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Technology applied to geriatric medicine

The effect of a newly developed wheelchair with thoracic and pelvic support on cervical movement and muscle activity in healthy elderly women

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ABSTRACT

Background: As the population ages, the number of elderly individuals using a wheelchair is increasing. A standard wheelchair with a vertical backrest (S-WC) pushes on a kyphotic spine and exacerbates forward head posture. Forward head posture limits cervical movement. We used a new wheelchair (N-WC) that does not exacerbate thoracic kyphosis. The N-WC does not have a flat backrest, but has a support belt for the thorax and pelvis. The purpose of this study was to compare head-neck angle, cervical range of motion, and cervical muscle activity in the N-WC and the S-WC in healthy elderly women.
Methods: We measured head-neck alignment, trunk tilt angle, cervical muscle activity, and pressure distribution on the backrest. Data from 17 subjects were analyzed.
Results: Head-neck angle was close to neutral in the N-WC. The trunk was tilted further back and the area over which pressure was distributed on the backrest was expanded in the N-WC. Cervical range of motion and cervical muscle activity during neck extension were significantly greater in the N-WC than in the S-WC, but during neck flexion, there was no significant difference between the wheelchairs.
Conclusion: In the N-WC, head-neck alignment was close to the neutral posture because the wheelchair support belt accommodated kyphosis and did not push the spine forward, so cervical muscle activity may be reduced when at rest. These results suggest that the N-WC prevented forward head posture and improved cervical movement and muscle activity.

As the population ages, the number of elderly individuals using a wheelchair is growing, and it is expected to continue to increase in the future. Wheelchair use affects work performance and social participation, and is an important tool for disabled people to improve their quality of life.

It is necessary to consider the effects of age-related changes in posture on sitting posture in a wheelchair. Several studies have reported a need for pelvic support during wheelchair use [1–4], but few studies have focused on the effect of thoracic kyphosis on sitting posture in a wheelchair in elderly individuals. When sitting in a wheelchair, the thoracic spine is in contact with the surface of the backrest and thoracic kyphosis affects the force exerted on the backrest. A standard wheelchair (S-WC) has a vertical and flat backrest that does not fit the rounded form of the thoracic spine. Because the flexibility of the spine decreases with age [5], the spine is pushed forward by the horizontal force exerted by the backrest. This may increase forward head posture (FHP). FHP is one of the most common postural problems in elderly individuals and results in the head being positioned anterior to the trunk [6,7]. Cervical range of motion (ROM) is limited by FHP [8–10], and this reduces the postural activity of the cervical neck muscles [11,12].

In this study, we used a newly developed wheelchair (N-WC) that has been designed to accommodate the spine shape that is common to elderly individuals, including spine deformations and reduced flexibility. The purpose of this study was to determine if head-neck alignment, cervical muscle activity, and cervical ROM differed between the N-WC and the S-WC. Subjects were healthy elderly women who exhibited a mild kyphosis and could safely perform the experiment.

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1. Material and methods

1.1. The S-WC and N-WC

The S-WC was the Nissin NA-400 (Nissin Medical Industries Co., Ltd., Kitanagoya, Japan). This wheelchair is shown in Fig. 1a. It is similar to the N-WC, but it has a vertical, flat backrest. The majority of wheelchairs in use have this type of structure.

The N-WC was the ZAOU wheelchair (Nissin NA-501, Nissin Medical Industries Co., Ltd.), which has been commercially available since 2011. This wheelchair is shown in Fig. 1b. The N-WC was created using the seating theory proposed by Nishimura [13]. The N-WC was created with the goal of minimizing the activity of antigravity muscles when the user is in a sitting posture with adequate head-neck alignment. Adequate head-neck alignment makes movement easier and requires less muscle activity by minimizing the cervical moment arm. In the N-WC, the center of gravity is positioned differently relative to the thoracic and pelvic regions.

The N-WC includes one pelvic support belt and two thoracic support belts, shown in Fig. 1c. The pelvic support belt has a hook and Velcro loop fastener and can be set at one of several pelvic angles. The upper end of the pelvic support belt was set to support the iliac crest, and the back was set to support L4-L5. Thus, the pelvic support belt was set to support the pelvis from the side and the back, and was set to support a pelvic angle of 15–19.

The thoracic support cross belt was set to support the lower thorax and the thoracic support straight belt was set to support the upper thorax, as is standard. The intersection of the cross belt was positioned approximately 1 inch above the pelvic support belt. The lower thoracic support angle was set to 30–35°. The function of the thoracic straight belt was to provide relaxation and not to inhibit movement. The height of the thoracic straight support was set so that the patient could sit and relax comfortably, and the tension in the belt prevented the frame of the wheelchair pressing into the spine or the armpits.

1.2. Participants

Nineteen healthy elderly women over the age of 65 years participated in this study. Participants were recruited though the Sapporo Silver Human Resources Center. Potential participants were screened and included in the study if they could be safely transferred into a wheelchair. Participants were excluded if they had scoliosis or any disability that affected cervical ROM, the maintenance of sitting posture, or prevented them from sitting safely in a wheelchair. This study was approved by the Hokkaido University Health Sciences Research Institute Ethics Committee and informed consent was obtained from each participant.

1.3. Postural measurement

Rand markers were placed over the left lateral orbital margin, tragus, lateral condyle, and C7 spinous process. A skin reference marker was placed on the skirt of the wheelchair at the projected location of the left trochanter. The location of each marker was recorded and automatically digitized using DARTFISH software (Dartfish Co., Ltd., Lausanne, Switzerland). Head angle was defined as the angle between the vertical and the line through the tragus and the lateral orbital margin, and neck angle was defined as the angle between the vertical and the line through the C7 spinous process and the tragus [8,14–16]. Trunk tilt angle was defined as the angle between the vertical and the line joining the trochanter and C7.

1.4. Electromyography (EMG)

EMG was measured from the cervical erector spinae muscle (CES) and the sternocleidomastoid muscle (SCM) using surface

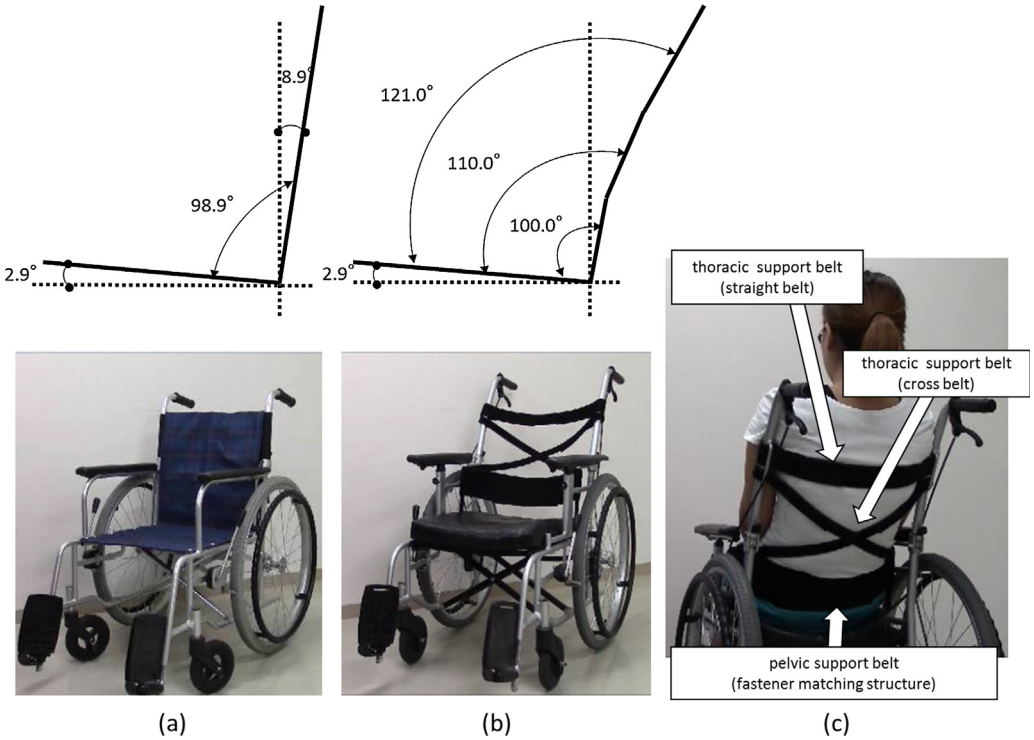

Fig. 1. The two wheelchairs. Illustrations of the standard wheelchair (a) and the new wheelchair (b) from the side, illustrating the structure of the backrest. Both the seat and the backrest planes were 400 × 400 mm. The seat angle was 2.9° for both wheelchairs. Photograph (c) of the new wheelchair showing the structure of the thoracic and pelvic support.