IOS Press.

NARIC Accession Number: O13473

ABSTRACT: Paper providing an overview of the research and development projects of the Rehabilitation Engineering Research Center on Telerehabilitation, including projects on telerehabilitation in the home, vocational telerehabilitation, tele-assessment of skin health, behavioral and mental health telehealth, use of virtual reality to assess gaze attention in persons with autism and right hemisphere stroke, teleplay for children with motor disabilities, and integrating telerehabilitation into the health care marketplace. This paper was a contribution to the 5th biennial European Conference for the Advancement of Assistive Technology in Europe (the 1999 conference of the Association for the Advancement of Assistive Technology in Europe [AAATE]).

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Documents from the Cochrane Database of Systematic Reviews search at www.thecochranelibrary.org are listed below:

2008

Bernabeu, M., Giacomozzi, C., Hermens, H.J., Huijgen, B.C., Ilsbroukx, S., Magni, R., Marcellari, V., Marchese, S.S., Opisso, E., Van Nieuwenhoven, J., Vollenbroek-Hutten, M.M., & Zampolini, M. (2008). **Feasibility of a home-based telerehabilitation system compared to usual care: Arm/hand function in patients with stroke, traumatic brain injury and multiple sclerosis.** *Journal of Telemedicine and Telecare*, 14(5).

ID: CN-00643802

ABSTRACT: We conducted a randomized controlled multi-center trial to investigate the feasibility of a telerehabilitation intervention for arm/hand function (the Home Care Activity Desk [HCAD] training) in a home setting. Usual care was compared to HCAD training. The hypothesis was that the clinical outcomes of the HCAD intervention would be at least the same as those measured after a period of usual care for patients with stroke, traumatic brain injury (TBI) and multiple sclerosis (MS) with respect to their arm/hand function. Eighty-one patients with affected arm/hand function resulting from either stroke, MS or TBI were recruited in Italy, Spain and Belgium; eleven were lost during follow-up (14 percent). The outcome measures were the Action Research Arm Test (ARAT) and the Nine Hole Peg Test (NHPT). There were no significant differences between the two groups on the outcome measures (ARAT and NHPT); in both groups, patients maintained or even improved their arm/hand function. The HCAD training was found to be as feasible as usual care in terms of clinical outcomes, and both therapists and patients were satisfied with the HCAD intervention. A telerehabilitation intervention using HCAD may increase the efficiency of care.

Giacomozzi, C., Hermens, H., Huijgen, B., Ilsbroukx, S., Macellari, V., Prats, E., Rogante, M., Schifini, M.F., Spitali, M.C., Tases, S., Vollenbroek-Hutten, M., & Zampolini, M. (2008). **Clinical assessment of the HELLODOC tele-rehabilitation service.** *Annali dell'Istituto Superiore di Sanità*, 44(2), 154-63.

ID: CN-00650047

ABSTRACT: Within the EU project HELLODOC, the clinical effectiveness was investigated of the home care activity desk (H-CAD). Eighty-one patients with chronic stroke, traumatic brain injury and multiple sclerosis were recruited; 50 out of 81 received one month of H-CAD intervention, with one training session a day lasting 30 minutes for five days a week. The overall satisfaction of both patients and therapists was high. The Action Research Arm and the Nine Hole Peg Test were used as main outcome measures. They proved the H-CAD system to be at least as effective as usual care. Maybe due to limited length and intensity of treatment, during the training month subjects improved on the individual H-CAD exercises but, as in the usual care group, the arm/hand function remained at the same level.

Hoffmann, T., Nelson, M., Russell, T., Thompson, L., & Vincent, A. (2008). **Using the Internet to assess activities of daily living and hand function in people with Parkinson's disease.** *NeuroRehabilitation*, 23(3), 253-61.

ID: CN-00649111

ABSTRACT: The ability to measure activities of daily living (ADL) and hand function for people with Parkinson's disease via an Internet-based telerehabilitation system would have a significant impact on the equity, accessibility, and management of the condition for patients who live in rural and remote communities. A low-bandwidth computer-based telerehabilitation system, which incorporates videoconferencing with calibrated assessment tools, has been recently developed at the University of Queensland. This study aimed to determine the validity, intra- and inter-rater reliability of the telerehabilitation system in measuring ADL and hand function in twelve people with Parkinson's disease. ADL status was assessed using the motor component of the Functional Independence Measure and selected items from the Unified Parkinson's Disease Rating Scale. The Nine Hole Peg Test, Jamar dynamometer and Preston pinch gauge were also used to assess hand function. For half of the participants, an assessor administered assessments in the traditional face-to-face manner while another assessor simultaneously scored the same assessments via the telerehabilitation system. For the remaining participants, the telerehabilitation assessor administered the assessments via the telerehabilitation system while a face-to-face assessor simultaneously scored the assessments. The telerehabilitation system was found to be a

valid measure of ADL status and hand function in people with Parkinson's disease and to have a high level of intra- and inter-rater reliability (all ICCs > 0.80). These results suggest that therapists can confidently use a low-bandwidth telerehabilitation system to assess ADL status and hand function in people with Parkinson's disease.

2007

Anderson, K.M., Bhatt, E., Carey, J.R., Durfee, W.K., Lewis, S.M., Nagpal, A., & Weinstein, S.A. (2007). **Comparison of finger tracking versus simple movement training via telerehabilitation to alter hand function and cortical reorganization after stroke.** *Neurorehabilitation and Neural Repair*, 21(3), 216-32.

ID: CN-00587219

ABSTRACT: OBJECTIVE: To compare two telerehabilitation training strategies, repetitive tracking movements versus repetitive simple movements, to promote brain reorganization and recovery of hand function. **METHODS:** Twenty subjects with chronic stroke and ten degrees of voluntary finger extension were randomly assigned to receive 1800 telerehabilitation trials over two weeks of either computerized tracking training (track group) with the affected finger and wrist involving temporospatial processing to achieve accuracy or movement training (move group) with no attention to accuracy. Following movement training, the move group crossed over to receive an additional two weeks of tracking training. Behavioral changes were measured with the Box and Block test, Jebsen Taylor test, and finger range of motion, along with a finger-tracking activation paradigm during fMRI. **RESULTS:** The track group showed significant improvement in all four behavioral tests; the move group improved in the Box and Block and Jebsen Taylor tests. The improvement for the track group in the Box and Block and Jebsen Taylor tests did not surpass that for the move group. A consistent group pattern of brain reorganization was not evident. The move group, after crossing over, did not show further significant improvements. **CONCLUSION:** Telerehabilitation may be effective in improving performance in subjects with chronic stroke. Tracking training with reinforcement to enhance learning, however, did not produce a clear advantage over the same amount of practice of random movements. Two weeks of train-

ing may be insufficient to demonstrate a behavioral advantage and associated brain reorganization.

2006

Butterfield, T., Griffiths, P.C., Hargraves, K., Hoenig, H., Richardson, P., & Sanford, J.A. (2006). **The effects of in-home rehabilitation on task self-efficacy in mobility-impaired adults: A randomized clinical trial.** *Journal of the American Geriatrics Society*, 54(11), 1641-8.

ID: CN-00573467

ABSTRACT: OBJECTIVES: To examine the effect on mobility self-efficacy of a multifactorial, individualized, occupational/physical therapy (OT/PT) intervention delivered via teletechnology or in-home visits. **DESIGN:** Randomized, clinical trial. **SETTING:** One Department of Veterans Affairs and one private rehabilitation hospital. **PARTICIPANTS:** Sixty-five community-dwelling adults with new mobility devices. Thirty-three were randomized to the control or usual care group (UCG), thirty-two to the intervention group (IG). **INTERVENTION:** Four, once-weekly, one-hour OT/PT sessions targeting three mobility and three transfer tasks. A therapist delivered the intervention in the traditional home setting (trad group n = 16) or remotely via teletechnology (tele group n = 16). **MEASUREMENTS:** Ten-item Likert-scale measure of mobility self-efficacy. **RESULTS:** The IG had a statistically significantly greater increase in overall self-efficacy over the study period than the UCG (mean change: IG 8.8, 95 percent confidence interval (CI) = 3.8-13.7; UCG 1.2, 95 percent CI = -5.8-8.2). Descriptively, the IG exhibited positive changes in self-efficacy for all tasks and greater positive change than the UCG on all items with the exception of getting in and out of a chair. Comparisons of the two treatment delivery methods showed a medium standardized effect size (SES) in both the tele and trad groups, although it did not reach statistical significance for the tele group (SES: tele = 0.35, 95 percent CI = -2.5-0.95; trad = 0.54, 95 percent CI = 0.06-1.14). **CONCLUSION:** A multifactorial, individualized, home-based OT/PT intervention can improve self-efficacy in mobility-impaired adults. The trend toward increased self-efficacy irrespective of the mode of rehabilitation delivery suggests that telerehabilitation can be a viable alternative to or can augment traditional in-home therapy.

Cahill, L.M., Clark, K.M., Hill, A.J., Russell, T.G., Theodoros, D.G., & Ward, E.C. (2006). **An Internet-based telerehabilitation system for the assessment of motor speech disorders: A pilot study.** *American Journal of Speech-Language Pathology*, 15(1), 45-56.

ID: CN-00644842

ABSTRACT: *No abstract is available*

2004

Barker, L.M., Baron, C.R., Brennan, D.M., & Georgeadis, A.C. (2004). **The effect of videoconference-based telerehabilitation on story retelling performance by brain-injured subjects and its implications for remote speech-language therapy.** *Telemedicine Journal and e-Health*, 10(2), 147-154.

ID: CN-00602823

ABSTRACT: *No abstract is available*

Barker, L.M., Baron, C.R., Brennan, D.M., & Georgeadis, A.C. (2004). **Telerehabilitation and its effect on story retelling by adults with neurogenic communication disorders.** *Aphasiology*, 18(5-7), 639-652.

ID: CN-00551115

ABSTRACT: *No abstract is available*

2003

Buttrum, P., Jull, G.A., Russell, T.G., & Wootton, R. (2003). **Low-bandwidth telerehabilitation for patients who have undergone total knee replacement: Preliminary results.** *Journal of Telemedicine and Telecare*, 9(Suppl 2), S44-7.

ID: CN-00472625

ABSTRACT: We have developed a low-bandwidth, Internet-based telerehabilitation system to provide outpatient rehabilitation to patients who have undergone total knee arthroplasty. The preliminary efficacy of this treatment program in terms of both physical and functional objective outcome measures was assessed on twenty-one patients. Subjects receiving a six-week rehabilitation program were randomized to the telerehabilitation system or the usual face-to-face method. The physical and functional improvements in

the telerehabilitation group were similar to those in the control group. There was a non-significant trend for greater improvements in the telerehabilitation group for most outcome measurements. The telerehabilitation program was well received by patients. The results of this study provide evidence for the efficacy of low-bandwidth telerehabilitation consultations.

Egner, A., Phillips, V.L., Vora, R., & Wiggers, E. (2003). **Depression, fatigue, and health-related quality of life among people with advanced multiple sclerosis: Results from an exploratory telerehabilitation study.** *NeuroRehabilitation*, 18(2), 125-33.

ID: CN-00439390

ABSTRACT: This study reports on secondary data, depression, fatigue and health-related quality of life (HRQOL), collected on people with advanced multiple sclerosis (MS) as part of a larger study of the impact of a telerehabilitation intervention on people with severe mobility impairment. People with spinal cord injuries (SCIs) (n=111) and the prevention of pressure sores were the primary group of interest of the project. The focus here is on data collected from people with advanced MS (n=27), who were included as an exploratory cohort, as they experience increased risk of pressure ulcer development as their level of mobility declines. The study consisted of a nine-week intervention with three randomized groups: video, telephone, and standard care. Aside from information on pressure sores, data were also collected on fatigue, depression, and HRQOL for a two-year follow-up period. For the video group HRQOL scores trended higher and fatigue and depression scores lower for 24 months. Fatigue scores were significantly lower for the video group at month six, 12, and 18. In the sample overall, fatigue symptoms were far more prominent than depressive symptoms and affected 100 percent higher rates of depression than women. At baseline, controlling for Extended Disability Status Score (EDSS), depression and fatigue were correlated. However, contrary to indications from previous cross-sectional studies, no consistent relationship was observed over time between the two. Telerehabilitation interventions for people with advanced MS warrant further investigation. Findings here suggest that such interventions may be beneficial, although the results need affirmation through larger samples. In addition, the higher prevalence of male depression merits serious attention.

Jull, G.A., Russell, T.G., & Wootton, R. (2003). **The diagnostic reliability of Internet-based observational kinematic gait analysis.** *Journal of Telemedicine and Telecare*, 9(Suppl 2), S48-51.

ID: CN-00472624

ABSTRACT: We investigated the accuracy and reliability of observational kinematic gait assessments performed via a low-bandwidth Internet link (18 kbit/s) and a higher-speed Internet link (128 kbit/s). Twenty-four subjects were randomized to either bandwidth group. Gait was assessed with the Gait Assessment Rating Scale (GARS) in the traditional manner, which is from video-recordings, and with repeated measurements via the online method. Online assessment was found to provide as accurate a measure of gait performance as the traditional assessment (limits of agreement < 1 GARS point; intraclass correlation coefficient, ICC = 0.96) regardless of the speed of the Internet connection. The online assessment also demonstrated high intra-rater (ICC = 0.96) and inter-rater (ICC = 0.92) reliability. Low-bandwidth telerehabilitation applications appear to be feasible via the Internet.

2002

Bizzi, E. (2002). **Telerehabilitation for motor re-training in stroke.** *CRISP (Computer Retrieval of Information on Scientific Projects) Database.* <http://crisp.cit.nih.gov>.

ID: CN-00407028

ABSTRACT: *No abstract is available*

Egner, A. & Phillips, V. (2002). **Tele-rehabilitation intervention increases rates of employment among spinal cord injured persons [abstract].** *The Challenge of Collaboration: Proceedings of the 18th Annual Meeting of the International Society of Technology Assessment in Health Care, 2002 Jun. 9-12.*

ID: CN-00476244

ABSTRACT: *No abstract is available*

Kulke, H., Peetz, H., Reulbach, U., Rohring, S., & Schupp, W. (2002). **Therapy of attentional deficits by telerehabilitation: Improvements and their stability.** *European Journal of Neurology*, 9(Suppl 2), 212.

ID: CN-00421559

ABSTRACT: *No abstract is available*



2006

Dana, T.L., Helfand, M., Hersh, W.R., Hickam, D.H., Krages, K.P., & Severance, S.M. (2006). **Telemedicine for the Medicare population: Update evidence report/technology.** *Rockville: Agency for Healthcare Research and Quality.*

Publication No. 06-E007

Available in full-text from AHRQ: www.ahrq.gov/downloads/pub/evidence/pdf/telemedup/telemedup.pdf

ABSTRACT: *No abstract is available*

2005

Deickman, A., Elfrink, V., & Schlachta-Fairchild, L. (2005). **Patient safety, telenursing, and telehealth.** In R. Hughes (Ed.), *Patient Safety and Quality: An Evidence-Based Handbook for Nurses: Vol. 3, Chapter 48.*

Available in full-text from AHRQ: www.ahrq.gov/qual/nursesbdbk/docs/SchlachtaL_PSTT.pdf

ABSTRACT: *No abstract is available*

 **Documents from the National Library of Medicine PubMed search at www.pubmed.com are listed below:**

2009

Bendixen, R.M., Kobb, R.F., Levy, C.E., Mann, W.C., & Olive, E.S. (2009). **Cost effectiveness of a telerehabilitation program to support chronically ill and disabled elders in their homes.** *Telemedicine Journal and e-Health*, 15(1):31-8.

PMID: 19199845

ABSTRACT: Chronic illnesses account for approximately 75 percent of all healthcare costs in the United States today, resulting in functional limitations and loss of independence, as well as increased medical expenditures. The elderly population is at a higher risk for developing chronic conditions, increasing their risk for disabilities. Given the rapid growth of the aging popula-

tion, and the chronic illnesses, disabilities, and loss of functional independence endemic to elders, novel methods of rehabilitation and care management are urgently needed. Telehealth models that combine care coordination with communications technology offer a means for managing chronic illnesses, thereby decreasing healthcare costs. We examined the effects of a Veterans Administration (VA) telerehabilitation program (Low Activities of Daily Living [ADL] Monitoring Program-LAMP) on healthcare costs. LAMP is based on a rehabilitative model of care. LAMP patients received adaptive equipment and environmental modifications, which focused on self-care and safety within the home. LAMP Care Coordinators remotely monitored their patient's vital signs and provided education and self-management strategies for decreasing the effects of chronic illnesses and functional decline. The matched comparison group (MCG) received standard VA care. Healthcare costs 12 months pre-enrollment and 12 months post-enrollment were examined through a difference-in-differences multivariable model. Using actual costs totaled for these analyses, no significant differences were detected in post-enrollment costs between LAMP and the MCG. For LAMP patients, the provision of adaptive equipment and environmental modifications, plus intensive in-home monitoring of patients, led to increases in clinic visits post-intervention with decreases in hospital and nursing home stays.

Giansanti, D., Maccioni, G., Silvestri, G., & Tiberi, Y. (2009). **Toward the integration of novel wearable step-counters in gait telerehabilitation after stroke.** *Telemedicine Journal and e-Health*, 15(1), 105-11.

PMID: 19199855

ABSTRACT: In the management of stroke, after the first critical care period at the hospital, it is important for the subjects to plan a neural and motion rehabilitation program at home. Telerehabilitation could represent a valid aid for subjects involved in a rehabilitation process at home. Motion and neural rehabilitation are strictly correlated. Prompt motion rehabilitation is essential to ensure good recovery performance from the stroke defect. Remote therapy, which involves a telerehabilitation program, should monitor daily motion activity. An optimal telerehabilitation program should be capable of monitoring patient activity starting from a high disability of imbalance, when there is the need for properly designed aids or prosthesis. The program

should continue when the patient improves his or her condition, and progressively changes or abandons aids or prosthesis. New home care for remote activity monitoring has been proposed. It includes a sensorized-codivilla-spring and a gastrocnemius expansion measurement unit to allow activity monitoring in terms of step-counting for the continuity of care at home. This home care has been integrated in a telerehabilitation process. Preliminary clinical trials have shown the effectiveness and the high degree of client satisfaction (patient and therapist). The next phase will be the integration with other units to allow the monitoring of other physiological parameters (blood pressure, heart rate, blood glucose) useful to investigate in stroke telerehabilitation.

2008

Barker, L.M., & Brennan, D.M. (2008). **Human factors in the development and implementation of telerehabilitation systems.** *Journal of Telemedicine and Telecare*, 14(2), 55-8.

PMID: 18348747

ABSTRACT: Telemedicine services must be designed and implemented with the users in mind.

When conducting telerehabilitation, factors such as age, education and technology experience must be taken into account. In addition, telerehabilitation must also accommodate a range of potential patient impairments, including deficits in language, cognition, motor function, vision and voice. Telerehabilitation technology and treatment environments should adhere to universal design standards so as to be accessible, efficient, usable and understandable to all. This will result in improved access to a wider range of telerehabilitation services that will facilitate and enhance the rehabilitative treatment and recovery of people living with varying levels of injury, impairment and disability.

Bendixen, R.M., Chronister, K., Horn, K.R., Levy, C., Lutz, B.J., & Mann, W.C. (2008). **A telerehabilitation model for victims of polytrauma.** *Rehabilitation Nursing*, 33(5),215-20.

PMID: 18767403

ABSTRACT: The Low Activities of Daily Living Monitoring Program (LAMP) at the North Florida/South Georgia Veterans Health System is a telerehabilitation program that promotes independence for veterans experiencing difficulties with activities of

daily living by focusing on a combination of care coordination, assistive technology/adaptive equipment, and home environmental modifications. Initially designed to serve elders at risk of institutionalization, LAMP now is being adapted to the needs of veterans living with the effects of multisystem polytrauma. This article provides an overview of telehealth, explains the LAMP model, and presents a case history of a veteran who sustained complete tetraplegia and traumatic transfemoral amputation as the result of a blast injury and who lives successfully at home with the support of LAMP. A recent cost analysis of LAMP patients compared to a matched cohort receiving standard care also is presented. The LAMP model shows promise as a method for home-based management of combat-wounded veterans who experience multisystem polytrauma.

Brienza, D., Parmanto, B., Saptano, A., Schein, R.M., & Schmeler, M.R. (2008). **Development of a service delivery protocol used for remote wheelchair consultation via telerehabilitation.** *Telemedicine Journal and e-Health*, 14(9), 932-8.

PMID: 19035803

ABSTRACT: The purpose of this paper is to explain the development, methodology, and implementation of an assistive technology service delivery protocol using a telerehabilitation consultation model for evaluation of remote wheelchair prescriptions. The provision of wheeled mobility and seating interventions can be complex when considering people with intricate seating and positioning needs, environmental factors, and wide array of product interventions. The availability of qualified practitioners with specialty expertise in this area is limited, especially outside of urban areas. Therefore, people are potentially isolated from rehabilitation services due to geography or physical limitations. A repeated measure study design is used to evaluate the service delivery protocol measured by the effectiveness of wheeled mobility and seating interventions provided in a remote location by a generalist occupational and/or physical therapy practitioner with consultation from an expert therapist via interactive teleconferencing. Effectiveness is measured by magnitude of change and scored by pre and post scores of the Functioning Everyday with a Wheelchair outcome measure tool. Two model programs have been specified and are currently implementing the service delivery protocol. The live interaction has enabled remote therapists the ability to exchange personal and health information to experts in the field from an urban facility. The impact of this ser-

vice delivery protocol will be augmented as it is to be launched and replicated in three additional sites. Telerehabilitation is a new field that can only be measured by its long-term impact; however, its success can be looked at by its development and implementation into everyday clinical service delivery.

China, S., Dallolio, L., Fantini, M.P., Menarini, M., Rucci, P., Soopramanien, A., Stainthorpe, A., & Ventura, M. (2008). **Functional and clinical outcomes of telemedicine in patients with spinal cord injury.** *Archives of Physical Medicine and Rehabilitation*, 89(12), 2332-41.

PMID: 19061746

ABSTRACT: OBJECTIVE: To compare the 6-month outcomes of telerehabilitation intervention with those of standard care for spinal cord injury (SCI). **DESIGN:** Multicenter randomized controlled trial. **SETTING:** Home, nursing, or unspecialized hospital care provided after discharge from a spinal cord unit. **PARTICIPANTS:** Adult patients with nonprogressive, complete, or incomplete SCI discharged for the first time from the spinal cord unit to their homes (Belgium and Italy) or to their homes or another facility (England). **INTERVENTIONS:** All patients received the standard care they would have normally received after discharge from the spinal cord unit. In addition, patients in the telemedicine group received eight telemedicine weekly sessions in the first two months, followed by biweekly telemedicine sessions for four months. **MAIN OUTCOME MEASURES:** Functional status at six months, clinical complications during the postdischarge period, and patient satisfaction. **RESULTS:** No significant differences in the occurrence of clinical complications were found between the study groups. A higher improvement of functional scores in the telemedicine group was found only at the Italian site: FIM total score 3.38+/-4.43 (controls) versus 7.69+/-6.88 (telemedicine group), FIM motor score 3.24+/-4.38 (controls) versus 7.55+/-7.00 (telemedicine group; P<.05). Items contributing to this difference were grooming, dressing upper body, dressing lower body, and bed/chair/wheelchair transfer. Higher satisfaction with care was reported by patients in the telemedicine group across all sites. **CONCLUSIONS:** Our study provides some of the first quantitative evidence, based on results from 1 site, that telerehabilitation may offer benefits to patients discharged from a spinal cord unit compared with standard care in terms of functional improvement. Further research is warranted to confirm or disprove this finding.

Giansanti, D., Maccioni, G., & Macellari, V. (2008). **Telemonitoring and telerehabilitation of patients with Parkinson's disease: Health technology assessment of a novel wearable step counter.** *Telemedicine Journal and e-Health*, 14(1), 76-83. PMID: 18328028

ABSTRACT: Step counting is an important index of motion in telemonitoring. One of the most diffused wearable systems, designed for this purpose, is the pedometer. The accuracy of commercial pedometers has been reported in the literature. Several limits have been found in many commercial systems both in healthy subjects and in people with disabilities. Furthermore, commercial pedometers lack interoperability. This paper introduces a new wearable system for step counting for telemonitoring applications. This system is based on a wearable device with a force-sensing resistor. It is affixed on the gastrocnemius muscle for monitoring muscular expansion correlated with the gait. The data exchange is assured by the XTR-434H (Aurel, FC, Italy) telemetric system. The proposed gastrocnemius expansion measurement unit (GEMU) was tested on five subjects with Parkinsons disease at Level 3 of the Tinetti test of unbalance. Ten repetitions of 500 steps with three different speeds (fast, slow, and normal) were performed. The mean error was <0.5 percent. Results also showed that GEMU performed better than an accelerometer unit (considered in the literature the best solution for this disability). The study showed that GEMU had a high performance in subjects with Parkinsons disease, causing a high degree of unbalance that confounded motion style. The next phase will be the optimization of GEMU for long-term medical applications at the patients' home.

Hill, A.J., Russell, T., Theodoros, D., & Ward, E. (2008). **Using telerehabilitation to assess apraxia of speech in adults.** *International Journal of Language and Communication Disorders*, 30, 1-17. [Epub ahead of print].

PMID: 18821157

ABSTRACT: Background: Telerehabilitation is the remote delivery of rehabilitation services via information technology and telecommunication systems. There have been a number of studies that have used videoconferencing to assess speech and language skills in people with acquired neurogenic communication disorders. However, few studies have focused on cases of apraxia of speech. In order to perform accurately differential diagnosis via the telerehabilitation medium,

it is important that validation of the assessment of apraxia of speech be established as part of the overall evidence base for telerehabilitation communication assessment protocols. Aims: To determine if valid and reliable assessment of apraxia of speech using a standardized assessment tool was feasible via telerehabilitation. Methods & Procedures: Eleven participants with an acquired apraxia of speech were assessed simultaneously via telerehabilitation and face-to-face methods on the Apraxia Battery for Adults - 2 (ABA-2). A custom-built telerehabilitation system developed at the University of Queensland enabled real-time telerehabilitation assessment over a 128 kbit/s internet connection. Data analysis included tests of significant difference between raw scores using the Wilcoxon signed rank statistic and analysis of the degree of agreement between the two methods using weighted Kappa statistics. Inter- and intra-rater reliabilities were also examined for the telerehabilitation-led assessments. Outcomes & Results: Results revealed no significant differences between the subtest scores of the ABA-2 obtained in the telerehabilitation and face-to-face test environments ($p = 0.06-0.68$). Weighted Kappa statistics indicated moderate to very good agreement (0.59-1.00) between the two environments for the subtests of the ABA-2. The reliability study was hampered by small sample size; however, the data were suggestive of reasonable reliability. Participants reported high overall satisfaction, comfort level, and audio and visual quality in the telerehabilitation environment. The speech-language pathologists (SLP) reported some difficulties assessing participants with severe apraxia of speech via the telerehabilitation system. Conclusions & Implications: This study suggests that valid assessment of apraxia of speech using the ABA-2 over the internet is feasible. The reliability study on the telerehabilitation assessments was encouraging with results suggesting that telerehabilitation assessment using the ABA-2 could be reliable. Findings from the participant satisfaction questionnaire were favourable. However, comments from the SLP suggested that participants exhibiting severe apraxia of speech might be better suited to face-to-face assessment. These findings may have implications for the development of evidence-based guidelines for the use of telerehabilitation in the assessment of apraxia of speech. The authors propose that future research should include larger sample sizes with a range of participant severity levels and be conducted over higher bandwidth connections to explore further the validity and reliability of telerehabilitation assessment of apraxia of speech.

Kairy, D., Lehoux, P., Vincent, C., & Visintin, M. (2008). **A systematic review of clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation.** *Disability and Rehabilitation*, 7, 1-21.

PMID: 18720118

ABSTRACT: Purpose. To identify clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation for individuals with physical disabilities. Method: Relevant databases were searched for articles on telerehabilitation published until February 2007. Reference lists were examined and key journals were hand searched. Studies that included telerehabilitation for individuals with physical impairments and used experimental or observational study designs were included in the analysis, regardless of the specific clientele or location of services. Data was extracted using a form to record methodological aspects and results relating to clinical, process, healthcare utilization and cost outcomes. Study quality of randomized clinical trials was assessed using the PEDro rating scale. Results: Some 28 articles were analyzed. These dealt with rehabilitation of individuals in the community, neurological rehabilitation, and cardiac rehabilitation, follow-up of individuals with spinal cord injuries, rehabilitation for speech-language impairments, and rehabilitation for varied clienteles. Clinical outcomes were generally improved following a telerehabilitation intervention and were at least similar to or better than an alternative intervention. Clinical process outcomes, such as attendance and compliance, were high with telerehabilitation although few comparisons are made to alternative interventions. Consultation time tended to be longer with telerehabilitation. Satisfaction with telerehabilitation was consistently high, although it was higher for patients than therapists. Few studies examined healthcare utilization measures and those that did reported mixed findings with respect to adverse events, use of emergency rooms and doctor visits. Only five of the studies examined costs. There is some preliminary evidence of potential cost savings for the healthcare facility. Conclusions: While evidence is mounting concerning the efficacy and effectiveness of telerehabilitation, high-quality evidence regarding impact on resource allocation and costs is still needed to support clinical and policy decision-making.

Park, H.S., Peng, Q., & Zhang, L.Q. (2008). **A portable telerehabilitation system for remote evalua-**

tions of impaired elbows in neurological disorders. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 16(3), 245-54.

PMID: 18586603

ABSTRACT: A portable teleassessment system was designed for remote evaluation of elbow impairments in patients with neurological disorders. A master device and a slave device were used to drive a mannequin arm and the patient's arm, respectively. The elbow flexion angle and torque were measured at both the master and slave devices, and sent to each other for teleoperation. To evaluate spasticity/contracture of the patient's elbow remotely, the clinician asked the patient to relax the elbow, moved the mannequin arm at a selected velocity, and haptically felt the resistance from the patient's elbow. In other tasks, the patient moved his/her elbow voluntarily and the clinician observed the corresponding mannequin arm movement and determined the active range of motion (ROM). The clinician could also remotely resist the patient's movement and evaluate the muscle strength. To minimize the effect of network latency, two different teleoperation schemes were used depending on the speed of the tasks. For slow movement tasks, real-time teleoperations were performed using control architectures that considered causality of the tasks, with performance similar to that during an in-person examination. For tasks involving fast movements, a teach-and-replay teleoperation scheme was used which provided the examiner with transparent and stable haptic feeling. Overall, the teleassessment system allowed the clinician to remotely evaluate the impaired elbow of stroke survivors, including assessment of the passive ROM, active ROM, muscle strength, velocity-dependent spasticity, and catch angle.

Russell, T., & Theodoros, D. (2008). **Telerehabilitation: Current perspectives.** *Studies in Health Technology and Informatics*, 131, 191-209. PMID: 18431862

ABSTRACT: Telerehabilitation in which rehabilitation services are provided at a distance using communication technologies is a new and developing field of telehealth. Primarily developed to provide equitable access to individuals who are geographically remote and to those who are physically and economically disadvantaged, telerehabilitation also has the capacity to improve the quality of rehabilitation health care. Online delivery of rehabilitation enables the rehabilitation thera-

pist to optimize the timing, intensity and duration of therapy that is often not possible within the constraints of face-to-face treatment protocols in current health systems. This chapter outlines the advances made to date in telerehabilitation applications in the fields of physiotherapy, speech-language pathology, occupational therapy, and biomedical engineering and provides evidence for the success of these applications. Applications to date encompass systems ranging from low-bandwidth low-cost videophones, to highly expensive, fully immersive virtual reality systems with haptic interfaces. A number of barriers to the establishment and advancement of telerehabilitation within health care systems have been outlined and include professional issues relating to the inherent hands-on approach of some treatments, licensure laws, professional skill development, patient disability, reimbursement, and the paucity of online assessment and treatment tools and outcomes data. In response, possible solutions to these barriers such as the development and validation of alternative assessment and treatment procedures, involvement in the international policy debate, as well as the resolution of national professional policies which hinder the wider uptake of telerehabilitation technologies, have been outlined. The future of telerehabilitation is promising as a new, yet complex form of telehealth with the capacity to provide a wide range of services specifically designed to suit the needs of the individual.

Theodoros, D.G. (2008). **Telerehabilitation for service delivery in speech-language pathology.** *Journal of Telemedicine and Telecare*, 14(5), 221-4.
PMID: 18632993

ABSTRACT: Communication disorders in adults and children can have a significant effect on their quality of life and on that of their families. Speech-language pathologists face several challenges in providing assessment and treatment services to such people. Challenges include facilitating equitable access to services and providing appropriate management within a changing social and economic context. Telerehabilitation has the potential to deliver services in the home or local community via videoconferencing and through interactive computer-based therapy activities. This form of service delivery has the capacity to optimize functional outcomes by facilitating generalization of treatment effects within the person's everyday environment, and enable monitoring of communication and swallowing

behaviors on a long-term basis. A number of image-based telerehabilitation applications have been used in the management of adult neurogenic speech and language disorders, stuttering, voice disorders, speech and language disorders in children, laryngectomy and swallowing dysfunction. Further development of such applications and other computer-based therapies, cost-benefit and cost-effectiveness analyses, and professional education are needed if telerehabilitation is to become an integral part of speech-language pathology practice.

2007

Burdea, G., Deutsch, J.E., & Lewis, J.A. (2007). **Technical and patient performance using a virtual reality-integrated telerehabilitation system: Preliminary finding.** *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 15(1), 30-5.
PMID: 17436873

ABSTRACT: Telerehabilitation is the provision of rehabilitation services at a distance by a therapist at a remote location. Integration with virtual reality (VR) is a relatively new addition to this field. This paper describes the technical and patient performance of a telerehabilitation application the remote console (ReCon) that is integrated with a VR system. The VR system consists of the Rutgers Ankle prototype robot, a local PC which is connected with a remote PC connected over the Internet. Six individuals in the chronic phase post-stroke participated in a four week training program. They used the robot to interact with two VR simulations, while the therapist was in the same room during the first three weeks or in another room during the fourth week. Technical and patient performance was assessed in the transition from the third to the fourth week of training. Technical performance of the system was assessed based on bandwidth and lag of message transmission, which were found to be suitable for clinic-to-clinic communication. Patient performance (in terms of accuracy of ankle movement, exercise duration and training efficiency, mechanical power of the ankle and number of repetitions) did not decrease during telerehabilitation in the fourth week. These preliminary findings over a short telerehabilitation intervention support the feasibility of remote monitoring of VR-based telerehabilitation without adverse effects on patient performance.

Feng, X., Foil, J., Johnson, L.M., Wang, Y., & Winters, J.M. (2007). **Progress toward universal interface technologies for telerehabilitation.** *Conference proceedings: Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2004, 7, 4777-80.*

PMID: 17271378

ABSTRACT: One of the overriding needs in the field of telerehabilitation is for user-centered interfaces that provide individuals with differing abilities with access to effective remote communication. This paper provides a foundation for developing and evaluating interfaces that move towards the aim of universal accessibility, and reports on progress for four types of interfaces: multimedia conferencing technologies involving persons with different roles and disabilities participating in goal-directed tasks; physical devices for therapy and assessment; communication/control for computer-assisted teletherapy; and an intelligent telerehabilitation assistant that supports the dynamic rehabilitative process.

Jadhav, C., & Krovi, V. (2007). **A low-cost framework for individualized interactive telerehabilitation.** *Conference proceedings: Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2004, 5, 3297-300.*

PMID: 17270986

ABSTRACT: In this paper we examine the issues pertaining to development of a low-cost telerehabilitation framework for upper-limb dysfunction, that is suitable for deployment in patients' homes. We use the example of a Virtual Driving Environment to present the overall architecture and discuss issues of: (1) quantitative data-acquisition using commercial-off-the-shelf gaming devices; (2) model-based parametric data transmission/playback; and (3) parametric biomechanical identification and data reduction; to support individualization within the telerehabilitation regimen.

Russell, T.G. (2007). **Physical rehabilitation using telemedicine.** *Journal of Telemedicine and Telecare, 13(5), 217-20.*

PMID: 17697506

ABSTRACT: Telerehabilitation is the provision at a distance of rehabilitation services such as physiotherapy, speech pathology or occupational therapy. The primary aim is to provide equitable access to rehabilitation services. Broadly speaking, the technologies used for

telemedicine-based physical rehabilitation can be classified as: (1) image-based telerehabilitation; (2) sensor-based telerehabilitation; and (3) virtual environments and virtual reality telerehabilitation. To date, much of the research has been technology focused, and has consisted of single case or small sample research designs. The next step is to demonstrate viable telerehabilitation services in real world environments using well controlled research methodologies with large patient cohorts. In addition, the broader issues of cost-benefit and cost-effectiveness require investigation. If this can be done, then the undoubted potential benefits of telerehabilitation, for both the patient and health-care systems, can be realized.

2006

Galea, M., Garback, L.M., & Tumminia, J. (2006). **Telerehabilitation in spinal cord injury persons: A novel approach.** *Telemedicine Journal and e-Health, 12(2), 160-2.*

PMID: 16620171

ABSTRACT: The care of a spinal cord injury (SCI) person constitutes a great challenge for the provider: SCI persons are mobility impaired, and they are prone to develop multiple co-morbidities such as diabetes mellitus, hypertension, obesity, bladder infections, wounds, and depression. Furthermore, disease manifestations can be misleading depending on the level of injury. The utilization of telemedicine to monitor patients and deliver care has opened a new horizon for SCI persons. Several telehealth programs are now in use to monitor pressure ulcers and post-discharge rehabilitation in SCI persons. To answer the need for a more comprehensive approach to the multifaceted manifestation of SCI at the James J. Peters VAMC has started a customized telerehabilitation program. The program monitors the most common co-morbidities of SCI, it is instrumental in the reintegration of the SCI person in the community, it offers individualized in-home rehabilitation programs, it addresses safety issues, and it offers counseling, weight reduction, and maintenance plans. A team of SCI specialists-including an internist, a registered nurse, a physical therapist, a nutritionist, a psychologist, and a recreational therapist-are available for weekly meetings with the patients. The programs are tailored to the patients' needs and agreed upon by both parties. Both messaging devices and video monitors are utilized. An interdisciplinary template is used to record

assessments and plans. Preliminary results are encouraging; coordination of the team and relative poor technology are some of the obstacles we have identified. Further evaluation is necessary to determine cost effectiveness.

2005

Boian, R.F., Burdea, G., Deutsch, J.E., & Lewis, J.A. (2005). **Remote console for virtual telerehabilitation.** *Studies in Health Technology and Informatics*, 111, 294-300.

PMID: 15718748

ABSTRACT: The Remote Console (ReCon) telerehabilitation system provides a platform for therapists to guide rehabilitation sessions from a remote location. The ReCon system integrates real-time graphics, audio/video communication, private therapist chat, post-test data graphs, extendable patient and exercise performance monitoring, exercise pre-configuration and modification under a single application. These tools give therapists the ability to conduct training, monitoring/assessment, and therapeutic intervention remotely and in real-time.

Demiris, G., Schopp, L.H., & Shigaki, C.L. (2005). **An evaluation framework for a rural home-based telerehabilitation network.** *Journal of Medical Systems*, 29(6), 595-603.

PMID: 16235812

ABSTRACT: This study was a needs assessment to inform the design and evaluation of a home-based telerehabilitation network for rural elderly patients. We conducted a literature review of telerehabilitation studies and a needs-assessment by interviewing 43 professionals, including homecare nursing staff, members of volunteer organizations and service agencies, social workers, discharge planners, researchers, and rehabilitation therapists. The survey addressed perceived needs, advantages, and disadvantages with the use of telemedicine technologies for rehabilitation services. All respondents agreed that there are unmet needs among elderly people who are discharged from hospital settings, and identified several problems including: medication noncompliance, isolation, limited access to specialists and community-based services. Our findings defined a framework for the development of a client-oriented rural telehealth network that will be used to guide patients discharged to homecare following stroke,

through a complex array of health, mental health, and social services, spanning all levels of care.

Schmeler, M.R., Wakeford, L., White, M.W., & Wittman, P.P. (2005). **Telerehabilitation position paper.** *American Journal of Occupational Therapy*, 59(6), 656-60.

PMID: 16363187

ABSTRACT: Though the use of telerehabilitation technologies is expanding quickly as a viable method of service delivery for many practitioners within the field of health care, there remain issues of efficacy, cost, reimbursement, legal and ethical ramifications, and practitioner competence. There is a significant need for occupational therapy practitioners to document, research, and publish on the efficacy of consultation, intervention, and follow-up services provided using telerehabilitation technologies. Further investigation of the use of telehealth technologies in professional development and supervision is needed to clarify effectiveness and efficiency, as demand for services, particularly in rural areas, threatens to exceed services available. Occupational therapy practitioners using telerehabilitation methods must adhere to the AOTA Occupational Therapy Code of Ethics (AOTA, 2000), maintain the AOTA Standards of Practice (AOTA, 2005), and comply with state regulations, ensuring both their proficiencies as practitioners and the well being of their clients.

2004

Bouchard, S., Rizzo, A.A., Strickland, D. (2004). **The challenge of using virtual reality in telerehabilitation.** *Telemedicine Journal and e-Health*, 10(2), 184-95.

PMID: 15319048

ABSTRACT: Continuing advances in virtual reality (VR) technology along with concomitant system cost reductions have supported the development of more useful and accessible VR systems that can uniquely target a wide range of physical, psychological, and cognitive rehabilitation concerns and research questions. VR offers the potential to deliver systematic human testing, training, and treatment environments that allow for the precise control of complex dynamic three-dimensional stimulus presentations, within which sophisticated interaction, behavioral tracking, and performance recording is possible. The next step in this evolution will

allow for Internet accessibility to libraries of VR scenarios as a likely form of distribution and use. VR applications that are Internet deliverable could open up new possibilities for home-based therapy and rehabilitation. If executed thoughtfully, they could increase client involvement, enhance outcomes and reduce costs. However, before this vision can be achieved, a number of significant challenges will need to be addressed and solved. This article will first present three fictional case vignettes that illustrate the ways that VR telerehabilitation might be implemented with varying degrees of success in the future. We then describe a system that is currently being used to deliver virtual worlds over the Internet for training safety skills to children with learning disabilities. From these illustrative fictional and reality-based applications, we will then briefly discuss the technical, practical, and user-based challenges for implementing VR telerehabilitation, along with views regarding the future of this emerging clinical application.

Chan, W.M., Jui, E., Lai, J.C., & Woo, J. (2004). **Telerehabilitation: A new model for community-based stroke rehabilitation.** *Journal of Telemedicine and Telecare*, 10(4), 199-205. PMID: 15273029

ABSTRACT: Community resources for stroke clients are underdeveloped in Hong Kong and stroke survivors often face difficulties in community reintegration. We have examined the feasibility of using videoconferencing for community-based stroke rehabilitation. The sample comprised 21 stroke patients living at home. All the subjects participated in an eight-week intervention program at a community centre for seniors. The intervention—which comprised educational talks, exercise and psychosocial support—was conducted by a physiotherapist via a videoconference link. The Berg Balance Scale (BBS), State Self-Esteem Scale (SSES), Medical Outcomes Study 36-item Short Form (SF-36) and a stroke knowledge test were administered at the start and end of the program. In addition, at the start of the study the Geriatric Depression Scale 15-item Short Form, the Elderly Mobility Scale and the Lawton Instrumental Activities of Daily Living Scale were used to assess subjects' baseline status, and a focus group was also held at the end of the program to gather qualitative findings. Nineteen subjects completed the eight-week intervention. The baseline functional status was high, although 52 percent had symptoms of depression. After the in-

tervention, there were significant improvements in BBS, SSES and knowledge test scores and scores on all subscales of the SF-36. All the subjects accepted the use of videoconferencing for delivery of the intervention. The pilot study demonstrated the feasibility, efficacy and high level of acceptance of telerehabilitation for community-dwelling stroke clients.

Dhurjaty, S. (2004). **The economics of telerehabilitation.** *Telemedicine Journal and e-Health*, 10(2), 196-9. PMID: 15319049

ABSTRACT: An analysis of the economics of physical telerehabilitation, at home, in the clinic, and at work; this study was a precursor to generating a business case for manufacturing telerehabilitation systems. Pilot studies were performed and structured interviews conducted with providers, payers, patients, and employers. The data obtained were analyzed, in conjunction with published data, to understand the economics with respect to parameters such as lost opportunity costs at work, faster rehabilitation, and cost savings to patients, providers, payers, and employers. The results showed that telerehabilitation has a positive business case with respect to all the stakeholders. The ability to quantify and analyze data from patients remotely is convenient and economical to providers. Patients benefit by getting back to their normal activities faster, both at home as well as work. Telerehabilitation at work allows employees to be treated at work without having to take time to go to a clinic. Lost opportunity costs for employers are minimized when workers return to work faster and are treated onsite. The ability to measure progress quantitatively is beneficial for patients, providers, payers, and employers. Additionally, malingering can be detected and eradicated using telerehabilitation. Proper application of appropriate telerehabilitation technologies makes eminent economical sense. There is a strong business case for the application of telerehabilitation, onsite, in large corporations and therefore is profitable to medical device manufacturers.

Forducey, P.G., Glueckauf, R.L., & Kaur, K. (2004). **Prototype database for telerehabilitation.** *Telemedicine Journal and e-Health*, 10(2), 213-22. PMID: 15319051

ABSTRACT: Telerehabilitation is a promising alternative health-care delivery system, but currently lacks broad-based empirical support for the efficacy and cost

utility of its interventions. This article describes the development of a database at INTEGRIS Jim Thorpe Rehabilitation Center that will link the delivery of telerehabilitation services, reimbursement, and outcomes evaluation. The database is a culmination of the combined efforts of administrators, clinicians, and information technology professionals. Feasibility of the project was first established from technical, economic, and organizational perspectives. The current workflow and documentation processes were analyzed and enhanced. This was followed by data modeling and design of the database architecture in terms of network, security, scalability, and system specification. A prototype was created in Microsoft Access with the final product planned in Structured Query Language (SQL) with a front-end in JAVA JSP. The initial results with the database have been encouraging in terms of increased efficacy and security, process streamlining, error reduction, and collection of comprehensive standardized data for statistical analysis of clinical and research outcomes.

Frnka, J., Gaddis, W., Garber, S.L., Henson, H.K., Itani, K.M., Krouskop, T.A., Matamoros, R., Monga, T.N., Rintala, D.H., & Wright, J.V. (2004). **Telerehabilitation for veterans with a lower-limb amputation or ulcer: Technical acceptability of data.** *Journal of Rehabilitation Research and Development*, 41(3B), 481-90.

PMID: 15543466

ABSTRACT: A study was undertaken to determine the technical acceptability of information available via a customized telerehabilitation system regarding patients with lower-limb ulcers or recent lower-limb amputations receiving care at a Veterans Affairs Medical Center. Among the 54 participants, 57 wounds (39 ulcers, 19 amputation incisions) were evaluated by means of still photographs and skin temperature data sent via ordinary telephone lines. Three experienced clinicians served as raters. Intrarater agreements and McNemar chi(2) tests were assessed between decisions made after telerehabilitation sessions and decisions made by the same rater after in-person sessions. Interrater agreements and kappa coefficients were assessed between two raters for both telerehabilitation and in-person sessions. The intrarater agreement on 57 wounds for the primary rater was 93 percent, and the McNemar test indicated no significant difference in the ratings ($p < 0.63$). Interrater agreement on 18 wounds was 78 percent ($kappa = 0.55$, $p < 0.02$) for the telerehabilitation

sessions and 89% ($kappa = 0.77$, $p < 0.001$) for the in-person sessions. Most qualitative comments by three clinicians on picture quality (54/63 = 86 percent) and temperature data (39/44 = 88 percent) were favorable (good to excellent). The information yielded from this study provides evidence that the telerehabilitation system has the potential to present sufficient information to experienced clinicians so they can make informed decisions regarding wound management. The next phase of the study will include in-home trials and improvements in the technology.

Rosen, M.J. (2004). **Telerehabilitation.** *Telemedicine Journal and e-Health*, 10(2), 115-7.

PMID: 15319039

ABSTRACT: *No abstract is available.*

2003

Boian, R., Burdea, G., Deutsch, J., & Lewis, J. (2003). **Real-time web-based telerehabilitation monitoring.** *Studies in Health Technology and Informatics*, 94, 190-2.

PMID: 15455890

ABSTRACT: Distance monitoring of rehabilitation exercises has been primarily conducted using two-way video conferencing. This paper presents a real-time web-based monitoring system that greatly enhances the capability of the clinician to direct rehabilitation therapies.

Brown, G.D., Hales, J.W., Quetsch, J.L., & Schopp, L.H. (2003). **A rationale and training agenda for rehabilitation informatics: Roadmap for an emerging discipline.** *NeuroRehabilitation*, 18(2), 159-70.

PMID: 12867678

ABSTRACT: Decreased length of inpatient rehabilitation stay, greater long-term injury survival rates, broader access to information technologies, and the growing role of the Internet create potential for new models of rehabilitation that are more community- and person-centered rather than historically hospital- and provider-centered services. In recent years, information-based rehabilitation technologies have grown rapidly, expanding the possibilities for numerous interventions to promote independent living. These programs have centered primarily on providing rehabilitation health services over a distance ("telerehabilitation"). Telerehabilitation can be conceived as part of a broader approach that includes elements of direct rehabilitation services, service co-

ordination, community resources, and information relay between numerous individuals, service providers, and community members ("rehabilitation informatics"). Because of the complexity of these information types and sectors, this broader conceptual approach of rehabilitation informatics borrows heavily from fields such as adaptive computing, robotics, computer networking, and high-level systems programming. As such, innovation in rehabilitation informatics will require new models of training that span these domains. This paper proposes a rationale for the new field of rehabilitation informatics, and offers a multidisciplinary training model for the next generation of rehabilitation informaticians.

Burdea, G.C. (2003). **Virtual rehabilitation: Benefits and challenges.** *Methods of Information in Medicine*, 42(5), 519-23.

PMID: 14654886

ABSTRACT: **OBJECTIVES:** To discuss the advantages and disadvantages of rehabilitation applications of virtual reality. **METHODS:** Virtual rehabilitation (VR) can be used as an enhancement to conventional therapy for patients with conditions ranging from musculoskeletal problems, to stroke-induced paralysis, to cognitive deficits. This approach is called "VR-augmented rehabilitation." Alternately, VR can replace conventional interventions altogether, in which case the rehabilitation is "VR-based." If the intervention is done at a distance, then it is called "telerehabilitation." Simulation exercises for post-stroke patients have been developed using a "teacher object" approach or a video game approach. Simulations for musculo-skeletal patients use virtual replicas of rehabilitation devices (such as rubber ball, power putty, peg board). Phobia-inducing virtual environments are prescribed for patients with cognitive deficits. **RESULTS:** VR-augmented rehabilitation has been shown effective for stroke patients in the chronic phase of the disease. VR-based rehabilitation has been improving patients with fear of flying, Vietnam syndrome, fear of heights, and chronic stroke patients. Telerehabilitation interventions using VR have improved musculo-skeletal and post-stroke patients; however less data is available at this time. **CONCLUSIONS:** Virtual reality presents significant advantages when applied to rehabilitation of patients with varied conditions. These advantages include patient motivation, adaptability and variability based on patient baseline, transparent data storage, online remote data access, economy of scale, reduced medical costs. Challenges in VR use for rehabilitation relate to lack of computer skills on the part of therapists, lack of support infra-

structure, expensive equipment (initially), inadequate communication infrastructure (for telerehabilitation in rural areas), and patient safety concerns.

Dawson, S.J., Forducey, P.G., Hantla, M.R., McDonald, N.B., Ruwe, W.D., & Scheideman-Miller, C. (2003). **Using telerehabilitation to promote TBI recovery and transfer of knowledge.** *NeuroRehabilitation*, 18(2), 103-11.

PMID: 12867673

ABSTRACT: Advances in the design and delivery of trauma care and acute medical management have increased the number of survivors of traumatic brain injury (TBI), producing societal consequences and medical challenges. Although access to health care for rural patients remains a critical challenge, teletherapy may represent a viable means for the delivery of therapeutic services to such patients. A case study is presented in which teletherapy was successfully utilized to improve the functional outcomes, both physical and cognitive, of a patient with a severe TBI.

A physical therapist from a metropolitan rehabilitation center employed teletherapy to provide Neuro Developmental Treatment for a patient and to mentor staff in a nursing home located over 100 miles from the metro area. The patient, who participated in 48 physical teletherapy sessions over a 24-week period, demonstrated improvements in physical functioning and neuropsychological status. During the course of therapy, goals were adjusted upward to match the patient's improvements. This case study provides confirmatory evidence that teletherapy represents an effective and efficient means for providing rehabilitation services for patients in rural communities, as well as for facilitating mentoring relationships between seasoned professionals and trainees located in rural settings.

Ricker, J.H. (2003). **Clinical and methodological considerations in the application of telerehabilitation after traumatic brain injury: A commentary.** *NeuroRehabilitation*, 18(2), 179-81.

PMID: 12867680

ABSTRACT: There is increasing interest and activity in the provision of teleassessment and telerehabilitation services to individuals with traumatic brain injury. Yet, little formal research exists, and there are no large-scale clinical trials or evidence-based applications of these technologies in TBI. The present commentary will address several areas that warrant critical consideration before telerehabilitation is likely to be widely implemented and reimbursed.

Torsney, K. (2003). **Advantages and disadvantages of telerehabilitation for persons with neurological disabilities.** *NeuroRehabilitation*, 18(2), 183-5.

PMID: 12867681

ABSTRACT: *No abstract is available.*

2002

Atzori, A.M., Dam, M., Massaro, C., Piron, L., Tonin, P., Trivello, E., & Zanotti, E. (2002). **Virtual environment system for motor tele-rehabilitation.** *Studies in Health Technology and Informatics*, 85, 355-61.

PMID: 15458114

ABSTRACT: The present cutting-edge communication technology applied to the rehabilitation may change the real possibility of providing therapeutic treatments to the patients at their home. In order to confirm this assertion a current study on motor telerehabilitation was undertaken. Through a virtual reality based system, and a complementary video conference apparatus, we supplied five post stroke patients with a motor rehabilitation therapy. The rehabilitation technique was based on the augmented feedback. Subjects underwent the telerehabilitation program for six weeks. Before and after the evaluated therapy, arm motor performance and the activities of daily living were evaluated by the means of clinical scales and measuring the affected arm velocity (end-effector). This pilot study suggested that telerehabilitation could promote the learning of arm motor abilities at distance from the health facilities. From an economic point of view, it could be proposed also as an opportune strategy for saving resources.

Nessler, J.A., Painter, C.C., Pang, C.T., & Reinkensmeyer, D.J. (2002). **Web-based telerehabilitation for the upper extremity after stroke.** *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 10(2), 102-8.

PMID: 12236447

ABSTRACT: Stroke is a leading cause of disability in the United States and yet little technology is currently available for individuals with stroke to practice and monitor rehabilitation therapy on their own. This paper provides a detailed design description of a telerehabilitation system for arm and hand therapy following stroke. The system consists of a Web-based library of status tests, therapy games, and progress charts, and can be used with a variety of input devices, including a low-cost force-feedback joystick capable of as-

sisting or resisting in movement. Data from home-based usage by a chronic stroke subject are presented that demonstrate the feasibility of using the system to direct a therapy program, mechanically assist in movement, and track improvements in movement ability.

Winters, J.M. (2002). **Telerehabilitation research: Emerging opportunities.** *Annual Review of Biomedical Engineering*, 4, 287-320.

PMID: 12117760

ABSTRACT: The field of clinical rehabilitation is rooted in the premise that carefully planned and delivered therapeutic intervention enhances patient outcomes. Underlying this statement is a deeper scientific reality: The field exists because biosystems (e.g., tissues, cells, organs, persons) are inherently adaptive and can dynamically change as a function of a sequence of inputs (e.g., exercise, pharmaceuticals). The tools of telerehabilitation help minimize the barrier of distance, both of patients to rehabilitative services and of researchers to subject populations. This enhanced access opens up new possibilities for discovering and implementing optimized intervention strategies across the continuum of care. Telecommunications technologies are reviewed from the perspective of systems models of the telerehabilitation process, with a focus on human-technology interface design and a special emphasis on emerging home and mobile technologies. Approaches for providing clinical rehabilitation services through telerehabilitation are addressed, including innovative consumer-centered approaches. Finally, telerehabilitation is proposed as a tool for reinvigorating the rehabilitative bioengineering research enterprise.

2000

Burdea, G., Colbert, K., Hentz, V., & Popescu, V. (2000). **Virtual reality-based orthopedic telerehabilitation.** *Hospital Case Management*, 8(3), 430-2.

PMID: 11001524

ABSTRACT: Rehabilitation interventions in remote areas are problematic because of distance and available resources. Orthopedic impairments acquired by individuals in remote areas can then lead to permanent disabilities/loss of function because of lack of appropriate rehabilitation. A system being developed by Rutgers and Stanford Universities provides therapy at the patient's home, with remote monitoring and periodic re-

assessment. This telerehabilitation system uses virtual reality and haptic interfaces, and a pair of networked PCs. It is intended for rehabilitation of patients with hand, elbow, knee, and ankle impairments. Data from the first patient treated with the telerehabilitation system is encouraging.

Cunningham, D., Greenleaf, W.J., Grimes, G.J., Dubois, H., Grimes, S.J., & Rothenburg, S. (2000). **Telerehabilitation services using web-based telecommunication.** *Studies in Health Technology and Informatics*, 70, 113-8.

PMID: 10977523

ABSTRACT: A World Wide Wide-based telerehabilitation platform has been demonstrated in a laboratory environment. This platform allows a rehabilitation provider to thoroughly evaluate the progress of a patient remotely with the same care and measurement precision that would be possible if the provider and the patient were in the same room. The platform was designed to be Web-based so that the service could be offered at the same price without regard to long distance telecommunication facility charges. The Web-based implementation allows enough bandwidth for a simultaneous video teleconference and a precision data acquisition mode even when the Web connection is a low cost analog modem computer interface at both ends of the connection.

1999

(1999). **'Telerehabilitation' may be in future of rehab care.** *Hospital Case Management*, 7(12), 213-4.
PMID: 11184599

ABSTRACT: *No abstract is available.*

Kinsella, A., Lathan, C.E., Rosen, M.J., Trepagnier, C., & Winters, J. (1999). **Aspects of human factors engineering in home telemedicine and telerehabilitation systems.** *Telemedicine Journal*, 5(2), 169-75.

PMID: 10908429

ABSTRACT: Human factors engineering and system design are critical elements in the newly developing field of telerehabilitation. Telerehabilitation is the remote delivery of rehabilitative services such as monitoring, training, and long-term care of persons with disabilities using telecommunications technology. This paper describes projects at the Rehabilitation Engineering Research

Center on Telerehabilitation in the context of three conceptual models: telecounseling and training, telemonitoring and assessment, and teletherapy. Issues pertaining to human factors engineering design are identified, and ongoing challenges are discussed.

Search Terms for Telerehabilitation

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|  Accessibility/Architectural |  Quality of Life |
|  Accommodation |  Rehabilitation Engineering Centers |
|  Activities of Daily Living |  Rehabilitation/Facilities/Medicine/Research/ |
|  Assistive Technology | Services/Standards/Technology |
|  Behavior Modification |  Remote Consultation/Service Delivery |
|  Biofeedback |  Research and Training Centers |
|  Brain Injuries |  Robotics |
|  Caregivers |  Rural/Health Services/Population/Services |
|  Children with Disabilities |  Service Delivery |
|  Chronic Illness |  Social Support |
|  Client Satisfaction |  Spinal Cord Injuries |
|  Clinical Management/Protocols |  Stroke |
|  Cognition Disabilities/Disorders |  Surveys |
|  Communication/Devices |  Systems Integration |
|  Community Health Services |  Task Performance and Analysis |
|  Computer/Applications/Methodologies/Systems |  Technology/Development/Transfer |
|  Computer-Assisted |  Telecommunications/Telehealth/Telemedicine/ |
|  Cost-Benefit Analysis | Telerehabilitation |
|  Delivery of Health Care/Methods/Standards |  Telemedicine/Ethics/Legislation/Standards |
|  Devices/Design/Evaluation/Selection |  Telephones |
|  Equipment/Analysis/Design/Failure |  Television |
|  Evaluation/Techniques |  Therapy/Computer-Assisted/Methods/Physical |
|  Exercise Therapy/Methods |  Trends |
|  Feasibility Studies |  User-Computer Interface |
|  Follow-Up Studies |  Veterans |
|  Health Services Accessibility/Research |  Vocational Rehabilitation |
|  Home Based/Care/Modification/Services |  Wheelchairs |
|  Independent Living | |
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|  Internet | |
|  Intervention | |
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|  Medical Informatics/Education/Methods/Trends | |
|  Medical Research/Technology | |
|  Microcomputers | |
|  Mobility/Aids/Impairments/Limitation | |
|  Model Programs | |
|  Monitoring | |
|  Motor Skills | |
|  Movement Disorders | |
|  Needs Assessment | |
|  Neurological Disorders | |
|  Occupational Therapy | |
|  Outcomes/Assessment | |
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|  Patient/Centered-Care/Education/Satisfaction | |
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|  Program Evaluation | |

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