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Development and Evaluation of Rollator for Elderly Farmers

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Objective: This study aims to develop and evaluate a multi-purpose rollator, which may be used as a seat, as a traditional walker, or as a storage basket for elderly farmers.

Background: The rollators on the market are not user-friendly designed and seen inconvenient for elderly farmers to use, although they are sold at considerably high price. Since they lack enough space to load stuffs and are not durable or stable enough, they do not seem to be suitable for elderly farmers to use in rural areas.

Method: Two types of methods were used in this study. First, the survey consisted of 19 questions was conducted among elderly farmers in rural areas, after using the developed rollator, to evaluate the usability of the rollator developed in this study. Second, EMG experiment was conducted to compare the existing rollator and developed rollator quantitatively. Through this experiment, we tried to verify the differences of muscle responses, when using the traditional and the developed ones, which have their own brake system, in the ramp.

Results: The developed rollator was highly evaluated in most of the questions in the usability survey, except for the 'Weight' category in which the opinions were divided into three different types (Worse: 31%, Similar: 30%, Better: 36%). The result of EMG experiment showed that the existing rollator (7.4%MVC) demands more muscle strength than the developed rollator (5.5%MVC) does. By statistically analyzing the results of upper limb and lower limb respectively, we found out that all the muscles except deltoid in upper limb showed statistically significant differences in muscle activity when using the existing and the developed rollator. However, there was no statistical difference in lower limb muscles.

Conclusion: The developed rollator in this study has maximized the functionality of the brake system, the storage and the chair, which were pointed out as the weaknesses of existing rollators. Furthermore, the developed rollator is designed to be more user-friendly, safe, durable, and effective for elderly farmers to use in rural areas, where roads are rough and bumpy.

Application: We expect that the emergency brake system developed in this study would be utilized for other convenience equipment, such as strollers and carts, and that it would be able to develop and produce more secure and reliable equipment in the future.

Keywords: Elderly farmer, Rollator, Walking assist device, EMG, Kyphosis

1. Introduction

The population of elderly farmers increased from 24.4% in 2001 to 30.8% in 2006, according to the 2012 Senior Citizens Statistics, and Korea already entered the super aging society. Also, the concentration of elderly people in rural areas is deepening (MOL, 2012). The aging and population drain in rural areas deteriorate agricultural labor activity, and therefore, the occurrence of musculoskeletal disease and other diseases is not reduced.

As mechanization of farm work is actively implemented, manual work by manpower is hardly necessary. However, almost half of field or orchard work is still carried out by manual work. Various health problems including farmer's syndrome and house syndrome occur chronically, since there are many uncomfortable and awkward postures, repetitive behaviors, excessive strength use, and high temperature environmental work in view of the characteristics of farm work (Park et al., 1994). Of those, the musculoskeletal disease occurs in various age brackets, and it emerges as a social concern, as well as a medical concern (Jaeng, 2006).

Especially, the prior plan of farm work is difficult on work load, moving path and working environment, and load is caused continuously to the body of a farmer, since farm work requires very diverse and unstable working postures and time. Therefore, especially, many diseases concerned with waist occur. In the disease survey of farmers in the course of working in 2012, the musculoskeletal disease showed the highest ratio in the diseases related with work, and also becomes the cause of kyphosis.

Looking into preceding researches, everyday life habits are presumed to have close relationship with kyphosis occurrence, given that most kyphosis patients worked in a squatting position for decades in the past (Bradford, 1988; Lee et al., 1997). Meanwhile, there is an assertion that such an everyday life habit affects waist extensor muscle in that almost no waist transformation kyphosis patients are found in the U.S. or Europe, where people mainly lead a life sitting in a chair (Perennou et al., 1994). Consequently, the occurrence of kyphosis is concerned, because Korean elderly farmers have maintained inferior working posture such as squatting or bending severely in everyday life or agricultural activities.

In addition, sensory response within the body declines, reflex to correct crooked body gets slow, muscular strength essential to maintaining proper posture of body diminishes, due to aging, and therefore, there can be lots of body shaking. All these changes affect the walking ability of elderly people (Chey et al., 2008).

To assist such a walking ability reduction, many domestic and foreign medical device companies sell rollators; however, most rollators are imported from Taiwan and China. The reason is that domestic medical apparatus companies are small and systematic R&D to support elderly people's welfare and activities are not carried out. Also, those products can be distributed without proper safety and design standards (Choi, 2007). Most rollators distributed in the market are imports, and they are not manufactured in consideration of the body shape or the use environment of Korea's elderly people. In this context, more appropriate safety regulations are needed in order to enhance the health of elderly farmers, who are direct/indirectly exposed to safety accidents.

If a rollator is designed to be suitable for the body shape of western people, whose skeleton is big and who are tall in general, unnecessary muscles are used to move the rollator, and especially, the waist and leg muscles will be relatively used more. Since more strength is needed for braking, design for more convenient and safe braking system is required.

Looking into the safety accident types of overall walking support tools, fall, tripping and sliding accounted for 55.3%, collision & shock 7.5%, cut or ripping off by an object 4.5% and being pressed or being trapped 4.0%. By the body part in an accident, head and face accounted for 26.4%, legs and feet 24% and neck, belly, back and waist 14.7% (Korea Consumer Agency, 2007).

Such a result mentioned above is presumed to occur more seriously in rural areas, where roads and working environment are inferior to cities. Because, many roads in rural areas, different from those in cities, which are flat and smooth, are rough and bumpy, and more unpredictable potential dangers exist. In this regard, the rollators used in cities and those used in rural areas need to be developed with different design standards.

Under such a background, this study developed a rollator that can assist the physical discomfort of elderly farmers and that can carry simple load and that can function as a chair, if necessary.

2. Method

2.1 Participants

2.1.1 Usability evaluation

This study carried out rollator usability evaluation targeting female elderly farmers aged 65 and over in terms of rollator usability evaluation. The questionnaire participants' average age was 75.1±6.34, and the number of the participants, who used a rollator, or other walking assist devices, was 24, and the number of participants, who did not use those, was 20. In summary, 44 female elderly farmers participated in the usability evaluation.

2.1.2 Muscle activity

The number of experiment participants to evaluate muscle activity in using a rollator was 20 adult males, who did not have the history of musculoskeletal disease and other relevant diseases. In the case of female elderly farmers mainly using a rollator, there is a concern of losing potential data, when attaching electrodes, due to skin aging, and there is physical strength limitation, owing to aging; therefore, they were impossible to participate in this experiment. For this reason, the experiment was carried out targeting the following experiment participants: This experiment had differences with other experiments that measure only strength necessary to operate brake in that the experiment in this study measured complex reactions of various muscles. The experiment participants' information is presented in Table 1.

Table 1. Information of participants

Age (yr)	Height (cm)	Weight (kg)
28.4±3.28	171.1±5.29	68.6±7.18

2.2 Apparatus

2.2.1 Usability evaluation

This study carried out usability evaluation on 19 items to compare walking assist devices, such as rollators and strollers generally distributed in rural areas. Table 2 shows the items to compare the developed rollator in this study with existing or currently sold rollator.

Table 2. Usability evaluation list of Rollator

	(%)	Worse	Similar	Better
Handle	Thickness			
	Width			
	Comfort			

Table 2. Usability evaluation list of Rollator (Continued)

(%)		Worse	Similar	Better
Brake	Strength			
	Form			
Wheel	Size			
	Rotation			
	Width			
Seat	Width			
	Cushion			
	Lazyback			
Basket	Width			
	Depth			
	Storage space			
Folding				
Wash				
Weight				
Stability				
Convenience				

2.2.2 Muscle activity

To measure muscle activity, this study used a surface electromyography (sEMG) sensor (Noraxon U.S.A., gain = 500; noise<1μV, sampling rate = 1,500Hz). The EMG electrodes were attached to eight parts, and SENIAM was referred to for the attachment locations (Table 3).

Table 3. Location of electrode (SENIAM)

Upper limbs	Anterior Deltoid
	Triceps Brachii
	Flexor Carpi Ulnaris
	Extensor Carpi Ulnaris
Lower limbs	Rectus Femoris
	Biceps Femoris
	Gastrocnemius
Trunk	Erector Spinae

The currently sold rollator in the market between the two rollators used in the experiment used a brake in the mode of putting the brake on the rollator using only hand's grip. In the rollator developed in this study, brake is released, when a user puts hands on the handle and slightly presses it. And, if the user lets go of the handle, the brake works. For speed control, an assistant brake system is used, which uses the same hand grip mode as the existing rollator.

Figure 1 demonstrates the two rollators used in the experiment.

Existing rollator Developed rollator

Figure 1. Rollators in Experiment

2.3 Procedure

2.3.1 Usability evaluation

To compare and evaluate the developed rollator in this study with the walking assist devices and other assist devices used by elderly farmers, explanation and education on the functions, and characteristics of the general rollator and the rollator developed in this study were sufficiently offered in the place, where usability evaluation was carried out. Also, evaluation was conducted by letting the participants observe and actually use them upon evaluation.

2.3.2 Muscle activity

This study measured MVC to standardize the muscle activity of different participants before the experiment. The measuring method is as follows:

- Anterior Deltoid: When a participant straightens up waist, stretches two arms forward in a sitting posture, and the measurer pushes those arms downward, the participant raises his arms with full strength. In doing so, measurement is made.
- Triceps Brachii: When a participant bends his waist 90˚ in the state of bending arm at a right angle, and if the measurer presses antebrachii in the vertical direction, the participant extends the arm with full strength. In doing so, measurement is made.
- Flexor Carpi Ulnaris: When a participant puts his antebrachii on the table with palm facing downward in a parallel way in the state of closing his fist, and if the measurer presses the fist downward, the participant raises his fist toward his body. In doing so, measurement is made.
- Extensor Carpi Ulnaris: Opposite to flexor carpi ulnaris, a participant's back of hand faces downward, and raises his fist upward with full strength. In doing so, measurement is made.

- Rectus Femoris: A participant stretches his legs forward, and contracts muscles with full strength in a sitting posture. In doing so, measurement is made.
- Biceps Femoris: When a participant stands straight, and faces one sole backward, and the measurer grabs the participant's ankle and presses it downward, the participant bends his leg upward with full strength. In doing so, measurement is made.
- Gastrocnemius: When the measurer presses a participant's top of the foot downward, when the participant sits straight, the participant raises the top of the foot upward with full strength. In doing so, measurement is made.
- Erector Spinae: When a participant lays face down, he fixes his legs, and raises his upper body up with full strength. In doing so, measurement is made.

%MVC was calculated using the following equation to standardize all different participants' muscle activity (Equation 1).

$$[(RMS_{MAX}-RMS_{TASK}) / (RMS_{MAX}-RMS_{REST})] * 100 \qquad (1)$$

The functions of the two rollators to compare are equal on flatland, but when emergency braking is necessary in an emergency situation (situation to be pulled down by the rollator and weight), this study tried to check the use degree of muscles. When the brake was on, while using a rollator on the slope, the following experiment was conducted to quantitatively analyze the muscle responses.

As for the rollator experiment method, muscle activity by rollator was evaluated by operating the brake with 5m distance, while walking down a slope for 15m in total. By assuming load, the two rollators were set to weigh 20km, respectively. The walking speed was set to be equal by using a metronome to minimize individual participant's difference in terms of walking speed.

The brake system of the existing rollator is to put the brake on the rollator by closing hand using hand grip. The brake operating principle of the developed rollator in this study is that the brake is automatically on, when a user releases hands off the handle.

The rollator experiment course is shown in Figure 2.

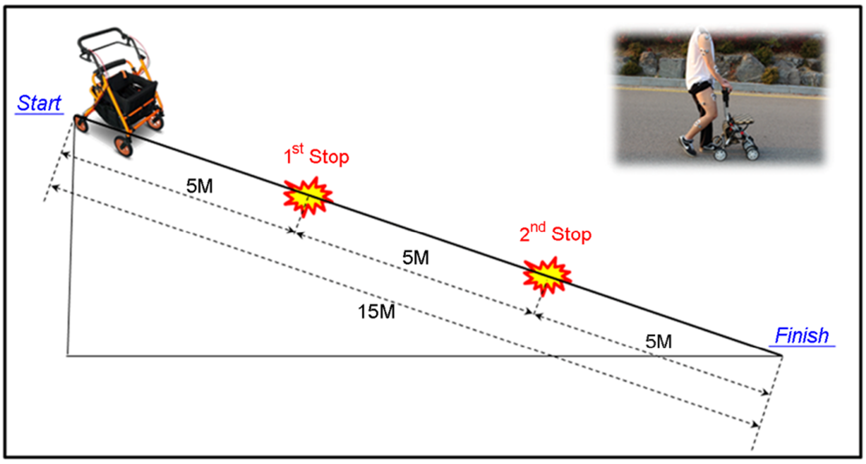

Figure 2. Experimental course of rollator

For data analysis, the two rollators were comparatively analyzed by averaging the 15m muscle response experiment course.

The experiment was conducted twice, repeatedly, and 3 minutes or more of resting time was offered between the experiments.

Since the participants' muscle size and density on the collected muscle signals are all different, RMS values were standardized and converted into %MVC.

For statistical analysis, SPSS 18.0k was used, and the muscle, and rollator were selected as independent variables on the dependent variable, muscle activity (%MVC). Statistical significance level (α) was set at 0.05, and Turkey HSD was carried out for post-analysis.

3. Results

3.1 Usability evaluation

The usability evaluation results obtained by comparing the rollator developed in this study with the existing rollator or walking assist devices are presented below:

As for the handle, most respondents, namely, 83% and more of them on average evaluated the developed rollator in this study higher. In the case of brake, 89% and more of the respondents evaluated the developed rollator higher. Concerning the wheel, seat, basket, folding, wash, stability, and convenience, more than 92%, 89%, 93%, 84%, 86%, 91%, and 93% of the respondents evaluated the developed rollator higher. However, regarding weight, worse evaluation was 34%, similar 30%, and better 36%, which were evenly evaluated, respectively, and thus, the different result on the weight was shown from other items (Table 4).

Table 4. Result of usability evaluation

	(%)	Worse	Similar	Better
Handle	Thickness	2	14	84
	Width	5	20	75
	Comfort	2	7	91
Brake	Strength	0	16	84
	Form	0	5	95
Wheel	Size	0	5	95
	Rotation	2	11	86
	Width	0	5	95
Seat	Width	2	2	95
	Cushion	0	11	89
	Back	5	11	84
Basket	Width	0	7	93
	Depth	0	9	91
	Storage space	2	2	95
Folding		5	11	84

Table 4. Result of usability evaluation (Continued)

(%)	Worse	Similar	Better
Wash	0	14	86
Weight	34	30	36
Stability	0	9	91
Convenience	2	5	93

3.2 Muscle activity

As a result of statistical analysis of muscle activity (%MVC) difference according to rollator, the existing rollator showed 7.4%MVC, while the rollator developed in this study showed 5.5%MVC, which implied that the existing rollator needed more use of muscles ($p<0.0001$).

Figure 3 shows the graph on eight muscles' %MVC, according to rollator.

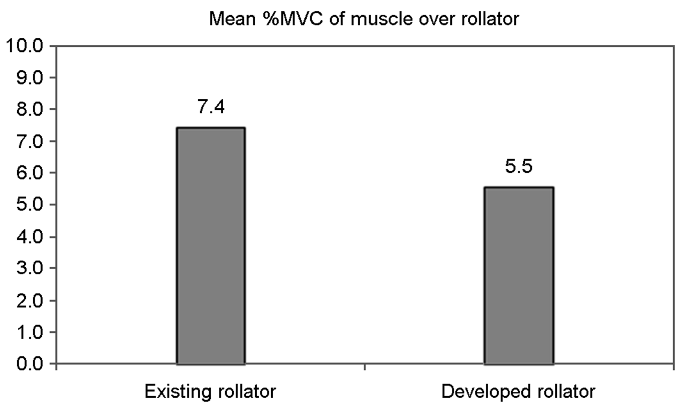

Figure 3. Mean %MVC of eight muscles over rollator

Interaction between the rollator and muscle also showed statistically significant result ($p<0.0001$). Figure 4 shows the graph on the interaction between the rollator and muscle.

The muscle use amount of the developed rollator was lower than the existing rollator. Meanwhile, according to statistical analysis result, in the case of upper limb muscles, the muscle activity differences were statistically demonstrated in the Extensor Carpi Ulnaris ($p=0.032$), Flexor Carpi Ulnar ($p=0.024$), and Erector Spinae ($p=0.037$), except Anterior Deltoid ($p=0.119$), and Triceps Brachii ($p=0.217$). However, concerning the lower limb muscles, all did not show statistical differences, since Rectus Femoris ($p=0.805$), Biceps Femoris ($p=0.71$), and Gastrocnemius ($p=0.199$) were demonstrated as such in the existing and developed rollators.

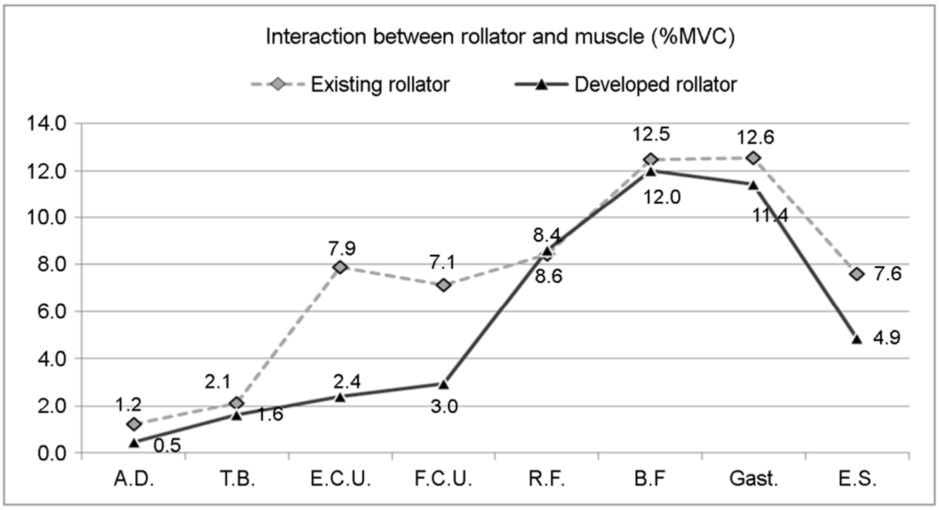

Figure 4. Interaction between rollator and muscle [A.D.: Anterior Deltoid, T.B.: Triceps Brachii, E.S.: Erector Spinae, E.C.U.: Extensor Carpi Ulnaris, F.C.U.: Flexor Carpi Ulnar, R.F.: Rectus Femoris, B.F.: Biceps Femoris, Gast.: Gastrocnemius]

4. Conclusion

The rollator is currently named a walking assist device, or a silver car in Korea. The function is a walking assist tool for those who feel discomfort in walking, or elderly people, and the rollator is used to go out. A rollator can be classified into three types: standard type, compact type, and no seat type. The standard type with a big seat and basket has good stability, since weight can be sufficiently supported. But, the compact type with a small seat and basket has no arm rest, and light weighted, therefore, stability is lower, but it is convenient for the elderly people, whose walking is stable, to use.

A light rollator is convenient to use a bus or a subway, or to transport it on the stairs, however, it is actually suitable for the elderly people, whose walking is stable to some degree. If the weight of a rollator is too light, the walking speed is not in proportion with the progress of the rollator, and therefore, a user may lose balance, and an accident of fall is likely to be caused. In the rural area environment, there are many rough and bumpy roads, and elderly people mostly work. Therefore, the size and stability of the rollator need to be taken into account in consideration of walking support and transportation of loaded stuff.

This study developed, evaluated, and verified a rollator suitable for elderly farmers on rough and bumpy roads in rural areas, since the walking circumstances in urban and rural areas are different.

This study carried out usability evaluation of the existing rollator and the developed rollator in this study on the basis of 19 items. The walking assist device types that elderly farmers were using, such as existing rollators or strollers sold in the market, were the standard type or compact type rollators suitable for urban areas. Looking into the evaluation results, opinions were polarized in the item of weight. The reason is that elderly farmers are used to at using a standard or compact type rollator or a stroller, instead of using the rollator suitable for elderly farmers in rural areas. However, most elderly farmers using a light walking assist device carried some bricks to add some weight, or carried load to increase the weight. This is a good example of the limitation of a light rollator that a user feels in the rough and bumpy roads in rural areas.

In the EMG experiment targeting 20 adult males, eight mean muscle activity (%MVC) showed statistical differences, according to rollator. This is the result showing muscle use amount of the rollator developed in this study is smaller. Also, the differences of muscle use amount in upper limb muscles were confirmed in the interaction. The existing rollator operates its brake using hand grip. In the rollator developed in this study, the brake is on, when user's hands are off the handle. Therefore, muscle activity was higher in the existing rollator than the developed rollator in this study. Concerning anterior deltoid, statistical difference was not shown, on the contrary to an assumption that muscle activity would be higher in the developed rollator using a principle that brake is on, when the hands are off the handle. In addition, the muscle activity was confirmed to be lower in the developed rollator quantitatively. This is considered to derive from the difference between the hand grip and behavior to let go of handle softly, according to user's intention. The rollator developed in this study was confirmed that it can actively reduce the waist muscle and arm muscle burden, compared to the existing rollator.

In Korea, many elderly people in cities, as well as in rural areas, need to spend lots of medical care expenses, and buy and use medical assist apparatus, due to waist-related diseases including kyphosis. Therefore, economic burden is big. However, it is not easy to buy and use a rollator in rural areas, where more than half of the farmers aged 65 and over account for the rural population, of which mean income reaches only 60~70% of the urban households. In this context, many female elderly people in rural areas use waste strollers, and a concern on safety accidents is added more. Especially, if kyphosis is neglected, its symptom deteriorates, and incurable stage may reach in the end, according to patient's state. In this regard, social interest and posture improvement are urgently required (Yang et al., 2006).

Based on the EMG experiment results of this study, the rollator developed in this study overcame the active brake operation, and functional limitation, which are the existing rollator's limit. Through usability evaluation that targeted elderly farmers, who actually used rollators and walking assist devices, or who could have access to them in their surroundings, this study developed a rollator suitable for the use in rural areas. The rollator developed in this study is expected to enormously contribute to elderly farmers' posture correction, walking assistance, and the prevention of musculoskeletal disease and other diseases in advance.

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