BrightArm Studies Annotated Bibliography
(as of July, 2021)

Burdea G, Kim N, Polistico K, Kadaru A, Grampurohit N, Tapia J, Hundal J and Pollack S. Robotic Rehabilitation Table for Integrative Training Early Post-Stroke: Two Case Studies. *Journal of Rehabilitation and Assistive Technology Engineering.* Special Issue on Design and Development in Rehabilitation Robotics for Home and Community-based Settings (under review). (n=2)

Burdea G, Nam Kim, Kevin Polistico, Ashwin Kadaru, Doru Roll, and Namrata Grampurohit. Novel Integrative Rehabilitation System for the Upper Extremity: Design and Usability Evaluation. *Journal of Rehabilitation and Assistive Technology Engineering.* 8:1-17. SAGE Publications. doi: 10.1177/20556683211012885 (n=4)

> Participants played four sessions of about 50 minutes each, with training difficulty gradually increasing. Participants averaged a total of 6,300 arm repetitions, 2,200 grasp counts, and 2,100 finger extensions when adding counts for each upper extremity. USE questionnaire data averaged 5.1/7 rating, indicative of usefulness, ease of use, ease of learning, and satisfaction with the system. Subjective feedback on the custom evaluation form was 84% favorable.

House G, G Burdea, N Grampurohit, K Polistico, D Roll, and F Damiani. Integrative Upper-Limb Rehabilitation with BrightArm Duo in the Early Sub-acute Phase of Recovery Post-stroke. *Journal of Medical Robotics Research.* Special Issue on Rehabilitation Robotics. June 2017, 2(2), 12 pp. (n=12)

> In early sub-acute phase post-stroke, N = 3 experimental group received customary rehabilitation plus 12 BrightArm Duo sessions over 4 weeks of inpatient training. Each experimental session induced up to 600 arm and grasping repetitions during therapeutic game play. Games adapted to each individual, at each session. N=9 control group received customary rehabilitation only, as inpatients at the same Skilled Nursing Facility in New Jersey, USA. The same rehabilitation company provided the customary training to all participants. Improvement for the experimental group was better than controls across 11 of 12 functional metrics and activities of daily living (p <0.006).

House G, G Burdea, N Grampurohit, K Polistico, D Roll, F Damiani, S Keeler, J Hundal, S Pollack. Longitudinal Study of Integrative Virtual Rehabilitation use in Skilled Nursing Facility Maintenance Programs for Residents with Chronic Stroke, *Proc. 11th Intl Conf. Disability, Virtual Reality & Associated Technologies*, Los Angeles, California 20-22 Sept. 2016. (n=10)

> 45-week longitudinal controlled study to examine the effects of integrative virtual rehabilitation with the BrightArm Duo System for maintenance of elderly skilled nursing facility residents with chronic stroke. The experimental group trained for 8-weeks followed by 3 booster periods at 8-week intervals. The experimental group played on average total of 407 games lasting an average of 986 minutes. These subjects exerted an average total of 19,020 arm repetitions and 12,540 hand grasps across the 45-week study. The improvement for the experimental group was significantly better than the controls in standardized assessments of UE range of motion (p=0.04), strength, and function (p=0.035), and for cognition and emotion (p=0.0006).

House G, Burdea G, N Grampurohit, K Polistico, D Roll, F Damiani, J Hundal, D Demesmin. A feasibility study to determine the benefits of upper extremity virtual rehabilitation therapy for coping with chronic pain post-cancer surgery. *The British Journal of Pain*, November 2016, 10(4):186-197. (n=6)

The aim of this study was to explore the feasibility of BrightArm Duo therapy for coping with post-surgical chronic upper body pain and associated disability in breast cancer survivors with depression. Community-dwelling women (n=6) with post-surgical breast cancer pain in the upper arm or shoulder trained on the system twice a week for 8 weeks. Subjects averages upwards of 1,300 arm repetitions and 850 hand grasps per session (summing both arms). Pain intensity showed a 20% downward trend (p=0.1) that was corroborated by therapist observations and participants' feedback. Cognitive metrics improved post training and a significant reduction in depression severity occurred. This study demonstrated feasibility of using BrightArm Duo Rehabilitation System to treat cancer survivors coping with upper body chronic pain, in the absence of pain medication use during BrightArm Duo sessions.

House G, G Burdea, N Grampurohit, K Polistico, D Roll, F Damiani, J Hundal, D Demesmin. Integrative Virtual Reality Therapy Produces Lasting Benefits for a Young Woman Suffering from Chronic Pain and Depression Post Cancer Surgery: A Case Study. 11th *Int Conference on Disability and Virtual Reality Technology*, September 2016, Los Angeles. Reprinted in *Journal of Alternative Medical Research*, 2018; 10(1).

This case study was part of an evaluation of the BrightArm Duo Rehabilitation System for treating the effects of chronic upper body pain following breast cancer surgery. The subject was a 22-year old woman with burning and stabbing pain in the right upper arm. Training consisted of playing custom bimanual 3D games while seated at the gravity-modulating robotic table for 16 sessions over 8 weeks. Standardized assessments demonstrated a meaningful improvement in motor, cognitive and emotive domains with a statistically significant reduction in pain. Gains transferred to daily activities enabling the subject to resume full time employment, driving and socializing.

House G, G. Burdea, K. Polistico, D. Roll, J. Kim, F. Damiani MD, S. Keeler, J. Hundal, S. Pollack. Integrative rehabilitation of stroke survivors in Skilled Nursing Facilities: the design and evaluation of the BrightArm Duo. *Disability and Rehabilitation-Assistive Technology*. November 2016. 11(8):683-94. (n=10)

The purpose of this research was to describe the novel BrightArm Duo bimanual upper extremity rehabilitation system and to determine its technology acceptance and clinical benefit for older hemiplegic participants. The games played were designed to improve upper extremity strength, motor function, as well as participants' cognition and emotive state. The system underwent feasibility trials spanning 8 weeks in two skilled nursing facilities. Seven participants had significant improvements in their active range of shoulder movement, supported arm reach, shoulder strength, grasp strength and their ability to focus. The group demonstrated higher arm function measured with FMA (p=0.01) and CAHAI (p=0.05) and had improvements in depression (measured with the Beck's Depression Inventory II test).

House G, G. Burdea, K. Polistico, N. Grampurohit, F. Damiani MD, S. Keeler, J. Hundal, S. Pollack. A rehabilitation first – nursing home tournament between teams of chronic post-stroke residents. *Games for Health*. February 2016. 5(1), 75-83. (n=7)

The purpose of this study was to describe the BrightArm Duo virtual reality system and determine its clinical benefit for maintenance of upper extremity function in nursing home residents who are chronic post-stroke. After 8 weeks of initial intensive therapy that trained arm and hand function, range of motion, emotional well-being and cognition, there were three booster periods at 8-week intervals. The last booster was a tournament competition where pairs of residents played games collaboratively from remote nursing homes. The tournament used two BrightArm Duo systems and each teammate controlled one of the two avatars in the game. Range of motion improved for 18 out of 23 upper extremity movement variables (p=0.01) between pre- and post-tournament assessments. The residents self-reported that they enjoyed playing with a partner. Affected hand and arm function and depression levels were maintained (no decline) after the tournament.

House G, G Burdea, K Polistico, D Roll, J Kim, F Damiani, S Keeler, J Hundal, S Pollack. BrightArm Duo integrative rehabilitation for post-stroke maintenance in Skilled Nursing Facilities, *Proc. Int. Conf. Virtual Rehabilitation*. 2015. Valencia, Spain. 207-214.

The purpose of this study was to determine the clinical benefit of the BrightArm Duo bimanual upper extremity rehabilitation system for maintenance of older hemiplegic residents of Skilled Nursing Facilities (SNF). The system underwent a longitudinal controlled study in two SNFs. 7 chronic post-stroke participants trained for 8 weeks followed by a 2 week booster period starting 10 weeks later. Training on the system resulted in an increase in movement for both affected and unaffected arms. About 60% of range of motion metrics improved between pre-therapy to post-booster. The greatest improvement in shoulder movement was in extension of the affected arm with mean pre-training angle of 18.7° and post-booster angle of 33.3°. Shoulder abduction increased on average 8.4° from 68.0° at pre-training to 76.4° at post-booster. Cognitive measurements were also taken where 9 of 12 cognitive metrics improved for the experimental group between pre-training and post-booster. The experimental group significantly improved in the motor and emotive domains over levels immediately after initial 8 weeks training.

G. Burdea, B. Rabin, D. Rethage, F. Damiani, J. S. Hundal and C. Fitzpatrick. BrightArm™ Therapy for Patients with Advanced Dementia: A Feasibility Study. *Proc. 10th Int. Conf. Virtual Rehabilitation*, Philadelphia, PA, August 2013, pp. 208-209.

Three residents of a Dementia Ward participated in a feasibility study of the BrightArm system. The custom therapeutic games targeted several cognitive domains including short-term and working memory. Participant 1 was an 88-year-old white female, Participant 2 was a 72-year-old white female and Participant 3 was an 84-year-old white female. Standardized measures did not reveal changes in cognitive function after therapy. Game performance was measured over the course of therapy, and each participant showed different performance trends. Participant 1 had less inhibited responses post-study and her composure was much more relaxed. Pre-therapy Participant 2 was significantly impaired, with flat affect and lack of autonomy. Post-intervention she had much bright affect and felt much more comfortable with the system. Participant 3 was extremely motivated by the therapy and cheered the other two participants.

Rabin B, Burdea G, Roll D, Hundal J, Damiani F and Polack S. Integrative rehabilitation of elderly stroke survivors: The design and evaluation of the BrightArm. *Disability and Rehabilitation – Assistive Technology*. 2012; 7(4):323–335. PMID: 22107353.

The purpose of this study was to evaluate the BrightArm upper extremity rehabilitation system and to determine its clinical feasibility with older patients with hemiplegia. The system underwent feasibility trials spanning 6 weeks (3 sessions/week) in a skilled nursing facility. Five participants, who were chronic post-stroke, had clinically significant improvements in their active range of shoulder movement, shoulder strength, grasp strength, and their ability to focus. Mood generally improved post-training, notably, a participant's depression level dropped from "moderate" to "mild." There was substantial improvement in verbal and visual attention post-therapy for example one participant progressed from moderately impaired verbal attention to the average range, and from mildly impaired visual attention to the average range. The pre-post mean difference in visual memory was 9.6.

Rabin B, G. Burdea, J. Hundal, D. Roll, F. Damiani. Integrative Motor, Emotive and Cognitive Therapy for Elderly Patients Chronic Post-Stroke. *Proc. Int. Conf. Virtual Rehabilitation 2011*, Zurich Switzerland, June, 8 pp.

This study presents the first feasibility study of the BrightArm robotic rehabilitation system on n=5 (1 female and 4 male) elderly skilled nursing facility residents chronic post-stroke. Their age ranged from 62 to 81 and their stroke occurred between 19 and 119 months prior to the intervention. Four of the 5 participants showed significant improvement in shoulder strength. None of the participants could lift wrist weights pre-therapy, but post-therapy they were able to lift between 2 and 2.5 lbs. Grasp strength improved in 4 participants where 3 participants had been unable to grasp pre-therapy. Shoulder extension and abduction improved in all participants with increases ranging from 5° to 30° and 15° to 30°, respectively. Participants' mood generally improved and depression severity decreased. Despite the severe motor and cognitive impairments with which the participants presented pre-training, they were all able to use and enjoy the system.