

## Mount Sinai School of Medicine's Rehabilitation Department Uses Dartfish in Clinical Laboratory



**PREETI RAGHAVAN MD, THE DIRECTOR OF THE MOTOR RECOVERY LABORATORY, AND EDWARD LI, AN ASSISTANT RESEARCHER IN THE MOTOR RECOVERY LAB IN THE DEPARTMENT OF REHABILITATION MEDICINE AT THE MOUNT SINAI SCHOOL OF MEDICINE IN NEW YORK CITY, USE DARTFISH TO OBJECTIVELY MONITOR PATIENTS' PROGRESS OVER TIME AND TO PROVIDE THEM WITH FEEDBACK ABOUT THEIR MOVEMENT CAPABILITIES AND FUNCTIONAL STRATEGIES.**

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### **OBJECTIVES AND CONCEPTS – to improve arm function over time in patients with neurological and musculoskeletal conditions**

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We use Dartfish in a clinical laboratory setting to monitor improvement in arm function over time in patients with neurological and musculoskeletal conditions. Using Dartfish has allowed us to observe patients' movements more objectively and understand the basis for improvement. In our lab we use Dartfish in conjunction with several other measurements to investigate *how* patients perform various functional upper extremity tasks. **We find that the data from Dartfish alone is very useful to examine the movement quickly and objectively using the data analysis features of the program through which we can measure angles, track limb segment displacements and calculate changes in joint range-of-motion. Dartfish also allows us to provide patients with a copy of their session, add audio commentaries about certain aspects of the session, and compare recent and past performances.**

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“We purchased Dartfish because subtle changes in motor function occur over the course of rehabilitation and recovery that are often not picked up by numerical scales. Dartfish enables us to record a patient’s performance at each visit, and analyze it objectively to detect subtle changes, as well as provide patients with feedback for further treatment.” Raghavan and Li

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### USE OF DARTFISH - to investigate the contribution of motor impairments to upper extremity function and design therapeutic protocols to optimize recovery

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**The parts of Dartfish used are *In the Action*, *Analyzer*, and the *Mediabook* features.** We use *In the Action* to record patients’ performance during functional tasks. We can set recording parameters to record for a determined length of time or use a remote cue to begin recording manually. Dartfish allows synchronization of the videos with other data collection programs as well. For example, if the task involves grasping and lifting, we can record the movement of the limbs in relation to the upper body using Dartfish, and also simultaneously record fingertip forces using an instrumented grip object. Using Dartfish in conjunction with other measures allows for a comprehensive examination of performance. Most of our use of Dartfish is in a research lab setting at present. In the future we plan to set up Dartfish on a laptop and bring a camera to record task performance in the clinic or during therapy as well.

We use the *Analyzer* to objectively examine and quantify patient performance using various data analysis tools. Angular measurements and limb segment displacements over the course of the movement can be placed into data tables and graphed to visualize trends and patterns. This is very valuable as it allows us to identify movement strategies employed by the patient to complete the task, determine which ones are to be encouraged and develop a therapeutic plan to do so. We can then also assess the benefits of treatment objectively. The case studies below illustrate our use of Dartfish for this process.

**NEUROLOGICAL CASE STUDY**

This case study by Edward Li demonstrates the use of Dartfish to quantify changes in arm function over time in a patient with post-stroke hemiparesis.

**Background Literature**

Hemiparesis is weakness on one side of the body, and is the most common motor impairment after stroke. While 82% of patients are expected to walk independently again (Kwakkel, Kollen et al. 1999), only about 50% of stroke survivors are likely to regain some functional use of the upper extremity (Broeks, Lankhorst et al. 1999). However, recent evidence that activity-dependent, task-specific interventions may contribute to motor recovery (Butefisch, Hummelsheim et al. 1995; Hallett 2001) suggests that a closer look at *how* functional upper extremity tasks are performed is necessary. A clearer understanding of the process may shed light on how therapeutic rehabilitation protocols may be structured to optimize recovery.

Rating scales are frequently used to assess recovery of upper extremity function after stroke. While they are useful to demonstrate whether changes in function occur, they cannot describe the process of recovery. Kinematic measurements are useful to describe changes in process as well as function, but they are often time consuming and require expensive equipment and an elaborate set up. Dartfish offers a unique and powerful tool to easily monitor how functional task performance changes over the course of recovery, at a fraction of the cost associated with conventional kinematic analysis. Moreover, it may be used in clinical settings and help inform therapeutic decisions. This case study reports changes in function captured using Dartfish in one patient with post-stroke hemiparesis when he performed a reach-to-grasp task over two visits six months apart.

**Use of Dartfish**

Figure 1 shows snapshots of the patient's position from a camera placed directly above the testing workspace on his first visit to the lab. Fig. 1a shows the patient's position at the start of the task. He reached towards a grip object placed at 75% of his arm's length, and grasped and lifted it using his thumb and index finger. Dartfish was used to track the position of his head and hand twice every second for the duration of the reach-to-grasp movement. The nose was tracked to indicate head position, and reflective markers placed on the wrist facilitated tracking of the hand. Head displacement was used as proxy for trunk displacement. The tracked positions were entered into a data table, and then exported to Microsoft Excel for further analysis. Fig. 1b shows the tracked positions of the patient's head and hand at object lift-off. Note that the distance covered by both tracked segments was similar, suggesting that he leaned his trunk forward with his hand during reach-to-grasp.

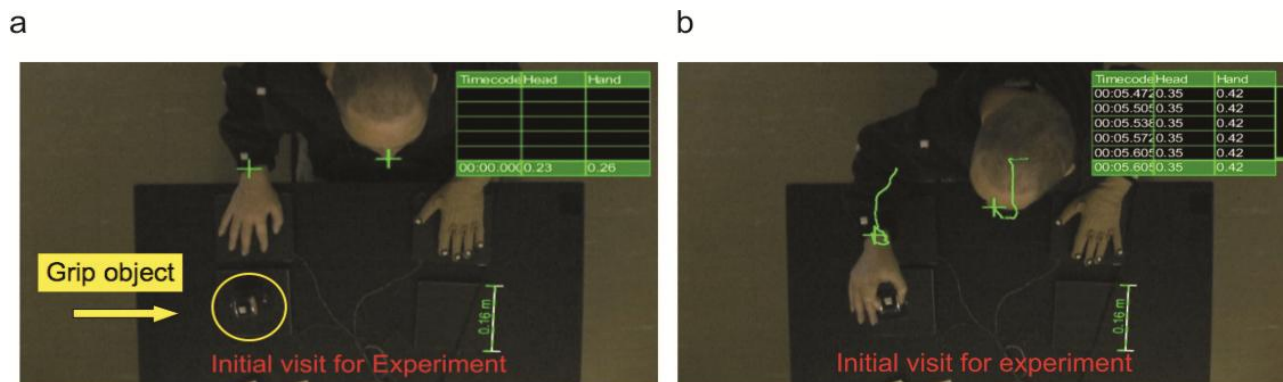


Figure 1

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### NEUROLOGICAL CASE STUDY CONTINUED.....

The patient returned to the lab 6 months later, and repeated the reach-to-grasp task performed at visit 1 under identical testing conditions to allow for direct comparison across the two visits. Figure 2a shows the patient's position at the start of the task, and figure 2b shows the tracked positions of his head and hand at object lift-off. We used the relative displacements of head and hand across the two visits to quantify whether the patient improved in his ability to isolate his trunk from his arm during reach-to-grasp at visit 2. A ratio of head displacement (H) to hand displacement (H') was used to quantify the degree to which the trunk and arm moved independently (HH' ratio). The HH' ratio has values ranging from 0-1. If the arm and trunk moved entirely together the HH' ratio would approximate 1, but if the arm could be extended independently of the trunk the HH' ratio would be close to 0.

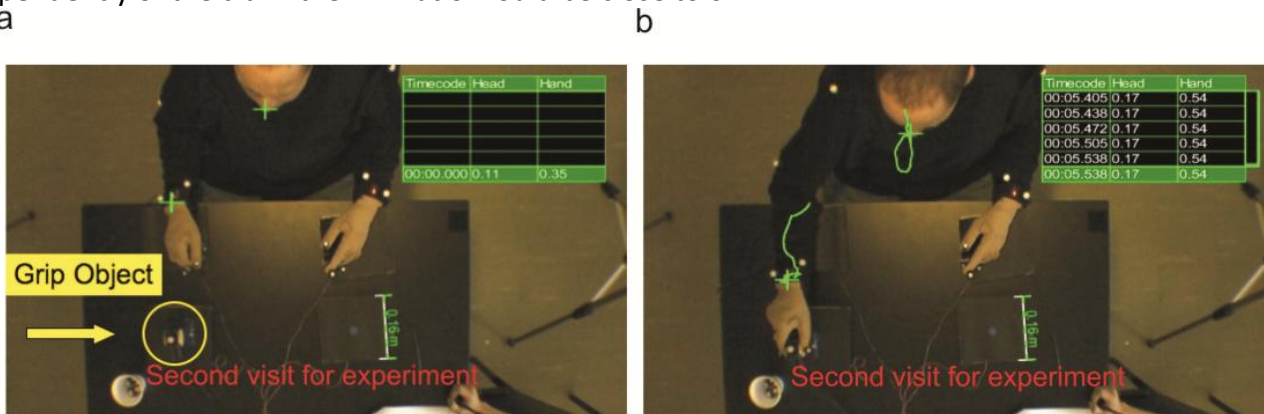


Figure 2

### Results

Figure 3, shows the HH' ratio plotted over the two visits. The blue line represents the initial visit and the red line represents the second visit 6 months later. Note that the strategies to initiate the reach-to-grasp movement, and lift the object were different across the two visits. During visit 1, at initiation of the movement, the HH' ratio decreased slightly and then began to increase suggesting that the trunk moved back slightly as the arm moved forward. However, after the first 100ms movements of the trunk and arm were coupled.

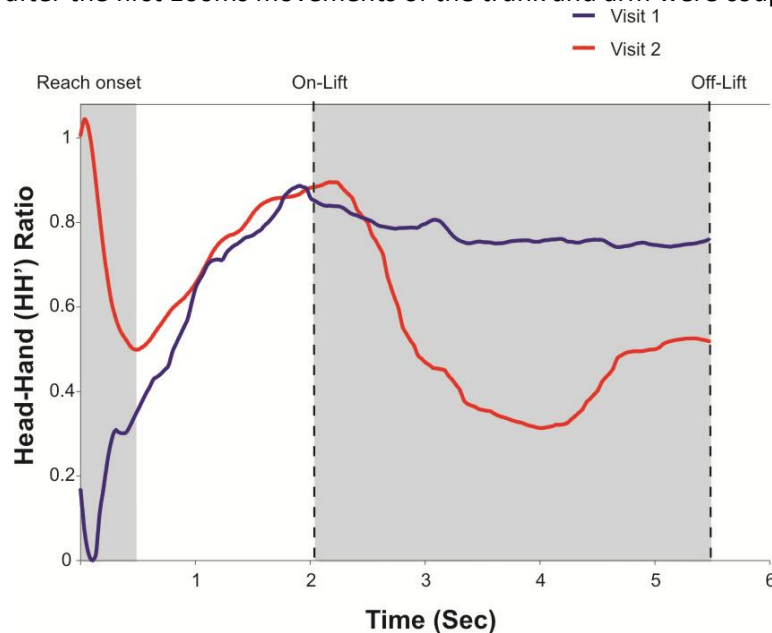
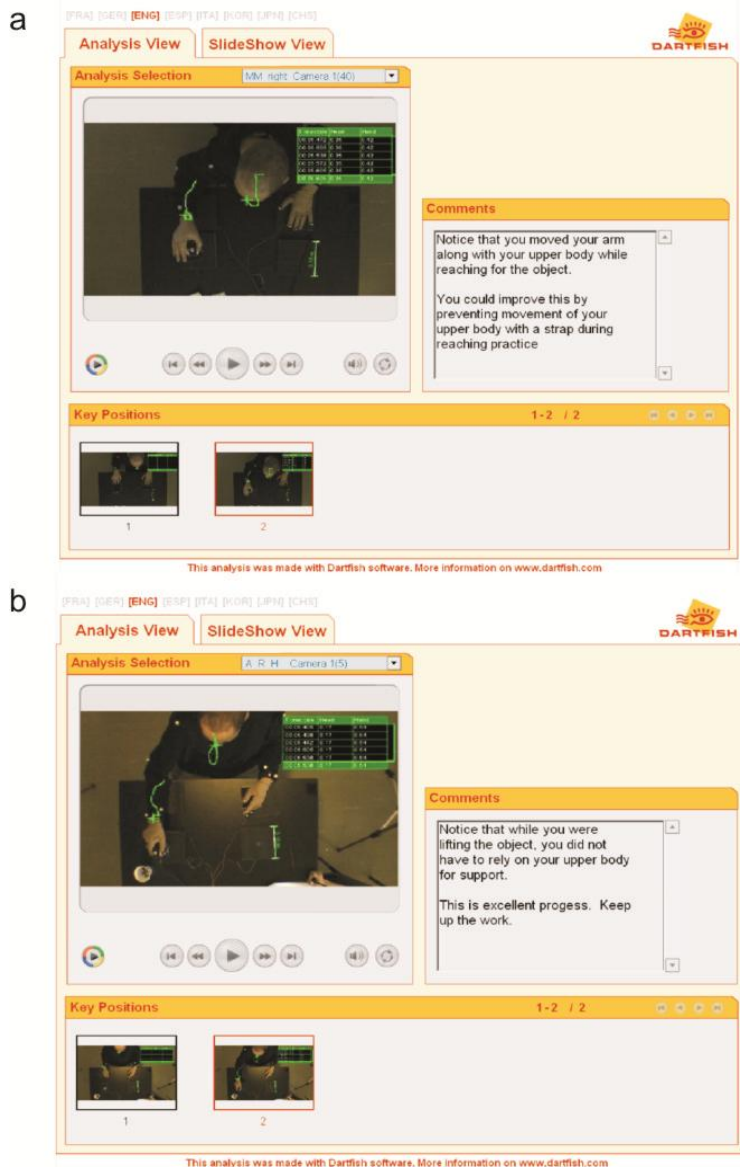


Figure 3

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### NEUROLOGICAL CASE STUDY CONTINUED.....

In contrast, during visit 2, the HH' ratio started out high, but decreased over the next 500 ms, suggesting that trunk and arm movements were coupled at movement initiation but became dissociated after the first 100 ms until later in the reach. During object lift (between on-lift and off-lift) the HH' ratio was clearly lower at visit 2 compared with visit 1, suggesting that the patient was able to uncouple trunk and arm movements during object lift. **These results demonstrate that it is possible to monitor subtle changes in a reach-to-grasp and lift movement during the course of post-stroke recovery using simple video analysis with Dartfish.**



### Mediabooks

To provide the patient with feedback about his performance during lab visits, we used Dartfish to create MediaBooks (Fig. 4). The MediaBooks allowed us to share key features of the patient's performance with him in a visually appealing format. Written and audio comments were added to videos/still pictures, and drawings and diagrams were used to emphasize aspects of movement that improved, and those that need special attention. The file can be sent via email or burned on a CD and given to the patient. MediaBooks can serve as a reference for what the patient needs to work on at a given point in their recovery, and thus provide powerful feedback for self-monitoring and goal-setting. They can also be useful to visually record and track a patient's progress over the course of recovery and to communicate the information easily to various members of the patient's health-care team.

### Technical Practical Tips

Practical tips for measuring displacements of the head and hand:

- > Camera positions needed to be set so that they would be the same across the two visits.
- > Starting positions also needed to be standardized across trials and visits.
- > Dark apparel on which reflective markers were affixed provided for good contrast to easily track the position of the markers. Good lighting further heightened the contrast.

Figure 4

### MUSCULOSKELETAL CASE STUDY

This research project by Edward Li demonstrates the use of Dartfish to quantify changes in shoulder range-of-motion with two types of treatment in subjects with non-traumatic shoulder pain. Non-traumatic shoulder pain is a common complaint among middle-aged adults that leads to a decrease in shoulder range-of-motion and arm function. The purpose of this study was to investigate whether a novel therapeutic protocol designed for the rehabilitation of non-traumatic shoulder pain using a videogame console, the Nintendo Wii, would lead to similar improvement in pain-free shoulder range-of-motion as with conventional therapy.

#### Background Literature

Non-traumatic shoulder pain, also known as subacromial impingement syndrome, is a very common cause of shoulder pain. It occurs due to an imbalance between the deltoid muscles which act to raise the humerus upward, the rotator cuff muscles (supraspinatus, infraspinatus, and teres minor, subscapularis) which are responsible for downward rotation of the humerus, and the scapular stabilizers (trapezius, serratus anterior, rhomboids, levator scapula and pectoralis major) which stabilize the scapula against the rib cage and vertebral column, and provide a stable base for movements of the humerus. Imbalance occurs when inactivity of the scapular stabilizers leads to forward and upward rotation of the scapula altering the direction of the glenoid fossa. Overactive deltoids force the head of the humerus to ride above the glenoid fossa and impinge on the tendons of the rotator cuff muscles which are attached to the superior aspect of the humeral head (Herrera and Stubblefield 2004). Restoration of the balance between these muscle groups is the basis for treatment of non-traumatic shoulder pain (Cailliet 1991). Conventional therapy protocols typically focus on strengthening the scapular stabilizers and rotator cuff muscles.

While conventional therapy is effective it demands a high degree of motivation. Individuals who are not highly motivated are often non-compliant as they perceive the exercises to be repetitive and boring. Anecdotal evidence from individuals who used the Wii Sports games to supplement their therapy suggested that there was noticeable improvement in shoulder pain in these individuals (Personal communication, Herrera 2007). Hence we hypothesized that training the same movements as are trained during conventional therapy using a Nintendo Wii gaming console would provide an interactive and fun complement to conventional therapy for the treatment of non-traumatic shoulder pain. Since the movements performed using the Wii are resistance-free we reasoned that excessive strain on muscles could be avoided if repetitions were limited and proper form was used, and that repetitive movements may no longer seem as tedious to someone absorbed in playing a game.

#### Use of Dartfish

Dartfish was used to measure pain-free shoulder range-of-motion (ROM) before starting and after completion of the 6 week, 12 session protocol of conventional therapy versus the Wii protocol in 13 subjects. 5 subjects were randomized to receive conventional therapy and 8 were assigned to the Wii protocol. Pain-free shoulder ROM was recorded in the frontal, sagittal, and horizontal planes. The subject's arms, neck, and chest were covered in dark apparel to contrast with reflective markers positioned on the acromioclavicular (AC) and elbow joints. Three trials of ROM in each plane were recorded on video in 10 second clips using Dartfish. **Dartfish's tracking feature enabled the shoulder angle to be tracked to provide an objective measure of change in ROM with the two protocols.**

#### Results:

Figure 5 shows the shoulder angles from one subject who completed the Wii protocol. At the start of the study he complained of left shoulder pain that was 8/10 at its worst on a visual analog scale, and reported excessive joint stiffness and restricted shoulder ROM. At final assessment, shoulder pain had decreased to 3/10 at its worst and he no longer reported stiffness or limitation in shoulder ROM. Pain-free shoulder ROM in the frontal plane from the initial (Fig. 5a) to the final visit (Fig. 5b) increased by 43.7°.

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**MUSCULOSKELETAL CASE STUDY CONTINUED.....**

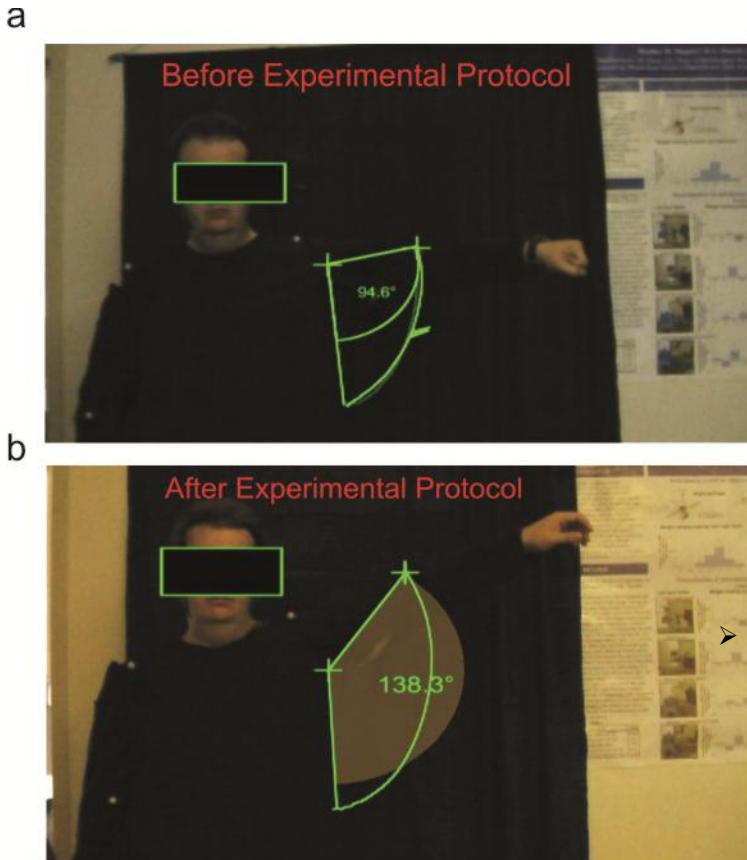


Figure 5

On average, across all subjects, pain-free ROM increased significantly after both conventional therapy and the Wii protocol in the frontal and sagittal planes, but not in the horizontal plane, and there was no difference between the two groups (Figure 6). Horizontal plane movements are typically not affected by shoulder impingement syndrome. The results suggest that a novel approach to treatment using structured protocols with gaming consoles, may be used to complement and to supplement conventional therapy for chronic non-traumatic shoulder pain.

**Technical Practical Tips:**

To accurately measure range of motion:

- >> A standard position for subjects is required
- > Camera positions must be standardized and focused on the same point of view
- > Reflective markers are useful to map movement trajectories
- > Subject should be provided a standard dark outfit worn over cloths to allow reflective markers to stand out.
- > Photographic lighting may help visualize the markers more clearly for tracking.

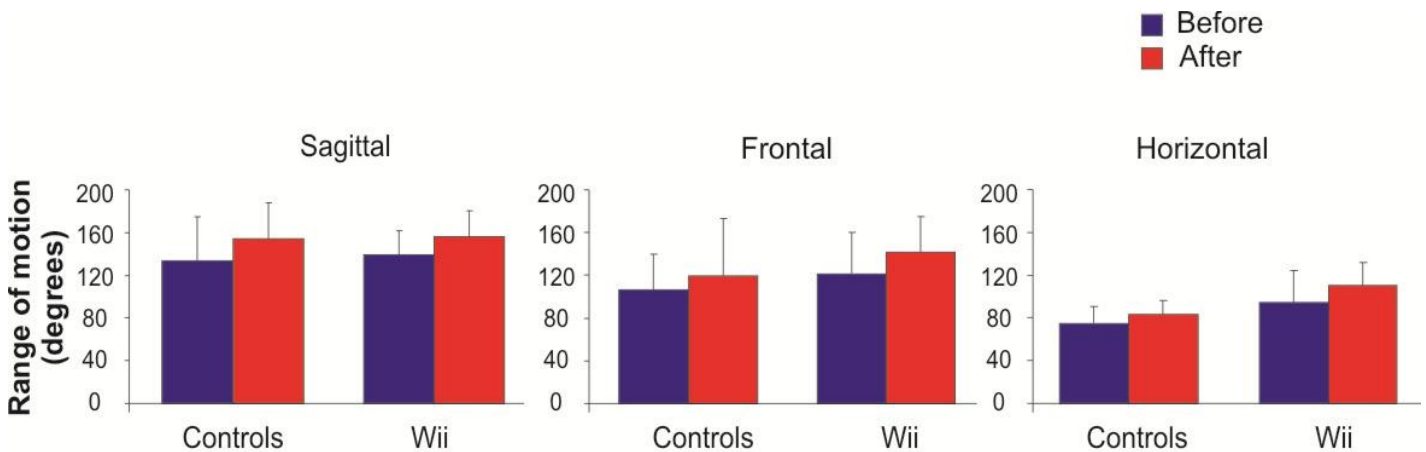


Figure 6