THE RELATIONSHIPS AMONG GAIT PARAMETERS AND SENIOR FITNESS VARIABLES IN EXPLAINING SENIOR FUNCTIONAL ABILITY OF KOREAN ELDERLY PEOPLE

Young-Kwan Kim, Ji-Yong Joo, Chang-Yei Baek, and Hyo-Sung Lee

Department of Physical Education, Chonnam National University, Gwangju, S. Korea

The purpose of this study was to investigate the relationships among gait parameters and senior fitness variables in explaining the fitness ability of senior people. Two hundreds elderly people aged 65 to 85 participated in this study and they performed level walking at different speeds, senor fitness test, and composition measures. Among 33 measured parameters, principal component analysis (PCA) revealed five PCs such as gait characteristics, physical featue, gait variability, and fitness levels. In addition, the correlation analysis showed a fitness score is closely associated with single support time, walking speed, step and stride lengths, and flexibility of upper arms. In conclusion, gait parameters would a moderate indicator explaining health condition of elderly people.

KEYWORDS: elderly people, gait, walking speed, principal componet analysis

INTRODUCTION: Recently, the elderly population across the world has increased as a result of improved life styles and medical supports. Korea is rapidly heading for a super-aged society. According to recent data from the Statistics Korea (2018), people aged 65 or older exceeded 14% out of total population as of 2017 in compared with 7.5% as of 2000(Statistics Korea, 2018). As a result, health issues of the elderly is becoming a major social problem. As aging progresses, changes in physical ability are seen across all aspects of the body. Especially a decrease in physical strength as a result of loss of muscle mass is easily detected (Tzankoff & Norris, 1978). Decline of muscle mass and strength results in loss of diverse daily functional ability, especially ambulatory ability. Therefore, exercise and other forms of physical activity are required for older people in order to prevent functional loss and to provide physiological and psychosocial benefits (Pescatello & DiPietro, 1993). Prior to applying exercise program to older people, it is important to precisely assess their levels of fitness with appropriate measures and to find the key factors that could enhance functional ability (ACSM, 2017). Among a lot measures of physical ability, the walking speed has been known as a biomarker of longevity of older people and a predictor of physical performance (Studenski, Perera, & Patel et al., 2011). In particular, older adults sometimes tend to fall when they have instability during walking.

The purpose of this study was to see charcteristics of gait and fitness ability of Korean elderly people aged 65 to 85. In addition, it was to investigate the relationships among gait parameters and senior fitness variables throughout senior fitness test, walking test at differerent speeds, and body composition measures, which would be used for maintaining Korean elderly peoples' ambulatory ability and healthy status.

METHODS: Two-hundred Korean elderly people aged 65 to 85 participated in this experiment. Participants consisted of 100 males (height: 1.65±0.0 m, mass: 66.5±7.7 kg, and age: 73.8±5.6 years) and 100 females (height: 1.52±0.05 m, mass: 58.9±8.1 kg, and age: 73.8±5.4 years). All of them are able to walk without assistant or assisted tools. Most of participants have a couple of chronic diseases including hypertension, diabetes, high cholesterol, osteoporosis, and etc.

Assessment measures consisted of senior fitness test, walking test at different speeds, and body composition measures. Senior fitness test was composed of measuring grip force, sit-to-stand during 30 s, dumbbell curls during 30 s, sit-and-reach, 2.44m timed up and go, vertical jump, shoulder flexibility, one-leg stand, and 6-minute walk. Walking test at different speeds consisted of three different speeds. At first, subjects walked naturally on 20m walkway. The

preferred walking speed was determined. Then they walked at 20% faster and 20% slower than the preferred speed, respectively. When participants did not achieve the target speed, they repeated trials until less than 10% error of the target speed. The walking motion at different speeds were measured by Smart Balance® system (JEIOS, Korea), having two inertial sensors built in mid-sole of shoes (Kim, Joo, Jeong, Jeon, & Jung, 2016). This system, already been proven at Kim et al. (2016), measured linear gait parameters including cadence, walking speed, step length, duration of stance phase and swing phase, and etc. Body composition test was performed by a bioelectric impedance analysis tool of In-Body® system (In-Body, Korea), measuring body mass index, lean body masses of upper body and lower body, and fat percentages of major body parts, respectively. Health score, indicating fitness score, was made by an equally weighted regression model of gait parameters in Smart Balance® system (JEIOS, Korea).
After collected data, PCA and correlation analysis were performed in SPSS® (ver. 21.0, IBM incorp., USA). Thirty-three variables including health scores, senior fitness test scores, gait parameters, and body composition data were used for PCA. Correlation analysis was Pearson's bivariate correlations among 33 variables.

RESULTS:
Figure 1 showed mean data of gait parameters (preferred walking speed, cadence, and stride length) and fitness measures (lean body mass, number of dumbbell curl repetition, and 6-min walk distance) according to age (below 75 vs. more than 75 years) and gender (male vs. female). There was no significant interaction by two factors (gender and age). Except preferred walking speed and cadence, there was significant main effect of age on other four variables (*p*<.05). People more than 75 years old showed significant lower values (stride length, lean body mass, dumbbell curl repetition, and 6-min walk distnsce) (p<.05).

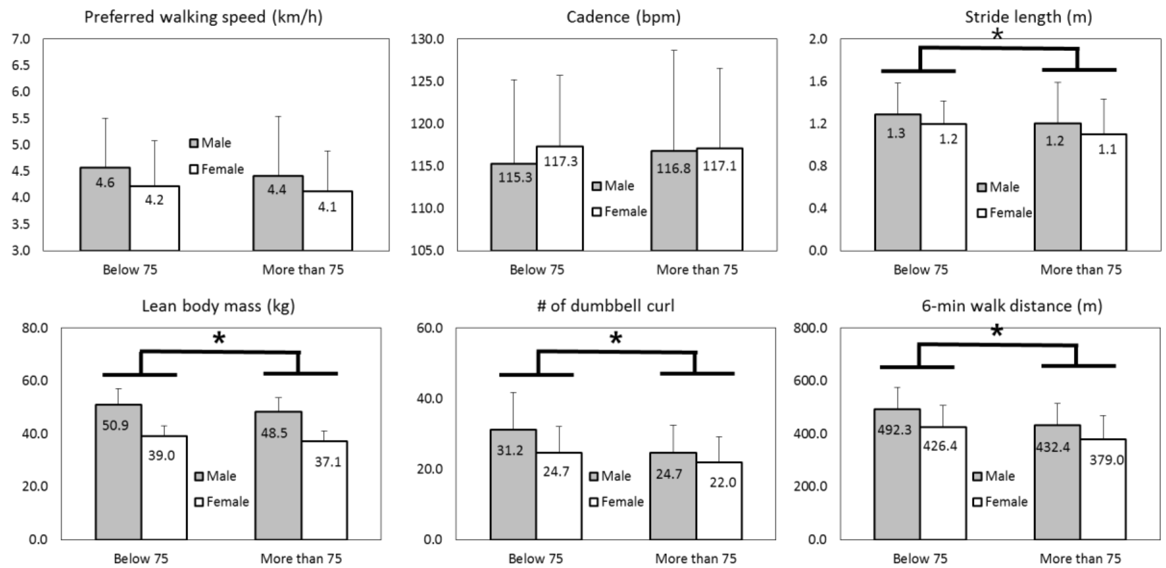

Figure 1: Changes in gait parameters and fitness measures according to ages and gender. * indicate significant main effect of age between groups.

Results of PCA showed 5 PCs such as characteristics of general walking (17.9%), physique (13.4%), walking variability (13.0%), body fat (11.4%), and physical fitness (8.7%). Those 5 PC accounts for 64.7% of total variability (Table 1). The health score was included in characteristics of general walking feature and gait asymmetry was done in characteristics of body fat feature. The 5th PC was characterized by physical fitness measures plus blood pressures and age.

Table 1: Results of PCA among gait and fitness variables

Variables	PC #1	PC #2	PC #3	PC #4	PC #5
Single Support Time	.901	-.076	-.044	-.209	-.032
Walking speed	.898	.101	-.222	-.012	.110
Stride Length	.879	.187	-.157	-.024	.058
Health Score	.492	-.056	-.146	-.107	-.038
Lean Body Mass	-.022	.966	.004	.096	.096
Height	.087	.922	.051	-.029	.057
Mass	-.134	.763	-.024	.601	.072
S.D. of Stride Length	-.030	.059	.911	-.048	.033
S.D. of Time of Toe Off	-.465	.033	.857	-.015	-.025
S.D. of Single Support Time	-.439	.010	.815	.013	.022
Fat Mass	-.187	-.059	-.044	.913	-.014
Body Mass Index (BMI)	-.254	.149	-.082	.835	.039
Gait Asymmetry	-.167	.018	.150	.242	-.113
Balance Score (Single Leg Stand)	-.050	.109	-.088	-.262	.640
6-min Walking	.120	.326	-.081	-.210	.617
Age	.103	.017	.117	.003	-.594
Diastolic Blood Pressure	.033	-.041	.149	.323	-.555
Dumbbell Curls	-.058	.357	-.046	-.076	.547
2.44 m Timed Up & Go	-.085	-.209	-.108	.271	.509
Vertical Jump	.143	.370	-.115	-.302	.490
Sit-And-Reach	-.267	-.407	-.086	.139	.416
Systolic Blood Pressure	.166	-.099	.181	.390	-.406
Shoulder Flexibility	.172	-.137	.044	.103	.359
Grip Force	.055	.032	.071	-.158	.298
Variance (%)	17.9	13.4	13.0	11.4	8.7
Accumulated Variance (%)	17.9	31.4	44.4	55.8	64.7

S.D. = standard deviation

Table 2: Pearson's correlation of measured variables with preferred walking speed and health score

Variables	Preferred Walking Speed	*p*	Health Score	*p*
Stride Length	.921**	<.01	.378**	<.01
Single Support Time	.766**	<.01	.419**	<.01
Double Support Time	-.765**	<.01	-.419**	<.01
S.D. of Time of Toe Off	-.645**	<.01	-.397**	<.01
S.D. of Single Support Time	-.620**	<.01	-.354**	<.01
S.D. of Double Support Time	-.520**	<.01	-.338**	<.01
6-min Walking	.289**	<.01	-0.034	.641
Gait Asymmetry	-.266**	<.01	-.312**	<.01
2.44 m Timed Up & Go	-.239**	<.01	-0.008	.912
S.D. of Stride Length	-.233**	<.01	-.173*	<.01
Fat Percentage of the Body	-.203**	<.01	-0.106	.135
BMI	-.182**	<.01	-0.13	.066

* *p*<.05, ***p*<.01, S.D.=standard deviation

Table 2 revealed the results of correlation of collected measures with a preferred walking speed and heath score, respectively. The linear gait parameters such as stride length and single support time were positively and double support time was negatively correlated with both preferred walking speed and health score (p<.05). The gait variability (e.g., standard deviations of time of toe-off, single support time, and double support time), body fat, and some of fitness scores, were negatively correlated with preferred walking speed and health score (p<.05). Physical fitness variables such as 6-min walking, 2.44m timed up and go, fat percentage of the body, and BMI were correlated with preferred walking speed but no significant correlation with health scores. The preferred walking speed was significantly correlated with health score (r=.388, p<.01).

DISCUSSION: Korean elderly people showed faster mean cadence (115 to 117 steps/min) and shorter stride length (1.1 to 1.3m) in comparison with Western older adults (103 to 112 steps/min and 1.35 to 1.53m for candence and stride length, respectively) (Aboutorabi et al., 2016). It might be attributed to physique of Korean elderly people, characterized by shorter heigt and less mass. As people get older, lean body mass decreases. This change induces weaker strength and sarcopenia that are associated with slower motions and slower walking speed (Castell et al., 2013). In this study, we detected significant drops of muscle mass (i.e., lean body mass), strength (i.e., repetition of dumbbell curls), and aerobic ability (i.e., 6-min walking distance) when people exceeded 75 year old in comparison with people less than 75 year old. However, we did not find any significant drop of preferred walkkng speed and cadence across 75 year old.
Previous study (Studenski et al., 2012) suggested that gait speed could be a simple and accessible summary indicator of vitality because it integrates multiple organ systems in response to known and unrecognized disturbances. Slower gait speed might reflect both damaged control system and loss of muscle mass (Studenski et al., 2012). According to current study, the preferred walking speed is closely correlated with health scores but low-to-medium level (r = 0.388). This might be partiallly explained that some variable (e.g., 6-min walking distance, 2.44 m timed up & go, fat percentage of the body, and BMI) well reflected the preferred speed well but did not well explain health scores.
The results of PC categorized the relationship of gait parameters and fitness test measures. The PC structure consisted of positive gait parameters (e.g., step length, single support time), negative gait parameters (e.g., double support time, standard deviation of time of toe-off), positive physique (e.g., lean body mass), negative physique (e.g., fat percentage, BMI), and fitness test scores. Those implied that gait performance and characteristics would be closely associated with levels of fitness state (McPhee et al., 2016).

CONCLUSION: For Korean elderly people, most of fitness measures were significantly affected by changes in age but some gait parameters (e.g., gait speed and cadence) did not well reflect changes in age. The preferred walking speed is partially associated with health score and fitness measures. Therefore, it is important to prevent the loss of muscle mass and strength from aging process for Korean elderly people.

REFERENCES

Statistics Korea (2018).http://kostat.go.kr/portal/korea/kor_nw/6/1/index.board?bmode=read&aSeq=372113
ACSM (2017). *ACSM's Health-Related Physical Fitness Assessment Manual* (5th Ed). Wolters Kluwer.
Castell, M.V., et al, (2013). Frailty prevalence and slow walking speed in persons age 65 and older: implications for primary care. *BMC Family Practice*, 14, 86.
Kim, Y.-K., et al. (2016). Effects of walking speed and age on the directional stride regularity and gait variability in treadmill walking. *J of Mech. Sci. and Tech., 30*(6), 2899-2906.
McPhee, J. S., et al. (2016). Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology*, 17 567-580.
Pescatello, L. S. & DiPietro, L. (1993). Physical activity in older adults: an overview of health benefits. *Sports Med*,*15*, 353–364.
Studenski, S., Perera, S., Patel, K. et al. (2011). Gait Speed and Survival in Older Adults. *JAMA.* 305(1), 50-58.
Tzankoff, S. O., & Norris, A. H. (1978). Longitudinal changes in basal metabolic rate in man. *J Appl Physiol*, *33*, 536–539.

ACKNOWLEDGEMENTS: This research project was supported by The Sports Promotion Fund of Seoul Olympic Sports Promotion Foundation From Ministry of Culture, Sports and Tourism.