Journal of Human Kinetics volume 25 2010, 35-40
Section I – Kinesiology DOI 10.2478/v10078-010-0029-y

Muscle Strength and Aerobic Endurance as Factors Differentiating Falling and Non-Falling Men over 70 Years

by
Janusz Maciaszek[1]

The aim of the study was to find factors which differentiate generally healthy elderly men who had fallen versus those whom had not fallen throughout the year prior to the study. The participants (66 generally healthy men aged over 70 years) were divided into two groups – those who had fallen (F) and those who had not fallen (NF) in the period of one year before the study. Their body mass index and fat mass were measured. On the basis of the value of maximum sways on a stable posturographic platform, the sway area was calculated. To study psychomotor fitness reaction time, an analysis was measured by the "Vienna System Test". Functional fitness was measured on the basis of selected tests from "The Senior Fitness Test". The complexity of the multiple mechanisms underlying postural control does not allow for clear indication of the risks of stability loss. The experimental group of men over 70 yrs who had fallen (F) was characterised by lower body strength ($p<0.05$) and endurance ($p<0.05$), compared to NF group. Exercise programs designed to prevent accidental falls should incorporate strength and aerobic exercises.
Keywords: balance, elderly, falls.

Introduction

Falls in elderly people have serious consequences, including fractures and even death (Rikli and Jones, 2001). For this reason, this population of subjects may be much more interesting to scholars than a large number of similar incidences in children and young adults. Kannus et al. (1999), who analyzed such incidences among people over 50 years of age from 1970 to 1997, indicated a systematic increase in the number of falls in one year per 100 elderly people. Progressively, more falls result in fractures. In effort to reduce the number of falls, it is necessary to identify the most serious risk factors (Akyol, 2007). However, the control of posture and maintaining stability involves cooperation of many systems and organs, among which it is difficult to indicate those which are more significant (Horak, 2006). Falls are the main cause of death among elderly people.

Although the problem of falls in the elderly is a potentially serious situation, the consequences of internal injuries are not well recognised. In order to indicate risks which contribute to falls, scientists denote various factors which characterize a person with an increased risk of falling. However, it is very difficult to isolate such main risk factors. Stalenhoef et al. (2002) observed 311 people aged over 70. In 36 weeks, 33% of the participants in the study reported a fall. Subjects whom had fallen were characterized by relatively greater body sways, lower levels of muscular strength in the upper limbs, and tendencies toward depression, compared to subjects whom had not fallen. Moreover, these same fallen subjects during the study had also fallen at least once in the year preceding the study. This implies that low muscle strength and greater body sways lead to potential postural instability and a more likely risk of falling. Brouwer et al. (2004) noted that elderly fallers ($\bar{x}=$ 69.8 years) are characterized by a lower muscular

[1] - *Academy of Physical Education In Poznań, Poland*

Authors submitted their contribution of the article to the editorial board.
Accepted for pinting in Journal of Human Kinetics vol. 25/2010 on June 2010.

strength of the lower body, lower walking speeds and worse general health than even the much older control group ($\bar{x}$ = 90.2 years) of non-fallers. Moreover, a tendency was noted to decrease the limit of stability (a possibility of moving the centre of gravity in relation to the plane of support) in people who had fallen in the last year. The value of this parameter decreases with age; therefore, it can be considered an indicator for efficient functioning of the balance maintaining system (Holbein et al., 2007). Maybe the most significant reason here is not primarily related to muscle, but rather to the nervous system and the sending speed of information. Reaction time can, thereby, be longer among falling (F) than non-falling men (NF).

The results of other studies carried out on the elderly ($\bar{x}$ = 78 years) suggest that the control of body position on a narrow support plane may be used as a significant tool to identify fallers (Melzer et al., 2004). An increase in sway in standing on a limited support plane was noted in those subjects who experienced a fall in the 6 months before the study. The aim of the study was to find factors which differentiate generally healthy, elderly men who had fallen (F) versus those who had not fallen (NF) in the year before the study.

Methods

Experimental approach to the problem

Subjects were tested as they became available. On the basis of an interview, the participants were divided into falling (F) and non-falling (NF) men. Differences between groups were analysed. Age differences were examined because falls in older people are more danger. Many authors showed that muscle strength is a very important factor in fall risk; therefore, in this study lower body strength was measured. Low physical fitness level among elderly people correlate with larger body sways on posturographic platforms. Subsequently, differences in body sways in F and NF groups were studied. Because postural stability and fall risk depend on a healthy functioning nervous system, a significant part of the analysis was measured reaction time on different impulses (colors or frequencies in tone). Every test can provide new information about the value of main risk factors among elderly men.

Subjects

The study included a total of 66 generally healthy volunteer men. The age of the subjects ranged from 70 to 82.5 years ($\bar{x}$ = 75.2). All studied men were from the local community. All subjects presented with similarly low activity levels and had the same lifestyles. They lived in big cities for many years and had not participated in any form of sport or exercise for health or recreational purposes for at least last 5 years. Participation in the study was voluntary. The measurements were in the spring. Subjects were informed of the experimental risks and every man signed a voluntary consent form after having received written information about the process of examination and taking part in the study. The investigation was approved by the Institutional Review Board for use of Human Subjects and the Local Committee of Ethics in Research. On the basis of the results of a short interview relating to falls in the year before the study, the participants were divided into two groups – falling (F), n=16 (70.0 – 82.5 years) and non-falling (NF), n=50 (70.0 – 82.1 years).

Procedures

Falling and non-falling men height and body mass were measured and BMI index was calculated. Using the method of electric bioimpedance (Akern RJT system – BIA 101/S), the value of fat mass was estimated (FM%). Maximum sway on a stable posturographic platform was then established. A computer posturographic system PE produced by the Military Institute of Aviation Medicine in Warsaw (a platform with four tensometric force transducers), with modified software made by Pro-Med (Warsaw, Poland), was used. Every subject had been clearly informed about the study protocol prior to the experiment. Every subject declared good functional capacity of their sense of sight. Before the test measurement, a subject took part in a preliminary test on the posturographic platform. He could observe and control movements projections of his own centre of body pressure on the floor (COP) by a monitor standing 1.5 m in front of the subject. The participant's task was to make a maximum forward sway and then maximum backwards sway, followed by maximum says to the left and to the right (Błaszczyk et al., 1993). The whole body was tense in the long axis, and sways were made using the ankle strategy. The sways in the frontal plane were made without taking feet off the ground. On the basis of the obtained values of individual sways, the sway area was calculated.

To study psychomotor fitness reaction time, corrections in decisions were measured by "Decision Test" (Vienna Test System, software for psychological diagnosis - product of Schuhfried, Austria). This test required correct and fast reaction, suitable to the right or left leg or hands, to particular signals (colors or frequencies in tone). Before the main test, which took 4 minutes each, a subject took part in a preliminary test. The subject sat in front of the monitor where physical signals were exposed. High and low tones were emitted from a loudspeaker. Each subject received about 200 signals. For each impulse, only one specific fast reaction (hand or leg) was correct (Maciaszek et al., 2006; Potter et al., 2003). In statistical analysis, mean reaction times for all signals were used.

Functional fitness was measured on the basis of selected tests from "The Senior Fitness Test" (Rikli and Jones, 2001): chair stand test (lower body strength), 8-foot up-and-go test (agility/dynamic balance), chair sit-and-reach test (flexibility) and 6-minute walk test (aerobic endurance).

Statistical Analyses

Data were recorded and coded for each group. Medium, minimum and maximum values were calculated for each variable. To compare F and NF groups, we used Statistica 7.0. The study groups were small and the data did not appear to have normal distributions; therefore, variables were compared using the nonparametric Mann-Whitney U test. The α level was set at 0.05 for all analyses. The dependant variables examined were BMI, FM, mean reaction time, flexibility, lower body strength, agility/dynamic balance, aerobic endurance and sway area.

Results

The differences between male fallers and non-fallers in terms of the analyzed factors

The age range of all participating men was relatively small (70-82 years). Nevertheless, groups of older fallers ($\bar{x}$ = 79.1 years, 70.0 – 82.0 years) and younger subjects ($\bar{x}$ = 75.6 years, 70.0 – 82.0 years) who did not fall in the period of the last year, which were significantly different ($p<0.05$), can be distinguished. The variable of falls were not statistically different in the studied men in terms of BMI or even FM%. No differences were noted in the values of reaction time (decision test), flexibility (chair sit-and-reach test) and agility (8-foot up-and-go test), between falling and non-falling. However, the non-falling group is characterized by a significantly larger ($p<0.05$) strength in the lower body (chair stand test) and aerobic endurance (6-minute walk test). The lack of statistically significant differences between the sway area of falling and non-falling is surprising.

Discussion

The results of the study indicate numerous incidences of falls in men over the age of 70. The effects and consequences of age has been emphasised many times (Lord et al., 2003; Scheffer et al., 2008). At an elderly age the risk of falls increases very rapidly. The mean age of the NF group was 75.6 years, while the average age of the F group was nearly 4 years older.

The relation between height, body mass and postural stability are ambiguous. Although body size and proportions were indicated as factors determining the risk of falls (Bergland et al., 2000; Richardson, 2002), this study was unable replicate these results. BMI and FM do not differ between men who fell in the last year, from those men who did not fall. The system of maintaining stability constantly undertakes actions appropriate for the changing needs, in which it considers all internal and external determinants (Horak, 2006). Body mass or proportions are considerations in controlling antigravitational movements; however, they do not play a significant role among each subject.

The lack of differences in reaction time between the two groups is surprising. This variable has been considered one of the main determinants in the risk of falling (Lajoie and Gallagner, 2004). Lord et al. (2003), however, indicated other causes for falls of the elderly, depending on the level of posture stability. Hence, the significance of reaction time may depend, among other things, on the level of general fitness, as the cause for loss of stability and fall. The progressively slower and decreased movements and activity seen in the elderly during everyday activities may be a form of compensation for the limitations in the functioning of the nervous system, which is manifested by a longer reaction time. Decreased possibility for fast reaction dictates increased care, slower and decreased movements, and thus minimizing the risk of falls. Agility/dynamic balance does not differ between falling and non-falling men.

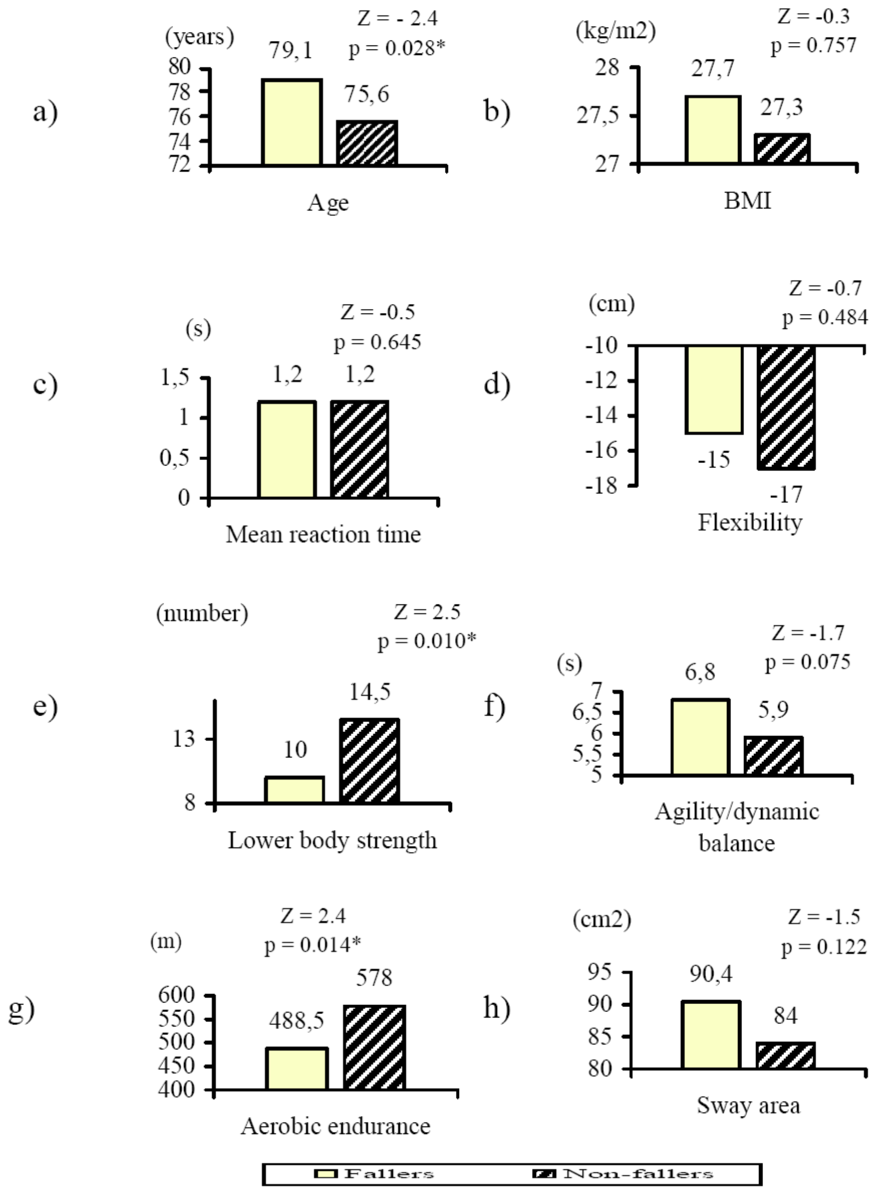

Figure 1

*Differences in a) age, b) BMI, c) mean reaction time, d) flexibility, e) lower body strength, f) agility/dynamic balance, g) aerobic endurance and h) sway area between fallers and non-fallers elderly men. * p<0.05*

The progressive weakening of muscular strength and aerobic endurance is also among fall risk factors (Karinkanta et al., 2005). The men aged over 70 years participating in the study, who fell in the year before the study, were also characterized by a reduced lower body strength ($p<0.05$) and a lower level of aerobic endurance ($p <0.05$). In this study, no relations were noted between incidence of falls and joint mobility-- the limitation of which may be a serious risk factor. With increasing age, soft tissue elasticity decreases and enhanced bone degeneration are noted, preventing sudden fast movements, which correct sways of the body in relation to the support surface.

The range of maximum sway in various planar directions is considered to be a sensitive indicator of the degree of fall risk. Rose and Lemon (2001) assumed that the stability limit established on the basis of the size of sways from the centre of gravity in the sagittal and frontal planes, may be used as an indicator of the risk of falls and motor fitness of the elderly. However, the sway area established in this study did not differ significantly between the falling and non-falling groups.

It is difficult to isolate specific factors determining the risk of falls. However, the complexity of the multiple mechanisms underlying postural control often do not allow for a clear indication of risks for stability loss (Horak, 2006). As indicated above, the group of male falling over 75 years of age is characterised by reduced strength and muscle endurance in the lower extremities, in comparison to the non-falling subjects.

References

Akyol AD. Falls in the elderly: what can be done? Int Nurs Rev, 2007. 54(2): 191–6.

Bergland A, Pettersen AM, Laake K. Functional status among elderly Norwegian fallers living at home. Physiother Res Int, 2000. 5(1): 33–45.

Błaszczyk JW, Hansen PD, Lowe DL. Postural sway and perception of the upright stance stability borders. Perception, 1993. 22(11): 1333–1341.

Brouwer BK, Musselman B K, Culham E. Physical Function and Health Status among Seniors with and without a Fear of Falling. Gerontology, 2004. 50(3): 135–141.

Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age Ageing, Supplement, 2006. 2 (35): 7–11.

Holbein J, Mary J A, McDermott K, Shaw C, Demchak J. Validity of functional stability limits as a measure of balance in adults aged 23-73 years. Ergonomics, 2007. 50(5): 631–646.

Kannus P, Niemi PS, Parkkari J, Palvanen M, Vuori I, Jarvinen M. Hip fractures in Finland between 1970 and 1997 and predictions for the future. Lance, 1999. 353: 802–805.

Karinkanta S, Heinonen A, Sievanen H, Uusi-Rasi K, Kannus P. Factors predicting dynamic balance and quality of life in home-dwelling elderly women. Gerontology, 2005. 51(2): 116–121.

Lajoie Y, Gallagner SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. Arch Gerontol Geriatr, 2004. 38(1): 11–26.

Lord SR, March LM, Cameron ID, Cumming RG, Schwarz J, Zochling J, Jian Sheng J, Makaroff J, Yin Yiow S, Tang Ching L, Brnabic A, Sambrook PN. Differing Risk Factors for Falls in Nursing Home and Intermediate-Care Residents Who Can and Cannot Stand Unaided. J Am Geriatr Soc, 2003. 51(11): 1645–1650.

Maciaszek J, Osiński W, Szeklicki R. Age, BMI, psychomotor and functional fitness as determinants of static and dynamic balance in elderly men with osteopenia or osteoporosis. Studies in Physical Culture & Tourism, 2006. 13(1): 25–32.

Melzer I, Benjuya N., Kaplanski J. Postural stability in the elderly: a comparison between fallers and non-fallers. Age Ageing, 2004. 33(6): 602–607.

Potter PC, Schepers JM, Van Niekert C. The effects of fexofenadine on reaction time, decision-making, and driver behavior. Ann Allergy Asthma Immunol, 2003. 91(2): 177–181.

Richardson JK. Factors Associated With Falls in Older Patients With Diffuse Polyneuropathy. J Am Geriatr Soc, 2002. 50(11): 1767–1773.

Rikli R, Jones J. Senior fitness test manual, Fullerton, California State University: Human Kinetics, 2001.

Rose DJ, Lemon N. The Limits of Stability Test as a Predictor of Faller Status in Community-Dwelling Older Adults. J Sport Exerc Psychol, Supplement, 2001. 23(2): 73.

Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij S. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age Ageing, 2008. 37(1): 19–24.

Stalenhoef PA, Diederiks JP, Knottnerus JA, Kester AD, Crebolder HF. A risk model for the prediction of recurrent falls in community-dwelling elderly: a prospective cohort study. J Clin Epidemiol, 2002. 55(11): 1088–1094.

Corresponding author

Janusz Maciaszek
Akademia Wychowania Fizycznego w Poznaniu
Zakład Teorii Wychowania Fizycznego i Antropomotoryki
ul. Królowej Jadwigi 27/39
61-671 Poznań Polska
phone: +48 618355214
fax: +48 618355211
e-mail: jmaciaszek@awf.poznan.pl