INTRODUCTION

Nearly 795,000 people suffer from a stroke each year [1]. Individuals that survive the stroke often suffer from hemiparesis, which is a weakness on one side of the body. This weakness inhibits patient ability to complete daily and basic tasks, which reduces their quality of life.

It has been previously hypothesized that weakness on one side of the body results in atypical hand movement patterns. As a result, stroke patients attempt to compensate using all available movement strategies [2]. Stroke patients are able to complete certain tasks using these compensations due to the natural redundancy of the musculoskeletal system. However, these compensatory strategies often involve using the affected side much less, so therapists believe that continually using compensation methods limits recovery after stroke [2]. To help aid in their recovery, therapists are developing new methods to treat stroke patients and help them regain motor function.

Evaluations of the effect that a therapy has on a stroke patient falls into two broad categories: qualitative or quantitative [3]. In addition to being designated as qualitative or quantitative measures, stroke outcome measures can be further broken down into which of the three levels of human functioning they test: body function, activity, and participation [4]. Measures testing the functions of body systems including psychology represent the level of body function. The activity classification is used on measures that test the subject’s execution of a specified task. Last, the participation classification is used to describe measures that involve an individual in a life situation [4].

When measuring the effect of a therapy on a stroke patient, a few of these measures are chosen across all categories. While body function measures such as the Fugl-Meyer Assessment of Motor Recovery after Stroke and the Modified Ashworth Scale are widely used and internationally accepted metrics, activity measures such as the Wolf Motor Function Test have been reported to have varying estimates of reliability [4]. Another outcome measure using kinematic analysis has been shown to be both reproducible and reliable for basic upper extremity reaching tasks. As such, kinematic analysis may provide a more thorough measure of task analysis to determine the effectiveness of a therapy [3].

OBJECTIVE

This study is a preliminary portion of the overall study that will occur at a later date. The overall study involves a new method of therapy, but the effectiveness of the therapy needs to be determined before and after the therapy. The preliminary study’s purpose is to create and validate a reflective marker model that will use a 3D capture system to track three subject tasks: reach to point, reach to can, and reach to box. An additional objective was create several MATLAB codes to calculate several kinematic variables of interest.

SUCCESS CRITERIA

For this preliminary study to be considered a success, several criteria must be met. First a reflective marker model must be developed and validated to capture motion for all three tasks. Data must be obtained to validate the flexion/extension, abduction/adduction, and the external/internal rotation of the shoulder joint as well the flexion/extension angles of the elbow joint for all 3 tasks. The model must also be able to be used to calculate some kinematic measures of interest.

METHOD

The model was created by placing 48 reflective markers on bony landmarks of the upper extremity on a subject. Of the 48 markers, several were composites of marker clusters, which each contain 4 markers. Two subject was used to test the model. After the markers had been placed on the subject, the subject was placed on a backless bench with armrests level with a table. The subject’s knees and elbows were flexed to 90 degrees with their feet flat on the floor. Starting hand position was determined to be at the edge of the table with the palms facing down. Ending position was determined by placing a target at 80% of the subject’s arm length from the chest on the table.

Data collection was done through use of a 100 Hz 14 camera Vicon Motion Capture System. The system uploaded marker positions to Motion Monitor, which used the data as well as anthropometric data to create a virtual skeletal model. Data was collected for three tasks. In the reach to point task, the subject reaches to the end position and returns. The reach to can task calls for a 12 oz soda can to be placed at the end position. The subject then reaches for the can, grasps the can, lifts the can up, brings it back down, and returns. The same motion is made for the reach to box task, with the exception of using two hands to make the motion with a box instead of a can. Flexion/extension for the shoulder and elbow and abduction/adduction angles for the shoulder were measured at the starting and ending positions using a goniometer. Motion Monitor was used to directly calculate the angles during the three tasks. Kinematic data was then exported to MATLAB for analysis.

Several kinematic measures of interest were calculated. They are the start and end of motion, the peak hand velocity, the motion time, T10 displacement, and index of curvature (IOC). Within the full motion, measures are calculated for both the forward and reverse motions. The start of motion was
defined as the time point where the hand velocity exceeds 5% of peak hand velocity. End of motion is the time point where the hand velocity returns below 5% of peak hand velocity. Peak hand velocity was defined as the highest velocity and where the acceleration changed over from a positive acceleration to a negative acceleration. T10 displacement is the displacement of the marker positioned at T10. IOC represents the ratio of the actual hand path the subject used during the reach motion to a straight line from the starting to ending positions.

RESULTS

Due to a Motion Monitor error, data for the left hand was corrupted, so the data for the reach to box motion could not be analyzed. As a result, data was only collected for the right hand for both the reach to point and reach to can tasks. In addition, markers were not placed at T10 or the end point, so neither T10 displacement, nor IOC could be computed. Reach to can results were found to be similar but were not included. Figure 1 shows the angular data for the reach to point task for the right hand.

![Figure 1: Shoulder and elbow angles during right reach motion.](image)

During the reach, elbow flexion, shoulder external rotation, and shoulder abduction all decrease, while the shoulder flexion increases. Start and end angles of the trial were consistent with goniometer readings. To calculate the kinematic measures, a velocity profile must be constructed. Figure 2 shows the hand velocity profile of a single reach to point motion. From this, the peak velocity of the forward was found to be 0.983 m/s. By taking 5% of the peak velocity, the start and end of motions were found to be at frames 568 and 628. This leads to the time of the forward motion to be 60 cs.

DISCUSSION

According to the results, the beginning and ending angles from the goniometer matched those exported through motion monitor. This validates the model for the initial angles. The angles during the motion were validated through visual inspection. When the shoulder physically flexed, the angle exported by Motion Monitor did as well. In addition, the elbow flexion and the shoulder flexion are anti-phase which must happen during the reach to point motion. As such, the model was determined to have been successful in determining the angles during motion.

The velocity profile showed that the reach to point motion could be captured, and the kinematic measures relating to the velocity profile could be calculated. It should be noted that the same process was used to validate the angles and calculate measures of the velocity profile for the reach to can motion.

Limitations of this preliminary study include the small sample size and the inability to quantitatively validate angles during the motion. For all measures currently tested, the model has been validated; however, additional experiments are necessary with addition of the T10 marker and the end tape position to further validate the model.

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REFERENCES


