Information Engineering Express
International Institute of Applied Informatics
2017, Vol.3, No.2, P.69 - 77

Measurement of Sitting Pressure Distribution with Gradient Changes for Wheelchair Users

Satoshi Ohashi *, Akito Shiogo †,
Kenta Kaito ‡, Akira Shionoya §

Abstract

The purpose of my work was to limit the spread of the wheelchair accident by using the information and communication technology (ICT). This paper presents the changing situation of the seating pressure distribution on wheelchair users by variations in the gradient of the road surface. The measurement experimentation of seating pressure distribution was recording the traveling state of a wheelchair using both an acceleration sensor and an angular velocity sensor. To estimate the effect of changing the attitude of an occupant by a change in slope surface state and to cope with the improving safety. As a result, the traveling on the slope was found to have effects on the more than about average 7 times in the variation in pressure distribution from front-back direction in comparison to traveling on the flat road. In conclusion, the results of the study can be used to support maintenance of posture by wheelchair users.

Keywords: Assistive Technology, Wheelchair, Seating Pressure

1 Introduction

Assistive technology helps people who have difficulty speaking, seeing, hearing, typing, writing, remembering, learning, pointing, walking, and many other things [1][2][3][4]. These technologies have become a crucial factor in the Improvement of quality of life (QOL), especially in the fields of medical treatment, rehabilitation, and welfare. Assistive technology devices and services assist person with disabilities (PWDs) to enhance their abilities and increase their level of independence, and enables PWDs to engage in daily life activities [5][6][7][8]. In addition, an integrated and collaborative approach for wheelchair propose for aid the elderly or disabled in a better way, not merely a navigation tool [9]. While wheelchair is available in daily life activities, there has been little discussion of how to address these issues in adverse situations of wheelchair users by changes in road conditions [10]. To address this issue, the important role of assistive technology in Japan's declining birthrate and aging society, we are working the research and development of assistive technology intended for wheelchair users and caregivers [11].

* National Institute of Technology, Tomakomai College, Hokkaido, Japan
† Fujitsu FSAS Inc., Kanagawa, Japan
‡ Nagaoka University of Technology, Niigata, Japan
§ Nagaoka University of Technology, Niigata, Japan

The purpose of our work was to limit the spread of the wheelchair accident by using the information and communication technology (ICT). In this paper, we focus on influence of posture by wheelchair passengers when driving the descending slope. Therefore, we examine the changing situation of seating pressure distribution on wheelchair users by variation in gradient of the road surface. The measurement experimentation of seating pressure distribution is recording the traveling state (acceleration, angular velocity) of a wheelchair at a time, too.

2 Method

2.1 Measuring instrument

In the experiment, a pressure detecting sheet and a small type sensor are employed to find the relationships between variations in the gradient of the road surface and the changing situation of the seating pressure distribution.

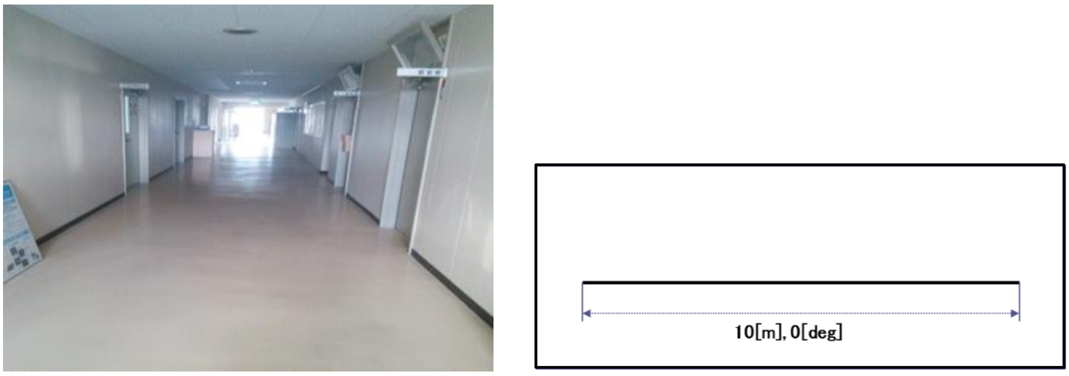
The measuring of seating pressure distribution uses "SR SOFTVISION" made by Sumitomo Riko Company Limited. The sheet size is 450×450 [mm]. The seating pressure distribution measure at 256 pressure sensor elements in the pressure detecting sheet. The measurement range of pressure value is 0 ~ 200 [mmHg]. The pressure detecting sheet (SR SOFTVISION) is illustrated in Figure 1. The measuring of angular velocity uses “SimpleLink SensorTag " made by Texas Instruments Incorporated. The SimpleLink SensorTag includes 10 low-power MEMS sensors in a package. The size is 50×67×12 [mm]. Network connection is supported Bluetooth Smart, 6LoWPAN and ZigBee. The small type sensor(SensorTag) is illustrated in Figure 2.

Figure 1: The pressure detecting sheet

Figure 2: The small type sensor

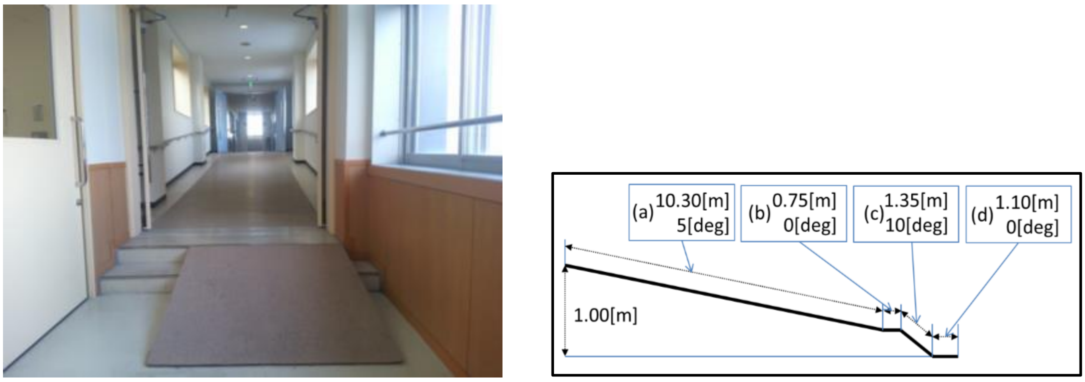
2.2 Measurement experimentation

In the measurement experimentation, seating pressure distribution and acceleration are measured both a flat road and a slope using "SR SOFT VISION" and SensorTag". The number of measurements is per person five times. The measurement data acquire from healthy adult men of 10 subjects. The experiment locations are illustrated in Figure 3 and Figure 4. The label (a) in the Figure 3 and Figure 4 illustrates pictures of the experiment location. The label (b) in the Figure 3 and Figure 4 illustrates the sectional view of a flat road and a slope. The values in the figure show the distance and the angle in degrees.



(a) location (b) Sectional view

Figure 3: Flat road



(a) location (b) Sectional view

Figure 4: Slope

3 Results

3.1 Angular rate change

The results of the measurements by an angular velocity sensor are illustrated in Figure 5 and Figure 6. Those graphs show an example of a representative result of one subject. The graph in Figure 5 illustrates the three-axis angular rate change on the flat road. It can be confirmed that no significant change occurs in the angular velocity of the three-axes. The graph in Figure 6 illustrates the three-axis angular rate change on the slope. It can be confirmed that the angular velocities of the three-axes are changed as compared with Figure 5. Points (a) to (d) shown in Figure 6 correspond to points (a) to (d) of variation in gradient of the road surface in Figure 4. In particular, it can be confirmed that the angular velocity in the pitch direction has points (c) and (d) where a large change of 10 times or more occurs. Table 1 shows the average of the all three-axis angular rate data. We see from Table 1 that the angular rate average of the slope is five to ten times more than the flat road. Especially, the pitch direction most affected by the gradient change is changed by about 10 times.

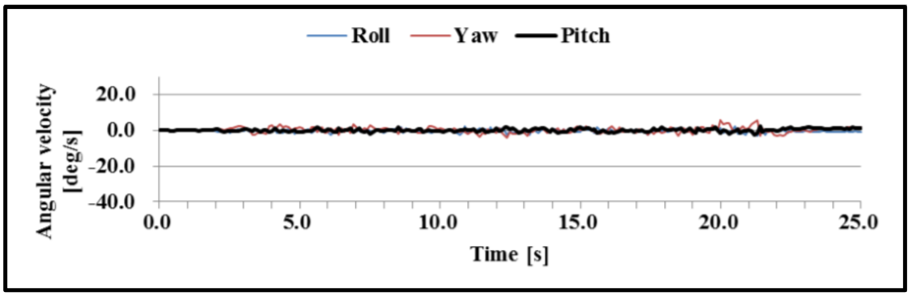


Figure 5: Angular rate change on the flat road

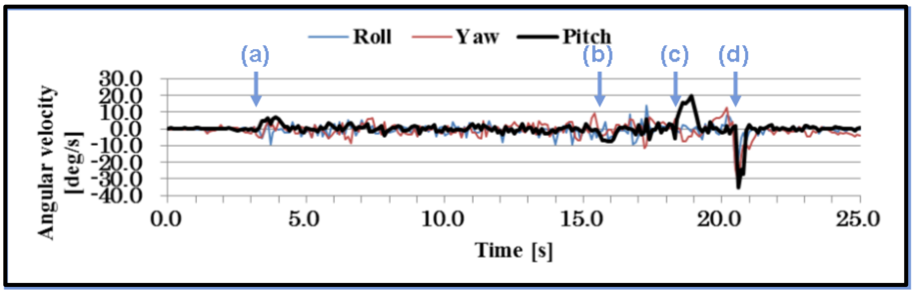


Figure 6: Angular rate change on the slope

Table 1: Average of angular rate

Rotation direction	Roll		Yaw		Pitch	
	+	-	+	-	+	-
Flat [deg/s]	3.9	3.7	6.2	4.8	2.3	2.3
Slope [deg/s]	32.3	23.5	36.0	38.4	20.8	32.8

3.2 Variation in seating pressure distribution

Figure 7 shows the variation in seating pressure distribution of a subject for three seconds (18.0-21.0[s]) in Figure 5. Similarly, Figure 8 shows the variation in seating pressure distribution of a subject for three seconds (18.0-21.0[s]) in Figure 6. The time interval of pressure measuring is 0.6[s]. The distance between the grids is 28.125 [mm]. The color scale of pressure distribution chart shows the variation with pressure from white color (0 [mmHg]) to red color (200 [mmHg]). A center position of pressure was calculated from the measurement data. The center position of pressure is a circular mark shown near the center in the pressure distribution. Then, the moving distance of the center position of pressure in the Front, Rear, Left and Right directions is illustrated in Table 2. As a result, the changing of the seating pressure distribution on wheelchair users by variations in the gradient of the road surface was about average 10 times higher in the front. Also, the rear was about average 7 times higher.

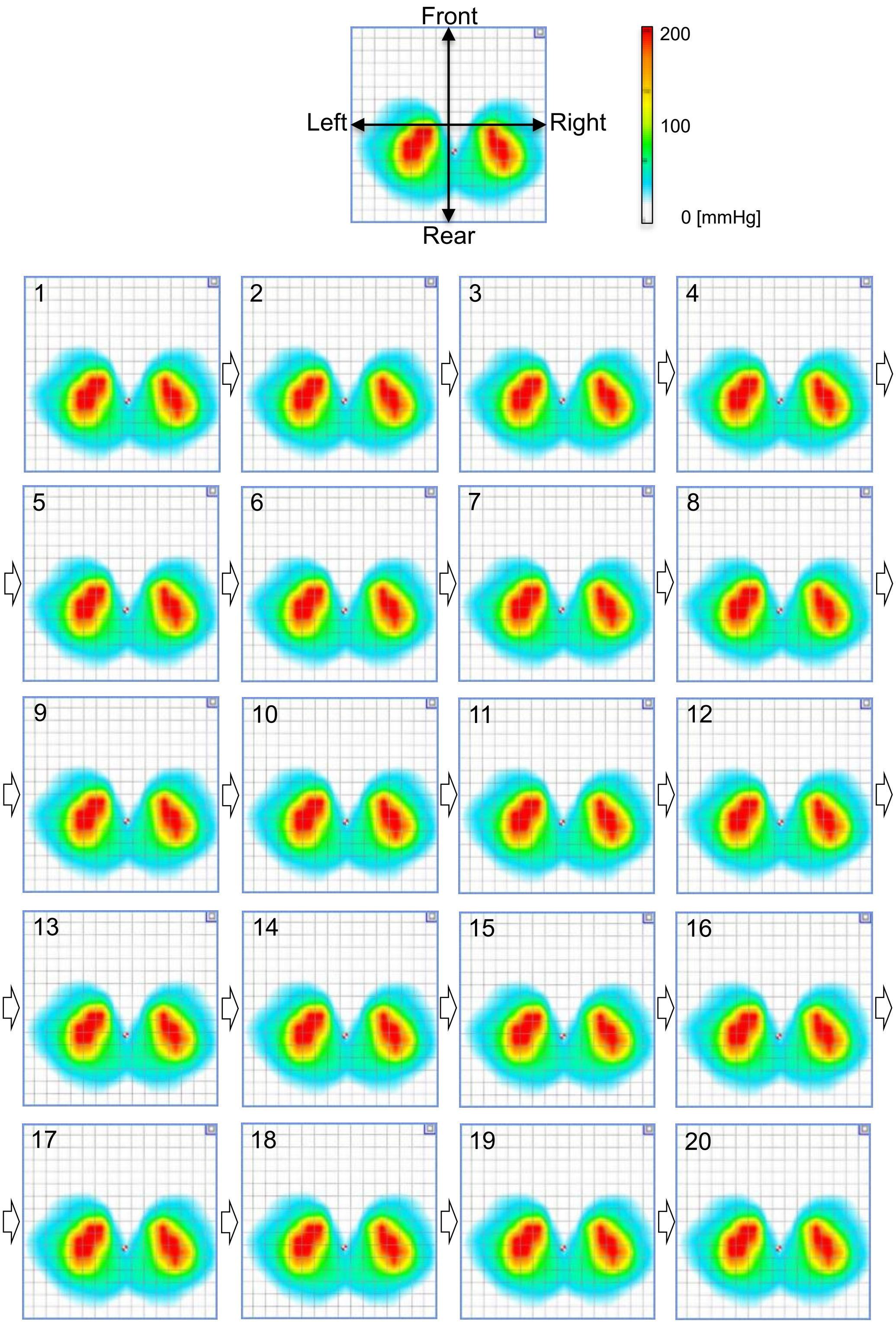


Figure 7: Seating pressure distribution on the flat road

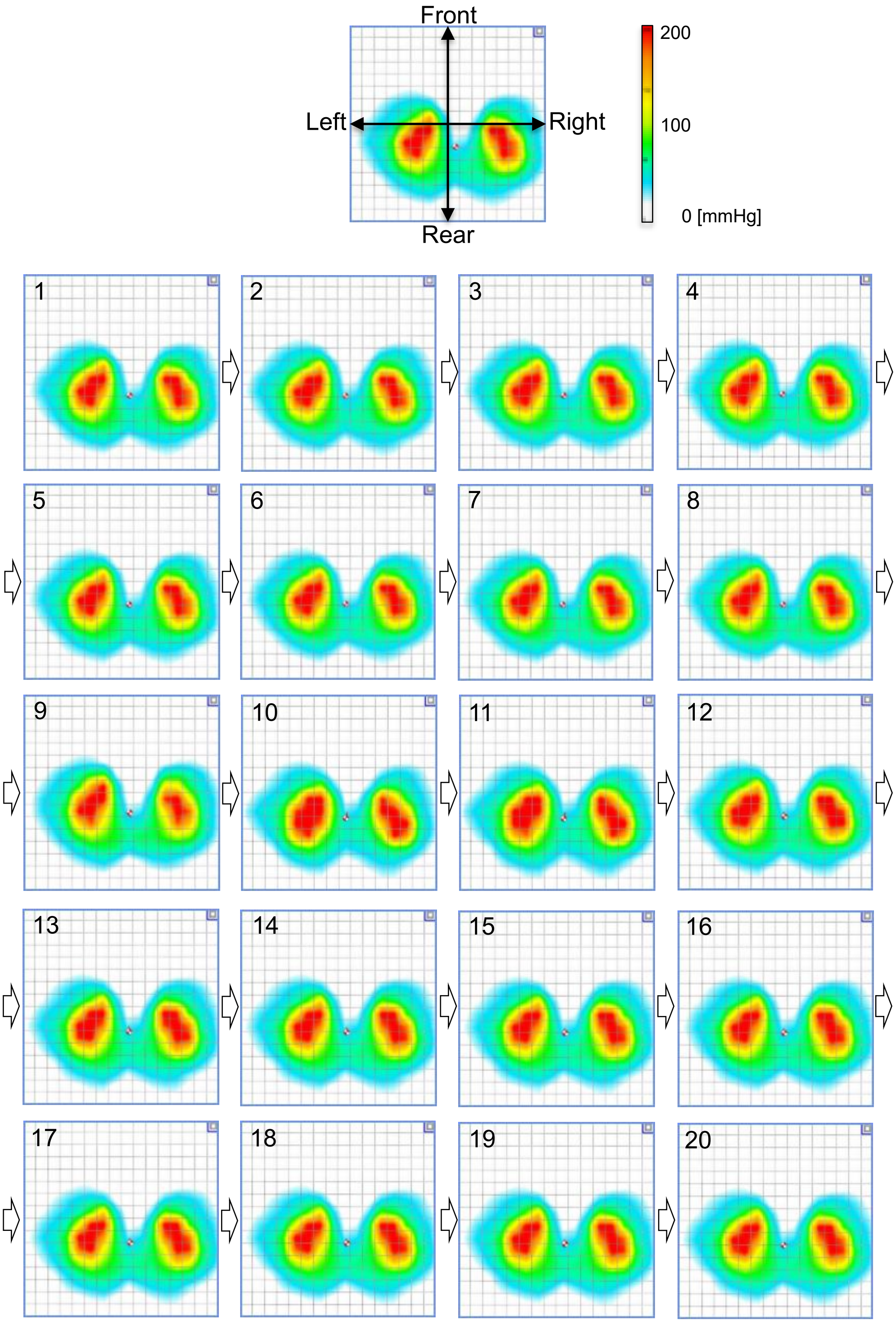


Figure 8: Seating pressure distribution on the slope

Table 2: Central position of the pressure

Direction		Front	Rear	Left	Right
Average [mm]	Flat	1.08	0.95	1.46	1.47
	Slope	10.95	6.56	4.29	4.67
Maximum [mm]	Flat	3.52	3.17	3.08	2.06
	Slope	24.03	11.44	8.80	10.01
Minimum [mm]	Flat	0.24	0.24	0.38	0.53
	Slope	3.36	2.88	2.06	1.89

4 Discussion

In this paper, we focus on the influence of posture by wheelchair passengers when driving the descending slope, it reports on the changing situation of seating pressure distribution of wheelchair users by variation in gradient of the road surface. From the measurement results, in a road surface condition with a gradient change of 10 degrees, the moving distance of the center position of pressure compared to a flat road was increased more than about 7 times in an anteroposterior direction. The timing of a change in the seating pressure distribution is consistent with results the traveling state (acceleration, angular velocity) of a wheelchair. In particular, the vibrations and impacts are more heavily added from the wheelchair to a passenger when the casters of wheelchair pass through of positions with the gradient change. As a result, the impact appears in the change of the attitude of the passenger. Also, when the wheelchair is traveling downhill slope, since the attitude of the passenger leans in the front direction, the attitude becomes increasingly difficult to maintain. In this case, the elderly peoples and PWDs with weak muscular strength have a risk of falling out of the wheelchair, they have to fast one's seat belt tight. We propose to distinguish passenger's posture situations into four types of A, B, C and D. A is "normal". B is "don't affect slippage of the attitude in a direct". C is "do affect slippage of the attitude in a direct". D is "risk of falling out". Consequently, at the time of the descending slope travel of the wheelchair in where gradient change occurs, the risk of distinction C is accompanied. In the case of elderly people with weak muscular strength and persons with disabilities, it is also necessary to consider the risk of D. In summary, the results of this study suggest that the possibility of being data which quantitatively evaluated the change of the seating position and the boarding posture on the wheelchair passengers. Measuring and evaluating the pressure distribution on a seating face is of special importance when the intense load on the passenger pose a high threat of pressure peaks or uneven load distribution.

5 Conclusions

The influence on maintenance of posture by wheelchair passengers have been investigated using seating pressure distribution measurements. Its experimentation was recording the traveling state (acceleration, angular velocity) of a wheelchair at a time, too. From the measurement results, we can conclude that if wheelchair passengers drive a descending slope accompanied by gradient changes of 5 [deg] to 10 [deg];

1. The changing of the seating pressure distribution on wheelchair passengers by the gradient change of 10 degrees is moved more than about 7 times in an anteroposterior direction.
2. The vibration and impact applied to the casters during the wheelchair will affect the seating pressure distribution of the passengers.
3. The elderly peoples and PWDs with weak muscular strength have a risk of falling out of the wheelchair.

Acknowledgement

This work was supported by JSPS KAKENHI Grant Number JP26282175 and Nagaoka University of Technology. We gratefully acknowledge the work of past and present members of our laboratory.

References

[1] A.J. Schmitt, E. McCallum, J. Hennessey, T. Lovelace and R.O. Hawkins, "Use of Reading Pen Assistive Technology to Accommodate Post-Secondary Students with Reading Disabilities," The Official Journal of RESNA, vol. 24, no. 4, 2012, pp. 229–239, doi: 10.1080/10400435.2012.659956.

[2] M.E. Wong, and S.K. Tan, "Teaching the Benefits of Smart Phone Technology to Blind Consumers: Exploring the Potential of the iPhone," Journal of Visual Impairment & Blindness, vol. 106, no. 10, 2012, pp.646-650.

[3] Y. Nishiura, T. Inoue and M. Nihei, "Appropriate talking pattern of an information support robot for people living with dementia: a case study," Journal of Enabling Technologies, vol. 8, no. 4, 2014, pp.177-187, doi: 10.1108/JAT-12-2013-0035.

[4] T.P. Garcia, B.G. González, L.N. Rivero et al., "Exploring the Psychosocial Impact of Wheelchair and Contextual Factors on Quality of Life of People with Neuromuscular Disorders," The Official Journal of RESNA, vol. 27, no. 4, 2015, pp.246-256, doi: 10.1080/10400435.2015.1045996.

[5] G. Constantinescu, I. Loewen, B. King, C. Brodt et al., "Designing a Mobile Health App for Patients with Dysphagia Following Head and Neck Cancer: A Qualitative Study," JMIR Rehabilitation and Assistive Technologies, vol. 4, no. 1, 2017, e3: pp.1-11, DOI: 10.2196/rehab.6319.

[6] T. Braun, D. Marks, D. Zutter and C. Grüneberg, "The impact of rollator loading on gait and

fall risk in neurorehabilitation – a pilot study," Disability and Rehabilitation: Assistive Technology, Vol. 10, no. 6, 2015, pp.475-481, DOI: 10.3109/.

[7] S. Yamamoto, S. Ibayashi, M. Fuchi and T. Yasui, "Immediate-term effects of use of an ankle-foot orthosis with an oil damper on the gait of stroke patients when walking without the device," Prosthetics and Orthotics International, vol. 39, no. 2, 2015, pp.140-149.

[8] K. Doughty and A. Appleby, Wearable devices to support rehabilitation and social care," Journal of Enabling Technologies, Vol. 10, no. 1, 2016, pp.51-63, doi: 10.1108/JAT-01-2016-0004.

[9] Junjun Kong, Jiannong Cao and Yang Liu et al., "Smarter wheelchairs who can talk to each other: An integrated and collaborative approach," 2012 IEEE 14th International Conference on e-Health Networking, Applications and Services (Healthcom), 2012, pp.522-525.

[10] O.O. Okunribido, "Patient Safety During Assistant Propelled Wheelchair Transfers: The Effect of the Seat Cushion on Risk of Falling," The Official Journal of RESNA, vol. 25, no. 1, 2013, pp.1-8, doi: 10.1080/10400435.2012.680658.

[11] S. Ohashi, A. Shiogo, K. Kaito and A. Shionoya, "Relationship Between Variations of the Road Surface and the Seating Pressure Distribution," The Fifth Asian Conference on Information System(ACIS2016), 2016, pp.227-228.