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The Influence of Rollators with Forearm Support on Walking Speed, Endurance and Dynamic Balance

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Abstract. [Purpose] The purpose of this study was to measure the effect of structural components on walking ability by conducting tests using subjects who used combined rollator-wheelchairs and walking aids in their daily lives. [Subjects] Ten residents living in a health care facility for the elderly who required walking aids participated in this study. [Methods] We measured maximum walking speed (MWS), step length, cadence and conducted the shuttle stamina walk test (SSTw), and the timed up-and-go test (TUG) under three conditions (rollator with forearm support, rollator with handgrip and cart). [Results] There were significant differences among the conditions with forearm support providing the best results in terms of MWS, step length, cadence, SSTw and TUG, showing in improved walking abilities of walking speed, endurance and dynamic balance. [Conclusion] These results show that therapists should advocate using rollators with forearm support as a safe method of expanding the range of walking activities for elderly who use walking aids or rollator-wheelchairs in their daily lives.
Key words: Walking aids, Rollator with forearm support, Walking ability

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INTRODUCTION

Ageing brings about a gradual decline in our ability to walk, however maintaining this ability is essential for elderly people to live an active daily existence[1)]. In order to compensate for the decline in walking ability, a variety of walking aids such as walking frames, carts and rollators have been developed. Through the development of machines and experimental models, a great deal of mechanical knowledge focusing on ergonomics has been accumulated[2–6)]. Although research has been carried out into how walking aids affect motor performance[7)], little quantitative research has been conducted into how the structure of walking aids affects walking ability. Furthermore, in comparison to rollators, carts are more widely used[8)] domestically in homes and welfare facilities by the elderly with a diverse range of walking abilities. Although carts are recommended as suitable walking aids by the Consumer Product Safety Association[9)], they warn against using them to support body weight whilst walking. Therefore, there isn't a clear distinction between carts and rollators specifically designed to stabilize walking. Hence, it can be said carts are being used without a comprehensive evaluation of their suitability.

In our previous study[10)], we examined the influence of walking aid grip configuration on walking ability. Healthy adult subjects used a variety of grip configurations and their effect on posture was measured using a force-plate. In the comparison of walking aids incorporating handgrips and those incorporating forearm support, we demonstrated that forearm support reduces the load on the lower limbs and assists forward movement. Therefore, providing forearm support would be an effective method for assisting users weight induced pain, walking instability and muscle weakness. However, because subjects were able-bodied, it isn't clear how these structural components would affect the walking speed and endurance levels of users who use walking aids in their daily lives. Therefore, the purpose of this study was to measure the effect of structural components on walking ability by conducting tests using subjects who use combined rollator-wheelchairs and walking aids in their daily lives. Differences in walking speed, endurance and dynamic balance were used to compare the structural effects of a rollator with forearm support, a rollator with handgrips, and a conventional cart with handgrips. Based

Fig.1 . Experimental condition

on the findings, we recommend walking aid configurations based on an understanding of how their structure influences usability.

SUBJECTS AND METHODS

Ten residents living in a health care facility for the elderly who required walking aids (1 male, 9 females; age 84.7 ± 6.2 years; height 144.8 ± 6.9 cm and weight 44.3 ± 10.6 kg) participated in this study. In terms of mobility 4 subjects used rollators or walking frames in order to walk, and 6 subjects used combined rollator-wheelchairs. The subjects' nursing care level was 2.6 ± 1.2. Previous medical conditions included three cases of femoral neck fracture and two cases of spinal compression fracture. Existing medical conditions were three cases of osteoarthritis of the knee, one case of lower back pain and one case of spinal canal stenosis. Subjects over 65 who had suffered from cerebral vascular disease, myocardial infarction or angina attacks in the last 6 months were excluded from the study.The research was approved by the Kawasaki Medical Welfare University Ethics Committee (Application No. 270). Before commencing this study, all participants received a written explanation of the aims and nature of the research and signed consent forms indicating that they understood these aims and voluntarily agreed to take part in the study.

Rollators with forearm support and handgrips (Model Name: 'Rabbit', manufactured by Well Partners Co. Ltd) and carts with handgrips (Model Name: 'United' manufactured by Suehilo Industries Co. Ltd) were used in this experiment. The Rabbit has four 7-inch castors: two at the front and two at the back. There is a flat forearm support across the top of the frame above the two handgrips. The forearm support can be lowered to make the two handgrips accessible. In the experiment, the rollator was tested in both the forearm support and handgrip configurations. During the experiment the height of the rollator forearm support was set at elbow height and the height of the rollator and cart grips was set at 30° of elbow flexion. Subjects completed all tests using the three types of walking aids. The order of the three conditions (rollator with forearm support, rollator with handgrips and cart) were randomized. There was 10 minutes rest between each test. Measurements were recorded using a stopwatch and tape measure (Fig. 1). Walking speed was calculated over 10 m of walking in a straight line. There were 3 m warming up and cooling down sections before and after the 10 m section of the walk that was measured. Maximum walking speed was calculated by measuring the time to cover the distance while exerting maximum effort and is expressed in this paper as maximum walking speed (MWS) (m/min). Furthermore, combined measurements for walking time and the number of steps were used to calculate average step length (distance walked/number of steps) and cadence (number of steps/min). Cadence is expressed in this paper as (steps/min). The shuttle stamina walk test (SSTw)[11] was used to assess endurance levels. Subjects walked at their chosen speed between two poles set at a distance of 10 m for a duration of 3 minutes. The total length walked was measured. The timed up-and-go test (TUG) was also conducted. Subjects stood up from the sitting position, walked around a pole placed 3 m ahead, walked back to their seat, and returned to the sitting position. The sitting position was leaning back against the chair, and the walk was carried out with maximum effort. The total time for this interactional sequence was recorded (sec).

Statistical analysis was performed using one-way analysis of variance (ANOVA) to compare MWS, step length, cadence, SSTw and TUG among the three conditions. When significant differences were recognized, a multiple comparisons test was performed using the Fisher's PLSD test method. Significance was accepted at values of $P<0.05$. Data was analyzed using SPSS 14.0 J statistics software.

RESULTS

Significant differences among the three experimental conditions were observed for all the parameters i.e. MWS, step length, cadence, SSTw and TUG. The results of the measurements are shown in Table 1. The multiple comparison results for MWS, step length, cadence and SSTw revealed significant differences between configurations, with forearm support providing positive results. The TUG results show significant differences among the configurations, with forearm support resulting in a faster completion of the test.

DISCUSSION

In order to adapt walking aids, it is necessary to understand both user ability and its relation to rollator structure. However, determining the exact nature of this relationship

Table 1. Comparison of walking abilities in the walking aid structure

	Rollators with forearm support	Rollator with handgrip	Carts
MWS(m/min)	43.7 ± 8.0*	33.8 ± 8.5	31.9 ± 9.3
step length(m)	0.40 ± 0.09*	0.34 ± 0.07	0.33 ± 0.07
cadence(steps/min)	110.9 ± 13.1*	98.3 ± 17.5	97.8 ± 20.6
SSTw(m)	83.7 ± 15.5*	66.2 ± 16.2	62.3 ± 11.7
TUG(sec)	20.7 ± 4.8*	22.5 ± 5.8	25.1 ± 3.6

*$p<0.05$. MWS：Maximum Walk Speed, SSTw：Shuttle Stamina Walk Test, TUG：Timed Up & Go Test

is a complex undertaking[12]. In our previous study[10] the relationship between walking aid structure (handgrip configuration) and walking ability was examined. The results showed that a rollator with forearm support reduces the load on the lower limbs and assists forward movement. However, that study used healthy adult subjects in the experiments. Therefore, in the present study differences in walking speed, dynamic balance and endurance were used to compare the effect of structural components on walking ability by conducting tests with subjects using combined rollator-wheelchairs and walking aids in their daily lives.

The results show significant differences among the three conditions with forearm support providing the best results in terms of MWS, step length, cadence, SSTw and TUG, showing improved walking abilities of walking speed, endurance and dynamic balance. The correlation between daily living functions and MWS[13] has been validated. SSTw is a validated method of evaluating endurance in field tests[11], and it shows a revealing the positive correlation between step length and endurance levels. In comparison to rollators with handgrips and carts, forearm support allows the user to rest their forearms whilst maintaining elbow flexion. When resting the forearm whilst maintaining elbow flexion, the trunk is tilted forward and the load of the head, body trunk and upper limbs is shifted. Thus, the effort needed to maintain trunk position is reduced[14]. Using walking aids increases the base of support as the load is carried both by the legs of the user and the walking aid casters. Furthermore, forearm support moves the load center forward resulting in an increase in load on the casters[15], facilitating improved driving potential. Therefore, increased driving force provides greater support for forward movement and increased step length and cadence. In other words, the increases in walking speed and endurance are the result of an increase in step length and cadence brought about by the increase in driving force which rollators with forearm support generate. The subjects of this study were elderly persons who required walking aids. According to Oku et al.[16], trunk and lower limb posterior muscle activity is reduced through the use of walking canes. Furthermore, according to Abellanas et al.[17], when using walking aids, control of lateral movement of the trunk is improved by upper limb support and results in improved walking speed. Thus, improved walking ability generated by load shift to the forearm support may be explained by its compensatory effect on maintaining trunk position.

Furthermore, when compared with the other 2 conditions, forearm support resulted in faster performance of TUG. A possible explanation for the results for walking speed and TUG combined is that straight after standing up and turning, forearm support stabilizes tilt and swing of the trunk and head resulting in a decrease in the change of center of gravity. Miyawaki[18] reported that when compared with conventional walking, cart users' center of gravity swing is reduced by around 12%. The TUG results of this study suggest that, when compared with the cart, the rollator with forearm support provided a further reduction in center of gravity swing resulting in a significant improvement in dynamic balance. This suggests that improved dynamic balance contributes to a higher level of walking stability. In contrast, when the rollator with handgrips and cart, were compared, there were no significant differences in MWS, step length, cadence, SSTw and TUG. These findings suggest that, in terms of walking speed, endurance and dynamic balance, the position of center of mass in the support base is more important than caster-size, frame structure or grip configuration. Moreover, compared to the rollator with forearm support, the extended position of the trunk, when using the rollator with handgrips or carts, increased muscle activity in the back and lower limbs[19], reduceing walking speed and endurance.

In the present study, we verified that a rollator with forearm support delivers improvements in walking speed, endurance and dynamic balance for users who use walking aids or rollator-wheelchairs in their daily lives. These results support the findings of preceding studies. Shimada[20] showed that, amongst ADL categories, the earliest to decline in the elderly was walking ability. In order to maintain an independent lifestyle, elderly individuals with impaired mobility need to maintain a safe and comfortable walking style in their daily walking routine[21]. Although carts are widely used in Japan to achieve this, due to a lack of understanding about suitability for specific conditions, their use can result in accidents[22]. When considering approaches to supporting safe and comfortable walking styles, it is important to properly understand the structure and attributes of walking aids. These results show that therapists should advocate using a rollator with forearm support as a safe method of expanding the range of walking activities for elderly who use walking aids or rollator-wheelchairs in their daily life. However, future studies should also focus on other elderly groups, such as the elderly who can walk with the aid of walking canes. This study was limited to a few subjects who used combined rollator-wheelchairs and walking aids in their daily lives. Furthermore, although both carts and rollators with handgrips are widely used in society, this study does not provide an analysis of the conditions under which walking aids without forearm support may be preferable. Therefore, in the future researchers will need to conduct studies of walking aids based on their functional application and increase the number of participants as well as range of walking ability.

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