

## Measurement of Shoulder and Trunk Movements in Hemiplegic Participants Using a System for Collecting Motion Data

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**Abstract**—Upper limb and trunk functionalities are important for performing activities of daily living, such as eating, drinking, clothing and personal care. However, hemiplegic patients impair upper extremity functionalities, the activities are performed by using compensatory movement strategies. Recently, Takahashi and Murata et al. developed a system for collecting motion data with a cloud service. The purpose of this study was to investigate whether clinical application of this system for collecting motion data is available as assessment for hemiplegic patients. Two hemiplegic participants and one healthy participant performed drinking task, and the angles of shoulder abduction and trunk flexion were calculated. Angles of shoulder abduction and trunk flexion during drinking between non-paretic and healthy sides were similar, however, the larger angles of shoulder abduction and trunk flexion during drinking by paretic side showed compared with them by non-paretic and healthy sides. We believe that this system will be available as a quantitative assessment of activities of daily living in patients with disabilities.

**Keywords**—rehabilitation treatment; activities of daily living; disability; functional recovery.

### I. INTRODUCTION

Upper limb functionality is important for performing Activities of Daily Living (ADL). However, patients who have suffered neurological damage owing to stroke may have impaired upper extremity functionality (hemiplegia), then the activity must be performed by using compensatory movement strategies. Therefore, hemiplegic patients needed the rehabilitation treatments to improve upper limb and compensatory functionalities. Thus, to assess the movements of upper limb and trunk when performing ADL is important to evaluate impairment severity and help in the design of physical and occupational therapy interventions tailored to hemiplegic patients.

Recently, many researchers have tried to estimate physical activities from acceleration and/or gyro sensor data obtained from wearable devices and/or smart phones. In addition, Zhang et al. developed a cyber-physical system for patient-centric healthcare applications and services that was built on cloud and big data analytics technologies [1]. The system consisted of a data collection layer, a data management layer and an application service layer to collect

and follow up on many kinds of big data. It used a security tag to maintain security. Doukas et al. also proposed a mobile system that enables electronic healthcare data storage, update and retrieval using cloud computing [2]. A mobile application was developed using Google's Android OS and Amazon's S3 to provide management of patient health records and medical images. Based on the above background, Takahashi et al. developed a system for collecting motion data using Google Firebase service [3]. The system collects and stores sensor and video data synchronously, and allows appropriate persons to access stored motion data. The number of subjects in previous studies for a quantitative assessment of movement, such as three-dimensional (3-D) motion analysis is relatively small [4][5]. However, we believe that the system developed by Takahashi et al. can be expected collecting big data. The collecting big data may allow a better understanding of limbs and trunk functionality for performing ADL and help in the design of physical and occupational therapy interventions tailored to hemiplegic patients.

The purpose of this study was to investigate whether clinical application of a system for collecting motion data is available as assessment on rehabilitation treatment for hemiplegic patients.

In Section II, the method in this study is explained. The results are outlined and discussed in Section III. Conclusion and future work are described in Section IV.

### II. METHODS

Two hemiplegic adult participants and one healthy adult participant were participated in this study. The upper limb functionalities in hemiplegic participants were assessed with Fugl-Meyer Assessment of Upper Extremity (FMA-UE). The arm impairment can be classified based on FMA-UE scores between 39 and 57 (moderate impairment) and 58 to 64 (mild impairment) in accordance with previous report [4]. Hemiplegic participant A had moderate arm impairment (FMA-UE scores: 43) and hemiplegic participant B had mild impairment (FMA-UE scores: 59). All participants could drink a cup of water without assistance. Participants performed drinking task three times on both sides, respectively. The angles of shoulder abduction and trunk flexion during second task were calculated. The task was

performed in the following steps: 1) reaching out for the cup, 2) grasping and transporting the cup forward to the mouth, 3) drinking, 4) transporting the cup backward to the pickup point, and 5) returning the hand to the initial position [5]. Shoulder and Trunk movements were measured with a 3-D-gyro sensor. We used two SONY Smart Watch 3 units as the 3-D gyro sensor [6]. 3-D gyro sensors were placed on the L1 spinous process and upper arm (see Figure 1).



Figure 1. Wearable device placements.



Figure 2. Recording of movie during drinking

The movies during drinking were recorded by the tablet-type device that accepted to 3-D gyro sensors (Figure 2). The data were expressed in relation to the percentage of the drinking task cycle that had lapsed (0–100% of the drinking task cycle).

### III. RESULTS AND DISCUSSION

Figure 3 showed the data of changes of angle on shoulder abduction (Figure 3A) and trunk flexion (Figure 3B) during drinking. Time of drinking by paretic side was longer than by non-paretic side in each hemiplegic patient.

Figure 4 showed angle of shoulder abduction (Figure 4A) and trunk flexion (Figure 4B) during drinking on normalized times. Angles of shoulder abduction and trunk flexion during drinking between non-paretic and healthy sides were similar, however, the larger angles of shoulder abduction and trunk flexion during drinking by paretic side showed compared with them by non-paretic and healthy sides.

In this study, we measured shoulder and trunk movements in two hemiplegic participants using a system for collecting motion data with a cloud service, and found that the larger angles of shoulder abduction and trunk flexion during drinking by paretic side compared with non-paretic and healthy sides. In general, 3-D imaging measurement technique is powerful tool for a quantitative assessment of movement in all degrees of freedom, previous studies have reported that movement when drinking for hemiplegic patients using 3-D motion analysis. In fact, some studies revealed that larger shoulder abduction in hemiplegic patients compared with healthy individuals [4][5]. In addition, we insist that angle of shoulder on normalized time during drinking (Figure 4A) in this study was similar to that using 3-D motion analysis [5]. Also, trunk movement has been reported to have a significant correlation with stroke impairment severity [4][7]. This was confirmed in this study, i.e., the difference of trunk flexion between paretic and nonparetic sides in hemiplegic participant with moderate impairment level was larger at 20% during drinking than that in hemiplegic participant mild impairment level (Figure 4B). Alt Murphy et al. [4] purposed that compensatory trunk movements should be considered as an essential part of movement patterns after stroke and included in evaluation models.

Finally, we suggest that using of a system for collecting motion data with a cloud service reflect more real physical activities and/or functionalities.

### IV. CONCLUSION AND FUTURE WORK

We believe that a system for collecting motion data with a cloud service will be available as a quantitative assessment of ADL in patients with disabilities. The future work must assess of the reliability of data obtained from this system. In addition, to be more developed this system need to investigate many patients who have suffered neurological damage owing to stroke and cervical spinal cord injuries.

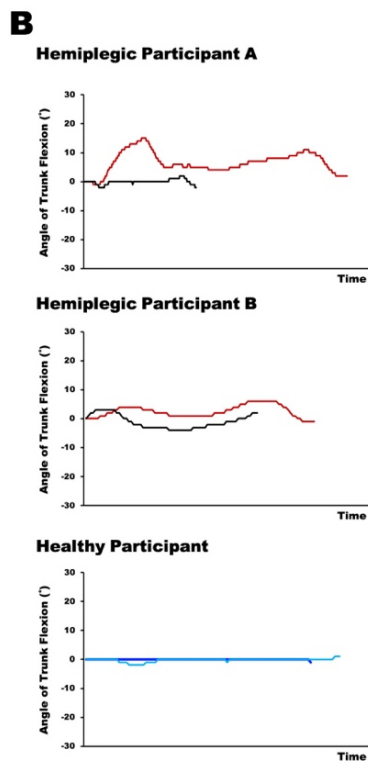
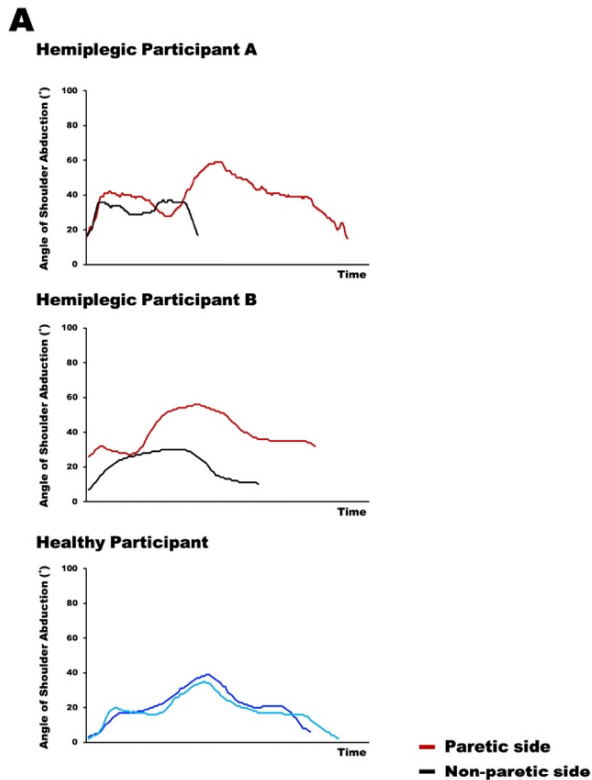


Figure 3. Raw data of shoulder (A) and trunk (B) in two hemiplegic participants and one healthy participant obtained from wearable devices.

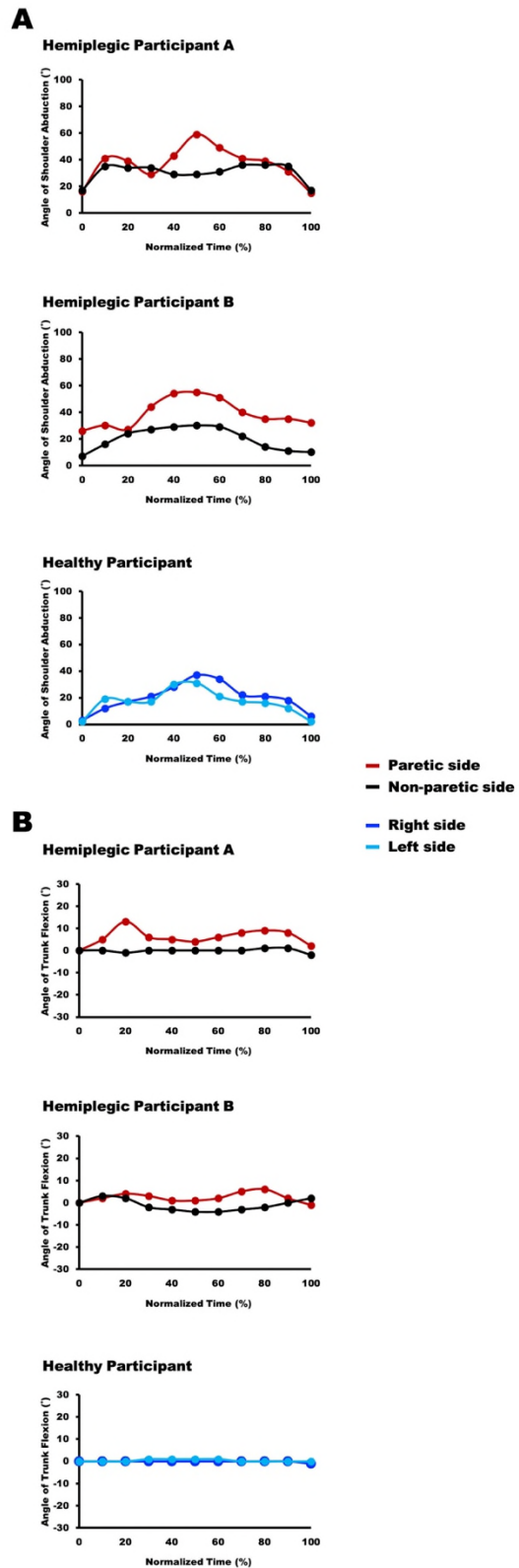


Figure 4. angles of shoulder (A) and trunk (B) on normalized time.

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#### REFERENCES

- [1] Y. Zhang, M. Qiu, C. W. Tsai, M. M. Hassan, and A. Alamri, "Health-CPS: Healthcare cyber-physical system assisted by cloud and big data", *IEEE, SystemsJournal*, vol. 11, no. 1, pp. 88-95, 2017.
- [2] C. Doukas, T. Pliakas, and I. Maglogiannis, "Mobile healthcare information management utilizing cloud computing and android OS", *IEEE, 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology*, pp. 1037-1040, 2010.
- [3] R. Takahashi, Y. Murata, and O. D. A. Primal, "A system for collecting motion data on patients' activities of daily living", unpublished.
- [4] M. Alt Murphy, C. Willén, and K. S. Sunnerhagen, "Kinematic variables quantifying upper-extremity performance after stroke during reaching and drinking from a glass", *Neurorehabilitation and Neural Repair*, vol. 25, no. 1, pp. 71-80, 2011.
- [5] K. Kim, et al., "Kinematic analysis of upper extremity movement during drinking in hemiplegic subjects", *Clinical Biomechanics*, vol. 29, no. 3, pp. 248-256, 2014.
- [6] SONY Smart Watch 3, <https://www.sonymobile.com/global-en/products/smart-products/smartwatch-3-swr50/#gref>, [retrieved: January, 2019].
- [7] G. Thielman, T. Kaminski, and A. M. Gentile, "Rehabilitation of reaching after stroke: comparing 2 training protocols utilizing trunk restraint", *Neurorehabilitation and Neural Repair*, vol. 22, no. 6, pp. 697-705, 2008.