A STUDY ON THE MAKING OF CG ANIMATION FOR THE IMPROVEMENT OF SAFETY AND COMFORT OF TRANSFER MOVEMENTS IN WHEELCHAIR-BOUND PERSONS

Jiyoung CHOI [1], Yutaka TOCHIHARA, Etsuo GENDA

Faculty of Design, Kyushu University, JAPAN

[1]ciawase@hotmail.com

ABSTRACT:

This study proposes a computer graphics-based visualization of biological information for aiding wheelchair users to safely transfer from a wheelchair to a bathtub. Time-series of changes in transfer motion were analyzed and compared under three different motion conditions: using a bath board, using a transfer board, and using no tool in entering/exiting a bathtub. Three-dimensional motion analyses were performed on the upper body angle in different phases under each condition to identify the characteristics under each condition. Then, a 3D human body data set based on computer graphics was constructed. By applying the captured data onto a human body model, the motions became controllable, and thus, we visually showed the changes over time in the upper body angle under the three motion conditions. Furthermore, we also produced animation films to show the trajectory of the range of body motion during transfers, providing visual images that allow an intuitive understanding of the range of joint motion.

Keywords: transfer movements, CG

1. THE BACKGROUND OF THE STUDY

There is a category that is called transfer movements in the group of daily movements of wheelchair users. Transfer movement means the movements from a wheelchair to a bed, to a bathtub, or to a toilet seat. If wheelchair users are able to carry out these transfer movements without difficulties, it widens their range of activities in daily life. Usually, physical therapists and occupational therapists guide and support the transfer movement of wheelchair users. Nevertheless, in the process of the director's guidance on movement and of the wheelchair users' acquirement of transfer movements, there is the possibility for making wrong poses due to the difficulty in understanding the active range of joints during a minute or total movement of the body.

2. THE PURPOSE OF THE STUDY

This study carries out a three-dimensional movement analysis to investigate distinctive features in the transfer movement from a wheelchair to a bathtub. Using a three-dimensional CG, we propose visual image information that helps wheelchair users to understand the transfer movement.

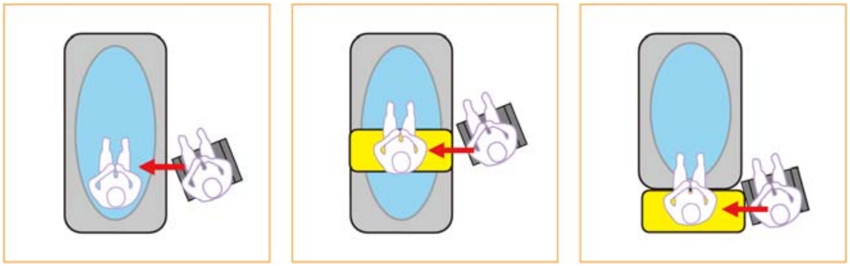
3. THREE-DIMENSIONAL MEASUREMENT OF MOVEMENT

・ Examinees

The examinees are 8 male students. Their average heights are 171.6$\pm$3.5cm and their average ages are 22.4$\pm$1.1.

・ The conditions of movement

We selected three types of movements as the conditions of movement, which are usually regarded as the fundamental transfer movements in a bathtub. All movements consist of the movement from a wheelchair to a bathtub, and in return, the movement from a bathtub to a wheelchair (Fig 1).



A B C

Fig 1: Conditions of transfer movements to a bathtub.

A: A movement from a wheelchair to a bathtub

B: A movement onto the bathboard on the bathtub

C: A movement using a transfer board

・ The conditions of the surroundings

The height from the bottom surface to the top of a side wall of the bathtub is 45cm.The height from the bottom to the top of the wheelchair seat is 45cm (Fig 2).

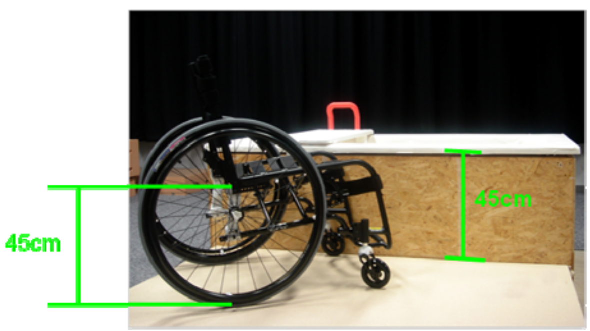


Fig 2: Conditions of the experimental surroundings

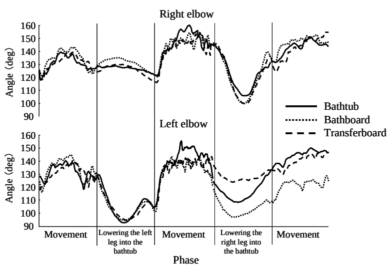
・ The Items of measurement

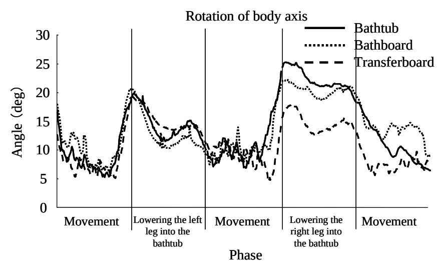
We used the MAC3D system of Motion Analysis Corporation in measuring the three-dimensional movement. After fixing reflective markers on 32 points around body joints, we measured the transfer movements in a bathtub according to the movement condition A, B, and C. And then, we analyzed the change of the elbow joint angle on either side around the upper body, the rotation angle around the body axis, and the ante flexion angle.

4. THE RESULTS OF MEASURING THE THREE-DIMENSIONAL MOVEMENT

We analyzed the movements after dividing the whole movements into 5 parts. (Movement: Lowering the left leg into the bathtub. Movement: Lowering the right leg into the bathtub.)

・ The Comparison of movements from a wheelchair to a bathtub





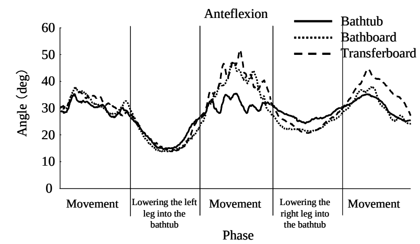
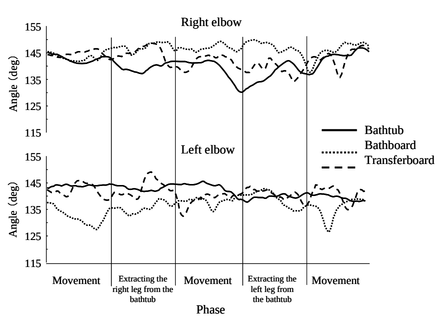
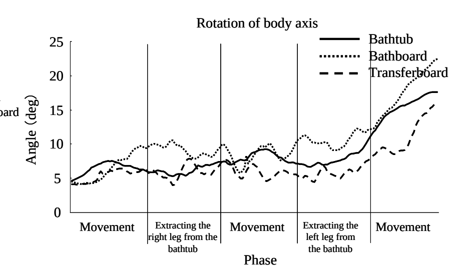


Fig 3: Elbow joint angle on either side Fig 4: Rotation angle around the body axis Fig 5: Ante flexion angle

Fig 3: Considering the elbow joint angle on either side, we can see that the movements of the right elbow differ little when going into the bathtub, but the left arm in the movement condition B shows the most outstanding flexion when lowering the right leg into the bathtub. We can see that the movement condition C shows the most outstanding extension. Fig4: If one twists one's body to the left, the rotation angle around the body axis increases. We can see that in the movement of lowering the right leg into the bathtub, one twists one's body more in the movement condition A and B than in the movement condition C. Fig 5: As for the ante flexion angle, compared with the movement condition B and C, the movement condition A is accompanied by the ante flexion of the upper body with the movement of the pelvic region during the process of lowering the right leg into the bathtub.

・ The comparison of Transfer movements from a bathtub to a wheelchair





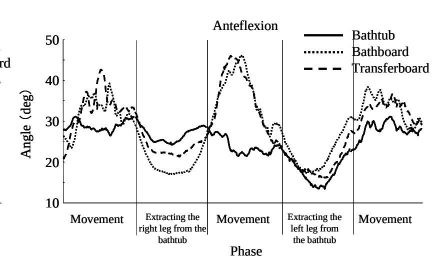


Fig 6: Elbow joint angle on either side Fig 7: Rotation angle around the body axis Fig 8: Ante flexion angle

Fig 6: The change of the elbow joint angle on either side is limited between 10° and 20° in every movement condition, which means a little change of angle. Figu7:The rotation angle around the body axis in each movement condition of A, B, and C differ little in the body twisting, differing from the transfer movements of the body into the bathtub. Fig 8: As for the ante flexion angle, we can see that the upper body bends further forward in the movement condition B and C than in the movement condition A. In addition to that, when one extracts one's right leg from the bathtub, in the opposite way, the upper body bends further forward in the movement condition A than in the other conditions.

5. VISUALIZATION OF BATHTUB-TRANSFER MOTION BY CG

Visual images in 3D computer graphics were generated based on the motion data on bathtub-transfer motion obtained in experiments under the three conditions. A 3D human skeletal model was constructed using computer graphics, and we showed the motion speeds and series of changes in motion over time. By applying the captured data on the 3D human skeletal model, we were able to control the motions. The results of motion analyses showed the changes visually over time in the upper body angle under the three motion conditions. Furthermore, we produced animated films to show the trajectory of the range of body motion during transfers. Fig9 shows an example of the computer graphics depicting the ante flexion angle. Visualization demonstrated the fact that the upper body leans forward more under the transfer board (C) condition compared with under the bathtub (A) condition and the bath board (B) condition when the hip is moved from a wheelchair to a bathtub so that the right foot could be easily bathed, allowing an intuitive understanding of the range of joint motion.

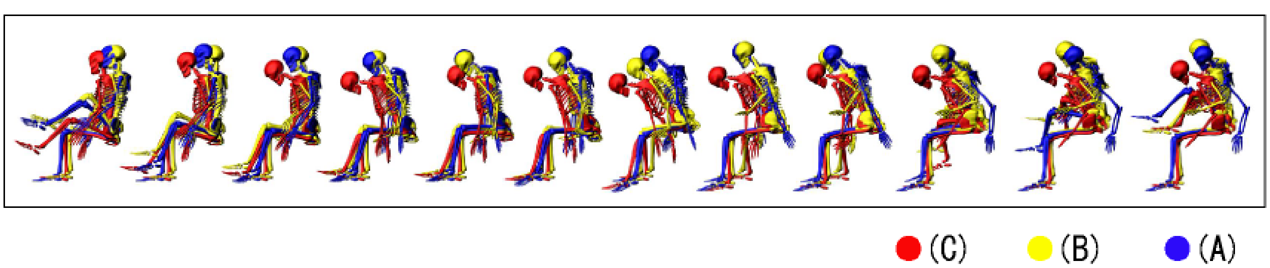


Fig 9: Expression through three-dimensional CG

6. CONCLUSIONS

This study used numerical calculations to identify the load conditions of joints and muscles associated with motion changes during transfer motions so as to assist wheelchair users in making safe transfer motions. Wheelchair users or seniors, however, may have a hard time understanding the details of the numerically or graphically shown information concerning the degrees of burden. Therefore, digital data was constructed by applying the forces of joints on a 3D virtual human model to show the characteristics of transfer motions, allowing emphases of the characteristics of body motion that have been difficult to demonstrate in video recordings. In addition, the three-dimensional mechanism of the transfer motion could also be understood visually. In the future, digital contents could be prepared to recreate visually realistic computer graphics that take into account the characteristics of each individual wheelchair users. This visualization of a transfer motion tailored to each individual will enable each wheelchair user to adopt such a motion in order to maintain a stable posture and to predict the ranges of motion. In addition, the digital contents may serve as a training aid to help wheelchair users and motion trainers to better understand the transfer motion and to learn the necessary information.

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