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Articles

The Quadrupedal Nature of Human Bipedal Locomotion

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Abstract

During rhythmic movement, arm activity contributes to the neural excitation of leg muscles. These observations are consistent with the emergence of human bipedalism and nonhuman primate arboreal quadrupedal walking. These neural and biomechanical linkages could be exploited in rehabilitation after neurotrauma to allow the arms to give the legs a helping hand during gait rehabilitation.

Summary: Neuronal interactions between arm and leg activity during rhythmic human movement assist in coordinating locomotion and may be usefully exploited in rehabilitation of walking.

[J Neurol Phys Ther.](#) 2009 Sep;33(3):136-43.

The accuracy of individual berg balance scale items compared with the total berg score for classifying people with chronic stroke according to fall history.

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BACKGROUND AND PURPOSE:: To determine whether individual Berg Balance Scale (BBS) items or a group of items would have greater accuracy than the total BBS in classifying community-dwelling people with stroke with a history of multiple falls. **METHODS::** The subjects were 44 community-dwelling individuals with chronic stroke; 34 had one or no falls in the past six months, and 10 had multiple falls. Each BBS item was dichotomized at three points along the scoring scale of 0-4: between scores of 1 and 2, 2 and 3, and 3 and 4. Sensitivity (Sn), specificity (Sp), and positive (+LR) and negative (-LR) likelihood ratios were calculated for all items for each scoring dichotomy based on their accuracy in classifying subjects with a history of multiple falls. These findings were compared with the total BBS score where the cutoff score was derived from receiver operating characteristic curve analysis. **RESULTS::** Dichotomized point 3-4 for items B11 (turning 360 degrees), B12 (alternate foot on stool), B13 (tandem stance), and B14 (standing on one leg) all revealed Sn greater than 60%. B14 had the best Sn and Sp (0.90

and 0.50). Combining B11, B12, or B13 with B14 did not improve Sn. Total BBS receiver operating characteristic curve revealed a cutoff score of 52 (Sn = 90% and Sp = 41%). CONCLUSION:: Using selected items from the BBS may be more time efficient and accurate than the total BBS score for classifying people with chronic stroke living in the community with a history of multiple falls. Prospective study is needed to validate these findings relative to fall prediction.

[Arch Phys Med Rehabil.](#) 2009 Oct;90(10):1692-8.

Observation of amounts of movement practice provided during stroke rehabilitation.

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Observation of amounts of movement practice provided during stroke rehabilitation. OBJECTIVE: To investigate how much movement practice occurred during stroke rehabilitation, and what factors might influence doses of practice provided. DESIGN: Observational survey of stroke therapy sessions. SETTING: Seven inpatient and outpatient rehabilitation sites. PARTICIPANTS: We observed a convenience sample of 312 physical and occupational therapy sessions for people with stroke. INTERVENTIONS: Not applicable. MAIN OUTCOME MEASURES: We recorded numbers of repetitions in specific movement categories and data on potential modifying factors (patient age, side affected, time since stroke, FIM item scores, years of therapist experience). Descriptive statistics were used to characterize amounts of practice. Correlation and regression analyses were used to determine whether potential factors were related to the amount of practice in the 2 important categories of upper extremity functional movements and gait steps. RESULTS: Practice of task-specific, functional upper extremity movements occurred in 51% of the sessions that addressed upper limb rehabilitation, and the average number of repetitions/session was 32 (95% confidence interval [CI]=20-44). Practice of gait occurred in 84% of sessions that addressed lower limb rehabilitation and the average number of gait steps/session was 357 (95% CI=296-418). None of the potential factors listed accounted for significant variance in the amount of practice in either of these 2 categories. CONCLUSIONS: The amount of practice provided during poststroke rehabilitation is small compared with animal models. It is possible that current doses of task-specific practice during rehabilitation are not adequate to drive the neural reorganization needed to promote function poststroke optimally.

[Phys Ther.](#) 2009 Oct 1. [Epub ahead of print]

A Functional Threshold for Long-Term Use of Hand and Arm Function Can Be Determined: Predictions From a Computational Model and Supporting Data From the Extremity Constraint-Induced Therapy Evaluation (EXCITE) Trial.

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Background Although spontaneous use of the more-affected arm and hand after stroke is an important determinant of participation and quality of life, a number of patients exhibit decreases in use following rehabilitative therapy. A previous neurocomputational model predicted that if the dose of therapy is sufficient to bring performance above a certain threshold, training can be stopped. **Objective** The aim of this study was to test the hypothesis that there exists a threshold for function of the paretic arm and hand after therapy. If function is above this threshold, spontaneous use will increase in the months following therapy. In contrast, if function is below this threshold, spontaneous use will decrease. **METHODS:** New computer simulations are presented showing that changes in arm use following therapy depend on a performance threshold. This prediction was tested by reanalyzing the data from the Extremity Constraint-Induced Therapy Evaluation (EXCITE) trial, phase III randomized controlled trial in which participants received constraint-induced movement therapy for 2 weeks and were tested both 1 week and 1 year after therapy. **RESULTS:** The results demonstrate that arm and hand function measured immediately after therapy predicts, on average, the long-term change of arm use. Above a functional threshold, use improves. Below this threshold, use decreases. **Limitations** The reanalysis of the EXCITE trial data provides a "group" threshold above which a majority of patients, but not all, improve spontaneously. A goal of future research is to provide the means to assess when patients reach their individual threshold. **CONCLUSION:** Understanding of the causal and nonlinear relationship between limb function and daily use is important for the future development of cost-effective interventions and prevention of "rehabilitation in vain."

[Ann Phys Rehabil Med](#). 2009 Apr;52(3):269-93. Epub 2009 Apr 9.

Rehabilitation of arm function after stroke. Literature review.

[Article in English, French]

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INTRODUCTION: In the recent literature we can find many articles dealing with upper extremity rehabilitation in stroke patients. New techniques, still under evaluation, are becoming the practical applications for the concept of post-stroke brain plasticity. **METHODS:** This literature review focuses on controlled randomized studies, reviews and meta-analyses published in the English language from 2004 to 2008. The research was conducted in MEDLINE with the following keywords: "upper limb", "stroke", "rehabilitation". **RESULTS:** We reviewed 66 studies. The main therapeutic strategies are: activation of the ipsilesional motor cortex, inhibition of the contralesional motor cortex and modulation of the sensory afferents. Keeping a cortical representation of the upper limb distal extremity could prevent the learned non-use phenomenon. The modulation of sensory afferents is then proposed: distal cutaneous electrostimulation, anesthesia of the healthy limb, mirror therapy, virtual reality. Intensifying the rehabilitation care means increasing the total hours of rehabilitation dedicated to the paretic limb (proprioceptive stimulation and repetitive movements). This specific rehabilitation is facilitated by robot-aided therapy in the active-assisted mode, neuromuscular electrostimulation and bilateral task training. Intensifying the rehabilitation training program significantly improves the arm function outcome

when performed during subacute stroke rehabilitation (< six months). Ipsilesional neurostimulation as well as mental practice optimize the effect of repetitive gestures for slight motor impairments. Contralesional neurostimulation or anesthesia of the healthy hand both improve the paretic hand's dexterity via a decrease of the transcallosal inhibition. This pathophysiological mechanism could also explain the positive impact of constraint-induced movement therapy (CI therapy) in an environmental setting for chronic stroke patients. **CONCLUSION:** To ensure a positive functional outcome, stroke rehabilitation programs are based on task-oriented repetitive training. This literature review shows that exercising the hemiparetic hand and wrist is essential in all stages of a stroke rehabilitation program. New data stemming from neurosciences suggest that ipsilesional corticospinal excitability should be a priority.

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What do acute stroke physiotherapists do to treat postural control and mobility? An exploration of the content of therapy in the UK.

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Objective: To investigate the content of acute stroke physiotherapy to treat postural control and mobility problems. **Design:** Stroke physiotherapists recorded the interventions used to treat postural control and mobility during treatment sessions. They recorded five sessions for at least five patients each. Descriptive statistics assessed the frequency with which the interventions were used. **Setting:** Hospital-based acute stroke care. **Subjects:** Thirty-six acute stroke physiotherapists recorded 2374 interventions in 364 treatment sessions for 76 patients. **MAIN MEASURES:** The Stroke Physiotherapy Intervention Recording Tool. **Results:** Facilitation techniques were the most frequently used interventions (n = 1258, 53%) with exercise (n = 115, 5%), teaching others how to help the patient (n = 99, 4%) and provision of equipment (n = 63, 3%) the least frequently used. **Conclusions:** Acute stroke physiotherapists primarily use therapist-led 'hands-on' interventions to treat postural control and mobility problems. Interventions to promote activity or practice outside the treatment session are infrequently used.

[Curr Opin Neurol.](#) 2009 Sep 5. [Epub ahead of print]

The neural basis of constraint-induced movement therapy.

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PURPOSE OF REVIEW: This review describes our current understanding of the changes in brain function and structure that occur in response to an intensive form of motor rehabilitation, constraint-induced movement therapy (CIMT), that has been shown to be efficacious in promoting motor function of the paretic upper limb of stroke patients. **RECENT FINDINGS:** Studies using transcranial magnetic stimulation have demonstrated consistently an increase in the size of the representation of paretic hand muscles in the ipsilesional motor cortex after CIMT. This motor map expansion occurs in response to CIMT delivered at all time periods after stroke,

from within days to after several years. Functional neuroimaging studies have shown varying patterns of change in activation within the sensorimotor network after CIMT. This variability may depend on the extent of stroke-induced damage to the corticospinal tract, the major descending motor pathway in the brain. This variability may also stem from interacting plastic changes in brain structure occurring in response to CIMT. **SUMMARY:** CIMT is the first well defined poststroke motor rehabilitation to have identified changes in brain function and structure that accompany gains in motor function of the paretic upper limb. However, a causal link between observed changes in brain function/structure and motor gains due to CIMT has not yet been established. There is still much work to be done to understand the relationship between changes in brain function/structure and gains in motor function. Such studies should employ rigorous experimental controls to enable strong conclusions to be drawn regarding the neural effects of CIMT and how those effects confer behavioral efficacy of the therapy.

[Top Stroke Rehabil.](#) 2009 Jul-Aug;16(4):237-53.

Gains in Upper Extremity Function After Stroke via Recovery or Compensation: Potential Differential Effects on Amount of Real-World Limb Use.

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In terms of integration of the paretic upper extremity in activities of daily living (ADLs), outcome is poor after stroke. Furthermore, amount of real-world arm use appears only weakly correlated with laboratory motor function scales. Therefore, amount of arm use may depend critically on the location, extent, and type of functional gains, which can be quantified with comprehensive kinematic and EMG analysis of ADL performance. Gains in upper extremity function can occur via compensation or recovery of premorbid movement and EMG patterns, and traditional treatment approaches encourage adoption of compensatory strategies early in the postacute period that can inhibit potential recovery. A new treatment approach called Accelerated Skill Acquisition Program (ASAP) focuses on impairment reduction coupled with repetitive, task-specific training of the paretic arm during ADLs. We present pilot data that show recovery in subjects who received the ASAP, while a usual care control subject showed increased use of compensation over the same period. Finally, we discuss the advantages of data reduction methods such as principal components analysis, confirmatory factor analysis, and structural equation modeling, which can potentially distill large kinematic and EMG data sets into the key latent variables that predict amount of real-world use.

[Arch Phys Med Rehabil.](#) 2009 Sep;90(9):1548-56.

Change of strength and rate of rise of tension relate to functional arm recovery after stroke.

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OBJECTIVE: To examine the relationship between individual strength parameters and functional motor ability over time during rehabilitation in stroke patients. **DESIGN:** A multiple-baseline experiment with assessment at inclusion and after 3 and 6 weeks. **SETTING:** Secondary-care rehabilitation center. **PARTICIPANTS:** A convenience sample of 16 subacute stroke patients. **INTERVENTIONS:** Not applicable. **MAIN OUTCOME MEASURES:** Maximal voluntary force and rate of rise of tension of hand grip, wrist extension, and elbow flexion and extension were recorded at all 3 times. At the same time, functional motor assessments were evaluated by the Action Research Arm Test (ARAT), Box and Block test, and Rivermead Test. **RESULTS:** We found no correlation between maximal voluntary force increases of various muscle contractions measurements. Neither the increase of grip strength nor that of wrist extension force correlated with improvement in ARAT score. Yet the improvement in the rate of rise of tension of hand grip (Spearman $\rho=0.91$) and of wrist extension (Spearman $\rho=0.73$) correlated with the improvement of the ARAT score and explained 77% of the variance of the ARAT. **CONCLUSIONS:** The change in the rate of rise of tension of the hand grip has a better predictive value for the functional recovery compared to the change in maximal voluntary force in patients with moderate arm and hand weakness after stroke. The rate of rise of tension of hand grip seems an adequate quantifiable parameter to detect small improvements during functional recovery.

[Curr Opin Neurol](#). 2009 Aug 29. [Epub ahead of print]

Motor rehabilitation after stroke, traumatic brain, and spinal cord injury: common denominators within recent clinical trials.

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PURPOSE OF REVIEW: Experimental studies and clinical trials that aim to improve motor function for use of the upper extremity and walking are traditionally separated by the category of neurological disease. This boundary may deter investigators from finding common denominators in the conceptual basis and deployment of rehabilitation interventions, especially across nonprogressive diseases in adults, such as stroke, brain trauma, and spinal cord injury. **RECENT FINDINGS:** The results of recent randomized clinical trials for walking by treadmill training and robotic devices and for the upper extremity by constraint-induced therapy, robotics, and brain stimulation suggest that more efficient strategies are needed to devise and prove the value of new therapies. **SUMMARY:** Investigators should consider working across disease platforms to develop and test the most optimal methods for training patients, the most practical trial designs, the best dose-response characteristics of interventions, the most meaningful outcome measures, and the likelihood of transfer of trained performance to real-world settings. Clinicians in the community may be more likely to adopt evidence-based practices drawn from positive trial results if these treatment strategies focus on key motor impairments and related disabilities, rather than on diseases.

[Neurol Res](#). 2009 Oct;31(8):832-40.

Stroke rehabilitation.

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OBJECTIVE: A review of the basic concepts of stroke rehabilitation that are worth emphasizing to all practitioners who treat patients with stroke. Also, suggestions are made for patients on how to functionally cope with daily activities after they have experienced a stroke. **METHODS:** Numerous articles that discuss stroke rehabilitation and recovery were reviewed and emphasized throughout this paper. **RESULTS:** The multidisciplinary approach of incorporating expertise from the realms of physical therapy, occupational therapy, speech therapy along with optimal medical care continues to be viewed as advantageous. Coordination by a physician with expertise in neurorehabilitation is also an important aspect of successful stroke rehabilitation. Such expertise takes the form of realistic expectations about recovery based upon performance of serial functional assessment scales, knowledge about the size and location of the stroke or strokes, incorporation of any cognitive or emotional detriments to recovery, as well as acknowledgement of medical comorbid factors. The care plan must also institute effective measures to protect against recurrent stroke, as stroke patients are generally at significant risk for further ischemic or hemorrhagic events. **CONCLUSION:** Stroke rehabilitation should begin during the patient's hospital admission. Obviously, the degree of recovery is impacted by the age of the patient, the magnitude of the initial deficit, the medical condition of the patient, the motivation of the patient and family members, the risk of recurrent stroke as well as the quality of the stroke rehabilitation process. There are numerous assistive devices available to stroke patients that can help them adjust to their new post-stroke lifestyle.

[Neurorehabil Neural Repair](#). 2009 Sep;23(7):679-91. Epub 2009 May 1.

Hemisphere specific impairments in reach-to-grasp control after stroke: effects of object size.

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BACKGROUND AND OBJECTIVE: The authors investigated hemispheric specialization for the visuomotor transformation of grasp preshaping and the coordination between transport and grasp in individuals poststroke. Based on a bilateral model, the authors hypothesized that after unilateral stroke there would be hemisphere-specific deficits revealed by the ipsilesional limb. **METHODS:** Right or left stroke and age- and limb-matched nondisabled participants performed rapid reach-to-grasp of 3 sized objects. The authors quantified grasp preshaping as the correlation between initial aperture velocity and peak aperture, and peak aperture and object diameter. A cross correlation analysis using transport velocity and aperture size was performed to quantify transport-grasp coordination. All statistical tests for hemisphere-specific deficits involved comparisons between each stroke group and the matched nondisabled group. **RESULTS:** Overall, the right stroke group, but not left stroke group, demonstrated prolonged movement time. For grasp preshaping there was a higher correlation between initial aperture velocity and peak aperture for the right stroke group and a lower correlation between peak aperture and object diameter for the left stroke group. For transport-grasp coordination the correlation between transport velocity and aperture size was higher for the left stroke group and lower for the right stroke group, which also demonstrated a higher standard deviation of time lag. **CONCLUSIONS:** After left stroke, there was deficient scaling of grasp preshaping and stronger transport-grasp coordination. In contrast, after right stroke, grasp preshaping began earlier and transport-grasp coordination was weaker. Together, these hemisphere-specific deficits suggest a left hemisphere

specialization for the visuomotor transformation of grasp preshaping and a right hemisphere specialization for transport-grasp coordination.

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The psychometric properties and clinical utility of measures of walking and mobility in neurological conditions: a systematic review.

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Objective: To identify psychometrically robust and clinically feasible measures of walking and mobility in people with neurological conditions. **Data sources:** MEDLINE, CINAHL, EMBASE, PEDro and AMED. **Review methods:** Independent reviewers selected and extracted data from articles that assessed the reliability, validity, sensitivity to change or clinical utility of measures of walking and mobility in adult neurological conditions. Measures with 'good' psychometrics and 9/10 clinical utility scores were recommended. **Results:** Seventeen measures were selected. Of these, the 5-m and 10-m walk tests, six-minute walk test, High Level Mobility Assessment Tool (HiMAT) and the Rivermead Mobility Index (RMI) reached the required standards and are usable in clinical practice. None of the recommended measures assessed wheelchair mobility. The least frequently assessed property was sensitivity to change. Further measures could be recommended if the minimal detectable change were demonstrated. **Conclusion:** The 5-m, 10-m and six-minute walk test, High Level Mobility Assessment Tool and the Rivermead Mobility Index are psychometrically robust measures of walking and mobility and are feasible for use in clinical practice.

[Neurologist.](#) 2009 Jul;15(4):185-92.

Rehabilitation approaches to hemineglect.

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BACKGROUND: Hemineglect is a difficult neurologic condition to rehabilitate. It arises predominantly from right brain injury, and manifests heterogeneously in clinical deficits such as poor visual exploration to the left, inaccurate assessment of the midpoint of a line, left limb hypokinesia, and anosognosia. Most of the cognitive dysfunction produced by hemineglect is because of an asymmetric distribution of attention, either with respect to extrapersonal space or to an object being viewed. Many treatments draw on hemineglect theory to attempt to mediate the basic asymmetry of attention. **REVIEW SUMMARY:** Treatment approaches can be divided into 2 main categories. Extrinsic or "top-down" approaches require active participation of the patient under the guidance of a therapist. The most common approach of this type is visual scanning therapy in which the patient is continually instructed to move the gaze leftward into the neglected space. Intrinsic or "bottom-up" approaches manipulate stimulus characteristics, sensory input, or the brain directly in an attempt to alter the interhemispheric attentional imbalance. Examples of this approach include vestibular stimulation of the left side, sensory activation of the left limb, and transcranial magnetic stimulation of the overactive left hemisphere. Combined approaches such as prism adaptation have also shown good results.

CONCLUSIONS: Hemineglect is a complicated disorder that poses challenges to treatment. A paucity of clinical trial evidence limits our ability to extrapolate experimental mediation of hemineglect to globally improved functioning. Nonetheless, many treatment approaches appear promising. Underlying neuroscience may help guide future treatment approaches.

[Chaos](#). 2009 Jun;19(2):026102.

Neuromechanical considerations for incorporating rhythmic arm movement in the rehabilitation of walking.

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We have extensively used arm cycling to study the neural control of rhythmic movements such as arm swing during walking. Recently rhythmic movement of the arms has also been shown to enhance and shape muscle activity in the legs. However, restricted information is available concerning the conditions necessary to maximally alter lumbar spinal cord excitability. Knowledge on the neuromechanics of a task can assist in the determination of the type, level, and timing of neural signals, yet arm swing during walking and arm cycling have not received a detailed neuromechanical comparison. The purpose of this research was to provide a combined neural and mechanical measurement approach that could be used to assist in the determination of the necessary and sufficient conditions for arm movement to assist in lower limb rehabilitation after stroke and spinal cord injury. Subjects performed three rhythmic arm movement tasks: (1) cycling (cycle); (2) swinging while standing (swing); and (3) swinging while treadmill walking (walk). We hypothesized that any difference in neural control between tasks (i.e., pattern of muscle activity) would reflect changes in the mechanical constraints unique to each task. Three-dimensional kinematics were collected simultaneously with force measurement at the hand and electromyography from the arms and trunk. All data were appropriately segmented to allow a comparison between and across conditions and were normalized and averaged to 100% movement cycle based on shoulder excursion. Separate mathematical principal components analysis of kinematic and neural variables was performed to determine common task features and muscle synergies. The results highlight important neural and mechanical features that distinguish differences between tasks. For example, there are considerable differences in the anatomical positions of the arms during each task, which relate to the moments experienced about the elbow and shoulder. Also, there are differences between tasks in elbow flexion/extension kinematics alongside differential muscle activation profiles. As well, mechanical assistance and constraints during all tasks could affect muscle recruitment and the functional role of muscles. Overall, despite neural and mechanical differences, the results are consistent with conserved common central motor control mechanisms operational for cycle, walk, and swing but appropriately sculpted to demands unique to each task. However, changing the mechanical parameters could affect the role of afferent feedback altering neural control and the coupling to the lower limbs.