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ANALYSIS STUDY ON BALANCING FACTORS TO PREVENT FALLING ACCIDENT BY THE AGED

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ABSTRACT

Recognition of the issues in aging society is on the rise globally. The aged, unlike the person in the younger age, needs to be more careful in their everyday life or activities because they require more time in recovering or easily become unrecoverable from the injury, when injured, such as fracture. The facilities in our society shall be changed to accommodate the social activities of the aged which is on the rise. And the guideline of the facilities in a bid to prevent the injury by the aged shall be provided, and particularly the facilities designed to protect the aged from falling accident which the aged has suffered more shall be provided. The major cause of falling accident is deteriorated ability to make them balanced. To prevent the injury to the aged, it's necessary to diagnose the balancing ability and identify the relevant characteristics. In this study, the result obtained from the analysis of balancing-related variables measured with the aged is suggested, which is expected to make commitment to improving the pedestrian facilities for the aged as well as establishing the guideline for the facilities.

Key Words: The aged, Falling, Prevention, Balancing factor, Center of Mass, Walking variable

Introduction

Average increasing rate of the aged in Korea is very high, indicating 26.9% and such fast increase in population of the aged is not only applicable to Korea but also other countries throughout the world showing the rapidly change to the population structure globally. Such a tendency implies another potential social problem which will be different from existing social problem or conflict. In the countries where population ageing has started already, like Japan for example, social problem resulting from ageing society including conflict between generations has become the challenge to the society and the government-level policy to deal with such problems has been made public day b day. One of such policies for the aged includes subsidy for the aged or reemployment of those retired which is designed to support them economically.

Besides, in a bid to help them participate in social activities, particular transport means which is modified or improved to provide the customized service for the senior people is also included.

The aged is generally considered the disadvantaged which is also called, in terms of transport, the mobility handicapped who is the bracket in need of particular attention in using the public facilities. In classifying the aged into the mobility handicapped, all of the aged is categorized into the mobility handicapped in addition to those with weak joint or muscular strength. Such classification is based in the fact that the aged, irrespective of their physical condition, walks at a slow pace and easily misjudges the situation and their walking pattern is different from others in younger age (Roh et.al.(2016)) As aforementioned, as the measure to cope with the physical handicap of the aged, it's necessary to provide them with the facilities designed in consideration of the walking pattern of the aged or provide them with the customized transport means, which could be available by means of procurement or lease and thus supplying by the government-level is impractical in fact. In such a case, the government may help those at low income bracket or the handicapped buy it in a way of granting the subsidy.

Pedestrian passage for the aged when walking or using the particular transport means is also designed for the convenience of other persons which often causes the inconvenience to the aged when using it together with other ordinary persons, through the facilities meet the required design criteria. Falling accident, when occurred, results in severe injury to the aged requiring a longer time than those in younger age till the injury is fully recovered which constrains the social activities to the aged.

Such falling accident is easily occurred to the aged than other younger ordinary persons which is considered attributable to deteriorated balancing ability. Deteriorated balancing ability of the aged brings about the difficulties in controlling the posture and when the body becomes unbalanced, the aged can hardly adjust the balance quickly while the younger persons can do that and falling accident is unavoidable to the aged. To cope with the gap in balancing ability, it's necessary to review the variables that determine the balancing ability while walking and the facilities that will help the aged reinforce the balancing ability could be provided. In this study, definition of the variables relating to the balancing ability of the aged is made with the comparative analysis.

Motion Analysis System

In an effort to identify and analyze the variables relating to the balancing ability of the aged, a motion analysis system was used. A Motion analysis system developed in this study comprises of a 7m-long pedestrian passage, two Ground reaction force plate(Kiestler) buried at the center of pedestrian passage and 14 infrared cameras to collect the marker data. Configuration of motion analysis system is as Fig 1 and the equipments as shown in Fig 2. 29 markers were attached to the body to monitor the walking pattern and the details are as Fig 3.

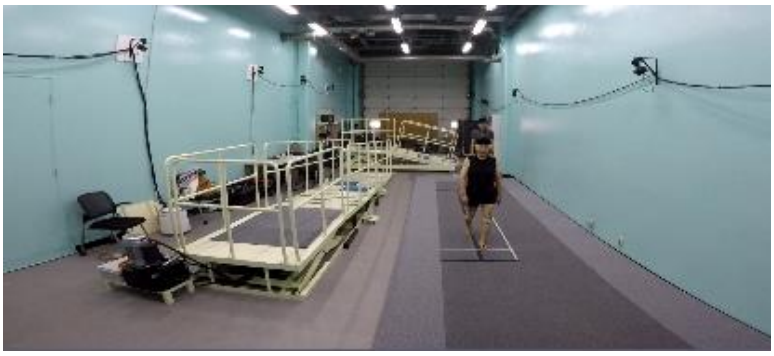

Figure 1 Configuration of motion analysis system

(a)Ground reaction force plate *(b) Infrared camera*

Figure 2 Equipments installed

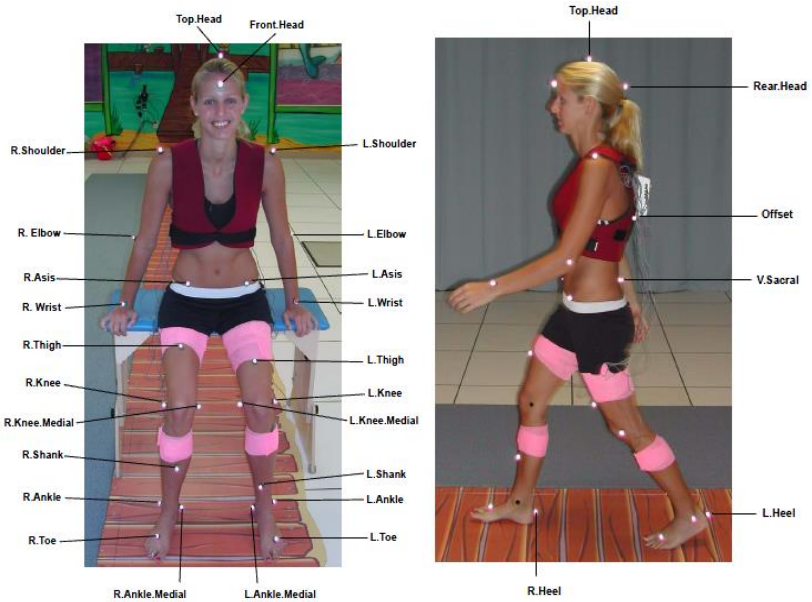

Figure 3 Markers attached to the body

Review of walking variables relating to the balance

The result from the analysis of data and variables from the motion analysis system is as Table 1. According to the data from the motion analysis system, the aged showed the walking

pattern with less shoulder motion and a wide angle between ankle and the floor, walking with mincing steps. More force on angle than other ordinary younger persons while the force to knee muscle is about 84% of the ordinary younger persons and the efficiency appeared less while more force was used for walking. The center of mass (hereinafter called as COM) which is intensively addressed with regard to the balance factors in this study is estimated as Fig 4 and COM of the aged was higher than other ordinary persons by 19%, which indicated the motion while walking is wider and the risk of falling may be increased due to obstacle or depending on condition of pedestrian passage.

To estimate COM accurately as Fig4, Motion Analysis System applied to this study shall be available because variables could be collected by measuring the ground reaction force through the force plate on pedestrian passage. Thus there might be the constraint in acquiring the data.

Table 1Motion analysis result (basic statistics)

Factor	Variable		Experimental group(70+)	Control group (20)	%Nor
General	Angle of Shoulder(°)	Right	4.06	8.97	45%
		Left	4.81	8.39	57%
	Angle of Ankle(°)	Right	10.71	8.52	126%
		Left	9.51	6.07	157%
Walking	Walking Speed (cm/sec)		98.70	137.30	72%
	Walk Ratio(cm/(steps/min))		0.47	0.65	72%
	Cadence(steps/min)		112.20	109.50	102%
	Step Length(cm)		52.50	57.10	92%
	Stride Length(cm)		105.70	129.80	81%
	Step Width(cm)		11.00	12.00	92%
	Foot Clearance(°)	Right	17.09	-	-
		Left	14.75		
Balance	Center of Mass (m)		0.19	0.16	119%
Muscles	Joint torque at ankle(Nm)	Right	150.33	145.6	103%
		Left	149.22	145.1	103%
	Peak torque at knee-flexion(Nm)		137.22	166.30	84%
	Peak torque at knee-extension(Nm)		51.47	61.30	84%

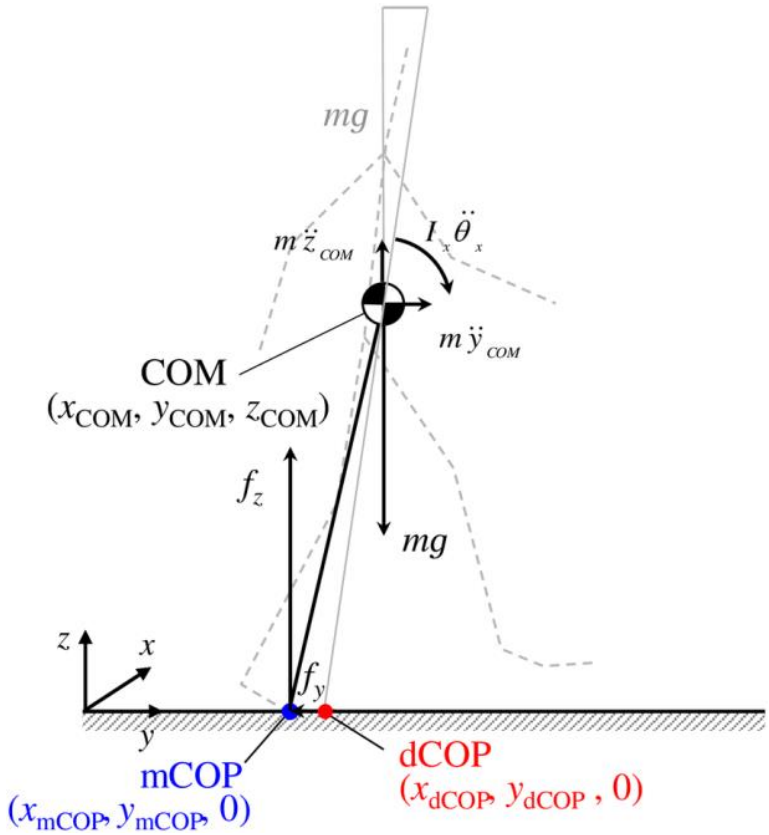

Figure 4 COPand COM

Using the variables which are easily useful among those suggested in Table 1, it's intended to identify the method to determine the balancing ability while walking. Angle and muscle variable are also the data obtainable from motion analysis system. But the data included in walking factors comprises of the variables that could be obtained by others than motion analysis system. Walking speed was measured by stop watch and related variable including stride length, step length and step width are measured by a 1.5m-long tape measure. Cadence is also measurable using a stop watch that can measure the steps per minute and walk ratio can be calculated by combining the walking speed and cadence. Thus, the balancing ability while walking could be determined without measuring COM, when the significance between walking factor variables and COM can be determined.

Characteristics of the subject

To identify the correlation between walking factor variable and COM, variables were measured with 41 aged persons using the Motion analysis system. 41 senior persons are 75.4 years old on average which were higher than the standard age of the aged, 65 years old to avoid any insignificant difference with other group of ordinary persons when measuring the persons aged 65 on average. And the facilities for senior persons were based on those aged 70 or higher

whose waking ability are relatively lower without walking assistance device than 65 who are not significantly different from other younger persons.

The result from reviewing the difference between the standard aged according to the "Report on survey of body dimension of the Korean" and the subject in a bid to put the external factors under the control to the extent possible is as Table 3. The difference in case of the men was less than 1% indicating the value similar to the standard and in case of the weight of women, it's -4.22%, indicating insignificant difference

Table 2Age of the subject

Category	No of persons	Age		
		Average	High	Low
Total	41	76.0	86	70
Men	15	75.7	85	70
Women	26	76.2	86	70

Table 3Difference between the standard aged and the subject

Classification		Subject	Standard aged	Difference
Men	Height	164.5	163.5cm	0.61%
	Weight	64.27	63.7kg	0.89%
Women	Height	153	150.5cm	1.66%
	Weight	54.5	56.9kg	-4.22%

Analysis of correlation between the center of mass and walking factor variable

Correlation analysis is the statistical analysis approach used to determine the correlation between the variables. It's intended to identify whether the distribution among the variables is in linear or curve with a certain consistency and whether the positive or negative and the scale in numerical value. And the result is identified as correlation coefficient which has the value between -1 and 1. In case of a complete positive relation, it's represented by 1 while a complete negative relation, it's represented by -1 and when no relations exist, correlation coefficient is 0.

In this study, Pearson correlation coefficient was used. Pearson correlation coefficient has the advantage in analyzing the correlations between the variables of interval scale and ratio scale. A null hypothesis and alternative hypothesis established in this study are as flows.

H_0: No correlation exists between COM and walking variable($\rho=0$)

H_1: Correlation exists between COM and walking variable($\rho\neq0$)

Table 4 Result of Person Correlation Coefficient

		Cadence	Walking speed	Stride length	Step width	Step length	Walk ratio	R/L foot Ratio			
								cadence	Walking speed	Stride length	Step width
Center of Mass	P.C.C.	.048	-.354*	-.459**	.391*	-.451**	-.391*	-.088	-.121	.010	.003
	Sig. (2-tailed)	.767	.023	.003	.012	.003	.011	.582	.453	.950	.985
	N	41	41	41	41	41	41	41	41	41	41

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Analysis result is as Table 4.Correlation between walking speed and walk ratio and length-related stride length, Step width and Step length appeared to have existed. Among them, correlation between stride length and step length were high negatively which indicated the greater the motion of central body (the greater the COM) the less the Stride length and Step length. No correlation between the Right and left foot ratio which indicated the difference in walking ability of the foot has less effect on balance.

Conclusion and further study

Review of correlation between COM and walking variable was made and as a result, two variables relating to the distance between the feet had a high correlation with COM. Measuring COM is possible through motion analysis which thus is difficult and immediate determination is unachievable. Accuracy would be relatively lower when using the result from this study but the diagnosis to determine the balancing ability while walking is achievable which is meaningful from such a viewpoint.

And the aged with a high walking ability with a short Stride length and Step length has a higher risk of falling and thus the floor that would be suitable to those with a short Stride length and Step length needs to be provided. That is, precast pavers on pedestrian passage where the aged uses more frequently need to be adjusted considering the Stride length and Step length. The precast pavers larger than the Stride length and Step length of the aged shall be used and the elevation gap among the pavers shall be minimized to mitigate the risk of falling accident.

The model that could be estimated based on COM calculation using such characteristics would possibly be developed. It would be also possible using correlation between walking variable and COM which is expected to make commitment to enhancing the walking environment for the aged.

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