

PHYSIOTHERAPY METHODS IN PREVENTION OF FALLS IN ELDERLY PEOPLE



MAŁGORZATA GAJOS

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: malgorzata.gajos0904@gmail.com

RADOSŁAW PERKOWSKI

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: perkowski.radoslaw@gmail.com

AGNIESZKA KUJAWSKA

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: agajos11@gmail.com

JOANNA ANDROSIUK

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: joannaandrosiuk@gmail.com

JOANNA WYDRA

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: joannawydra86@gmail.com

KAROLINA FILIPSKA

Nicolaus Copernicus University, Collegium Medicum,
Departament of Geriatrics,
Marii Skłodowskiej Curie 9, 85-094 Bydgoszcz, Poland
E-mail address: krolinafilipskakf@gmail.com

ABSTRACT

The process of population ageing is observed not only in Poland but also in other European countries. Physiological processes of ageing reduce the functional capacity. In particular, associated diseases, progressive weakness and failure of the motor system increases the risk of collapse in seniors. Dangerous consequences of falls, inter alia, injuries, can often cause death, what justifies its classification as a so-called geriatric giant. Health and psychosocial consequences of falls should be noted. Therefore, there is a great need for induction of preventive measures. Results of numerous studies constantly show that an effective intervention in preventing falls in seniors should include, first and foremost, multidirectional rehabilitation, which aims to improve balance and increase postural strength muscle. In addition, prevention should include: patient education, pharmacotherapy prescribed by a medical specialist, eyesight improvement, elimination of potential risks surrounding the patient. The introduction of multi-directional prevention of falls can reduce the risk of their occurrence up to 50%.

Key words: elderly, risk factors, falls, prevention

INTRODUCTION

Motor system disturbances can be caused by process of ageing. They consist of increased swing posture, decreased extensor reflex and increased latency in reaction time of some reflexes (Gajos, Kujawski, Gajos, Chatys, Bogacki, 2014, pp. 99-108). Decreasing effectiveness of vision, hearing and proprioception is related with ageing, which can cause decreased maintaining of balance. In older people the gait pattern is frequently changed to, so called, *elderly gait*. It is described as taking smaller steps, decreased velocity, raising the feet lower from the ground, decreased mobility in the hips and knees. Gait disturbances can coexist with many diseases such as Parkinsons Disease where gait velocity is decreased (Świątek, Urodow, 2013, pp. 195-200).

Falls are rapid, unintended changes of body posture. Falls lead to decrease of fitness performance, which is directly linked to a reduction in quality of life (Skalska, Żak, 2007, pp. 167-174; Kamińska, 2013, pp. 21-26; Edbom-Kolarz, Marcinkowski, 2011, pp. 313-318) . Falls are one of the senile, chronic disabilities included in Geriatric Giants. In addition, they are the base of psychosocial and economical issues. Usually, there are several reasons for the fall. It is impossible to distinguish one, main reason for such an event. The risk of fall occurrence increases with age. In European countries a growing interest in the topic of falls in public health policy occurred in recent years (Skalska, Żak, 2007; Świątek, Urodow, 2013; World Health Organization, 2007) .

EPIDEMIOLOGY OF FALLS

The epidemiological studies showed that 28-35% of people over 65 experience falls. This number increases to 32-42% in case of seniors over 70, to 50%

over 90. Patients living in nursing homes have falls more often than people living in their own homes. Almost half of these people have recurring falls (Skalska, Żak, 2007; Kamińska, 2013, pp. 21-26; World Health Organization, 2007).

The most frequent falls among seniors occur while walking. In other cases the reasons are environmental factors (about 44%) or the performance of dangerous activities (only 5%) (Kamińska, 2013, pp. 21-26). It should be noted that people with impaired cognitive function have twice the risk of falls than other people of the same age without this disorder (Kupisz-Urbańska, Broczek, Masakowska, 2013, pp. 8-9).

THE CONSEQUENCES OF FALLS

The consequences of falls among the elderly are, *inter alia*: increased morbidity, dependence on caregivers, long-term disability and even increased mortality among this age group. These factors lead to lower quality of life and increase the cost of treatment (Debra, 2011, pp. 37-48).

About 65% of falls are connected directly to the injury, of which 10-15% lead to serious injury, the most common effect is the bone fracture (common in patients who suffer from osteoporosis), head trauma, or injury to the soft tissues. The possible results of these complications are prolonged immobilization, which may result in pressure sores, venous thrombosis, urinary tract infections, pneumonia, dehydration, hypothermia and spasm in the joints (Skalska, Żak, 2007; Kamińska, 2013).

The occurrence of these complications, results in prolonged hospitalization. The consequence of the collapse are very often dangerous fractures of the proximal femur. In fractures in this area, approximately 20% can lead to death (within a year). Approximately 50% of patients do not regain the fitness level which they had before the accident, and in approximately 12% of cases break or fracture in the same location will occur again. Falls are the cause of changes in psyche of elderly, they tend to fear occurrence of similar incidents. They tend to feel discouragement, fear of performing activities of daily living, which results in reduced activity of the secondary decrease in overall efficiency and impaired daily functioning. The above mentioned factors lead to dependence on family caregivers. This sequence of events, occurring one after the other, is called "fear of falling". In patients with a recent fall, it affects approximately 73% of the cases, and approximately 46% of the patients who had falls in the past. It is assumed that approximately 40% of admissions of elderly patients to hospitals or care centres is directly connected with the consequences of falls (Skalska, Żak, 2007; Kamińska, 2013; Edbom-Kolarz, Marcinkowski, 2011).

MOST COMMON REASONS AND CIRCUMSTANCES OF FALLS

Reasons for tumbles can be divided into internal, caused by coexisting illness, which in turn entails overall poor health, as well as external, coming from the surrounding environment (Edbom-Kolarz, Marcinkowski, 2011).

Internal tumble causes. Bone health and bone preservation have a major impact on reducing the effects of a tumble. Monitoring the bone mass is of utmost importance for patients of more than 65 years of age. Early detection of osteoporosis allows for starting the treatment quickly, thus preventing the weakening of bones. Diabetic patients often suffer from sight issues (e.g. amblyopia), which may also be a cause of falls. Any motion system diseases i.e. paresis, joint dysfunction, increase the likelihood of a fall (Skalska, Żak, 2007; Edbom-Kolarz, Marcinkowski, 2011).

External tumble causes. Figures show, that the majority of collapses of elderly people happen in a place they know best – their homes. Rugs, carpets, stairs, sills, slippery floors are the problem. Falls happen also during the daily chores (e.g. hanging curtains, changing the light bulb) or after taking medicines, in this case it is not only the amount that is important but the type as well. Taking psychotropic drugs (antidepressants, hypnotics, sedatives), diuretics or antihypertensive drugs highly potentiates the risk of falls. The primary cause of a falls is often looked for in the environmental factors, however the true reason may be an internal factor, which is weakening the overall dexterity, as well as reflexes. Elderly people are prone to tumbling due to limited physical activity and high volume of activities that create risky situations, which may in turn lead to a collapse (Skalska, Żak, 2007; Dzieża-Grudnik et al., 2014, pp. 537-540; Wnuk et al., 2010, pp. 3-9; Edbom-Kolarz, Marcinkowski, 2011).

THE ASSESSMENT OF THE RISK OF FALLS IN GERIATRIC PATIENTS

The effective action which prevents falls among elderly people, in the first place should include a risk assessment of their occurrence. This could be part of a regular physical examination already performed by staff in primary health care (primary care). The substrate to determine the patient's care plan is a comprehensive geriatric assessment (Pearse et al., 2003, pp. 518-521). It is a comprehensive assessment aimed to identify medical problems, as well as functional capabilities in seniors, in order to determine a plan of treatment and physiotherapy, to provide care, as well as the initiation of therapy and long-term care. Comprehensive geriatric assessment is most effective in cases when it is used in patients at risk of reduced functional capacity or of those with necessary staying in hospital or institutional care. Effective implementation of comprehensive geriatric assessment permits not only to extend the life, but also to increase its quality. It's should include long-term care in the clinic and

in the home of the patient. Primary health care provides health care benefits to its patients directed at treatment, prevention and diagnosis of diseases or to reduce disability, rehabilitation, health education, and what is very important, also for the promotion of health.

As part of primary health care research is contracted aimed at detecting factors causing lowering of self-service, reducing the efficiency of the organism of seniors. The aim of these activities is to detect diseases, to identify the limits and needs, not only health but also social and psychological among elderly patients. Such an approach to the patient may consequently not only serve emergency assistance, but also long-term care (Kamińska, 2013; Brzozowski et al., 2014, pp. 41-44; Żak, 2008, pp. 18-21).

Separation of the causes which are most often reasons for falls in the elderly, can be the key to the implementation of measures to reduce their incidence. These activities should be multidirectional, containing all areas of human functioning. The outpatient procedure uses a lot of functional tests, in order to assess the risk of falls among people over 65 years old (Szot, Golec, Szczygieł, 2008, pp. 12-17).

Instruments for geriatric assessment in an evaluation of the risk of falls estimate physical fitness of the patient, is used in this case test:

- scale ADL (Activities Of Daily Living) and IADL (Instrumental Activities Of Daily Living), Barthel Index, The Tinetti Test, Get Up and Go, Test Berg, Stops Walking While Talking;
- intellectual function, and also emotional, apply here: test AMTS (Abbreviated Mental Test Score), scale MMSE (Mini Mental State Examination), scale GDS (Geriatric Depression Scale) and scale BDI (Beck Depression Inventory) (Vivrette et al., 2011, pp. 16-29; Wrislay, Kumar, 2010, pp. 761-773).

The methods of verifying the internal factors that contribute to the fall are classed as: control the exercise of orthostatic attempting in order to identify orthostatic hypotension, measuring blood pressure and heart rate and control of muscle mass and strength. It should also check the condition of sight and hearing. Emphasizing that the fall may also occur during examination, entails the need for proper preparation office and belaying patient (Skalska, Żak, 2010).

FALLS PREVENTION

Falls prevention is about eliminating the factors that cause it (Skalska, Żak, 2010). Considering the reasons mentioned beforehand, it should be clear that the environmental and situational factors can most notably be influenced. This is the reason why, education on tumble risk, behaviour change and reducing the risk of collapse in the house is important. Statistics support this fact, 75% of falls occur in homes, most often during avoidance of various furniture and items and using the stairs, thus the collapses are caused by external factors. In

order to ensure safety, preventive actions such as mounting appropriate grips and rails facilitating movement or standing up (eg. in the toilet or the shower cabin) should be taken. Other important safety measures include bright lightning, removing obstacles from the floor, using non-slip rugs, removing sills if possible. Commonly used items and often visited places should have easy access and maximum bed height should be 50cm (Debra, 2011; Świątek, Urodow, 2010).

Preventive actions carried out by the medical personnel should focus on informing the patient, modification of the pharmacotherapy, treating orthostatic hypotension, correcting sight and audition, removing the environmental hazards, osteoporosis treatment and prevention, rehabilitation including introduction of motion and balance exercises, as well as training leading to increase of muscle mass (Kamińska, 2013).

Every person above 70, that has a noted occurrence of falls, people with high-risk of collapse, as well as everyone, who suffered an injury or with balance and movement disorder should be considered for preventive actions (Skalska, Żak, 2007).

THE PURPOSE OF PHYSIOTHERAPY

The purpose of physical therapy is taking countermeasures to prevent occurrence of symptoms resulting from immobilisation. To achieve it while hospitalized the patients have physical therapy, that includes: anticoagulants exercises, breathing, active and passive exercises, that aim at keeping the correct mobility in the joints, flexibility of the soft tissue and strengthening the muscles. A very useful tool here is the 'stand up and go'- test, which makes it possible to check how strong, mobile and fit the lower limbs are and to check general coordination and dynamic balance (Skalska, Żak, 2007; Guccione, Wong, Awers, 2014, pp. 389-419).

Very important is the cooperation of the whole staff e.g. nurses, who ensure changes in position of the patients to prevent bedsores (Guccione, Wong, Awers, 2014).

The aim of physical therapy is to introduce exercises that ensure an improvement in balance and muscle strength (Kamińska, 2013). It slows down the progress of the disease in the body, thus lowering the risk of falling down, it helps to restore the normal function capability and enables the patients to perform the activities of daily living (Debra, 2011). Balance can be formed and improved effectively by means of training (Wnuk et al., 2010). A variety of exercises used aims not only at improving balance but flexibility, suppleness, coordination and response time as well. Moreover, physical activity could influence positively on cognitive functions of older people (Gajos, Kujawski, Gajos, Chatys, Bogacki, Ciesielska, Zukow, 2014, pp. 91-100). Results of cognitive tests, which are most often reported to be improved after participating

in physical training, are, inter alia, Mini Mental State Examination (MMSE), Auditory Attention Tests and Digit Span, Digit Span backwards (Kujawski, Gajos, Gjaos, Stemplowski, Ciesielska, Kędziora-Kornatowska, 2015, pp. 11-16). A moderate physical activity for 30 min about 5 times a week is recommended (Skalska, Żak, 2008; Son et al., 2015, pp. 51-57). Very important is to teach the patient how to change the position of the body in a safe way. This will prepare the patient for eventual falls, teach control, how to prevent harm by falling down and how to get up to prevent additional damage (Skalska, Żak, 2007; Son et al., 2015). All preformed actions should prevent falling down in the future and thus lower the rate of injuries, morbidity and mortality amongst the elderly. It will also prevent possible disabilities, **dependency** on family members and lower the number of hospitalized patients (Kamińska, 2013). A great role in lowering the risk of damages resulting from falling down and in ensuring free and confident movements is played by the right orthopaedic equipment. Individualized equipment fitting for the seniors ensures stability of the torso and the limbs and provides the right support for the body, which in turn helps to develop compensatory mechanisms and in some cases substitutes for the lost limb. Choosing the right orthopaedic equipment helps the patient to move freely and to feel comfortable. Shoes are also important as equipment which stabilize the ankle, contain anti-skid soles and should be easy to wear (Kamińska, 2013; Dzieża-Grudnik et al., 2014).

Seniors often tend to fall when changing the body position from the standing position to the sitting position; that is in situations in which the blood pressure in the body drops rapidly. The physiotherapist job in a geriatric ward or care homes is to teach the patients proper getting up techniques: first you should sit on the bed, than lower your feet first, than stand up. Each of the 'sitting up' steps should be made slowly until the breathing stabilizes (Świątek, Urodow, 2014).

TRAINING IN THE PREVENTION OF FALLS

Current studies showed that training among seniors has a positive effect on the improvement of daily activities. Individual strength and balance training decreases risk of falls and improves self-confidence in everyday duties (comparison of the exercisers group with not exercisers group) (Campbell et al., 1999, pp. 513-518; Mackenzie, Clemson, 2014, pp. 211-215). Individual training controlled by physiotherapist shows significant improvement of functional parameters and physical abilities in the balance tests, comparing to the study group, which had group balance training. A common feature of both trainings was statistically significant decrease of falls ($p < 0,0001$) (Nitz, Choy, 2004, pp. 52-58).

Undirected group exercises reveal significant improvement of physical ability but not reduction risk of falls (Lord et al., 1995, pp. 1198-1206). Decrease

of falls has been noted after oriented exercises whose purpose is to upgrade daily factors among weakened seniors (Bamett et al., 2003, pp. 407-414) and older women with repeating falls history (Skelton et al., 1995, pp. 1081-1087). In the second group, exercises were especially focused on dynamic balance and gait, muscle strength, physical strength, suppleness, functional skills. Besides that, there was recommended home training. Results showed 31% decrease in number of falls compared with control group, which had a home exercises programme twice a week (Campbell et al., 1999; Mackenzie, Clemson, 2014; Nitz, Choy, 2004).

Tai Chi is increasingly used in the prevention of falls. This method has a positive effect on physical and mental ability of seniors, and so it reduces not only risk of falls, but also the fear of falling. Nodim in study on group ≥ 65 years old with a slight imbalance disturbance noted improvement in balance after 10 weeks Tai Chi training focused on balance and overcoming obstacles. Intensive Tai Chi training did not reduce falls risk a in group of patients with general weakness. It was deduced that Tai Chi could be inadequate training for people with increased risk of falls. It seems that multifactorial training is more effective in this group (Skalska, Żak, 2004; Brzozowski, Chomiuk, Śliż, Folga, 2014; Hackney, Wolf, 2014, pp. 127-135).

Comparison of both interventions (Tai Chi and Otago) aiming prevention of falls and checking lower limbs strength, balance, gait time parameters in the group of older women, confirmed efficacy of both interventions in mobility. Moreover Otago group had greater improvement in strength of limbs, while Tai Chi group had better scores in balance (One Leg Stand test) and gait speed (Wolf et al., 1996, pp. 489-497. Balance training strengthening calf muscles twice weekly for 5 weeks, showed an increase of strength of calf muscles, functional capacity and better self-confidence in keeping balance (Maritz, Silbernel, 2015).

Kathleen K. Zettergren et al. (2011, pp. 88-94) conducted 8 weeks therapeutic programme and assessed influence of yoga on: control of posture, mobility, rising from the floor, gait speed in the elderly. They noted positive effects of yoga on control of posture and gait speed .

Bartosz Wnuk et al.(2010, pp. 3-9) examined the effect of gait exercises on a treadmill in group of 30 patients with osteoporosis and higher risk of falls. They used two kinds of training: first consisting of walking forward, second backwards. Additionally each study group had complex physiotherapy including active, coordination, respiratory and relaxing exercises. Intervention lasted 2 weeks: in the first week patients had 3 sessions of 10 minutes training, in the second week - 4 sessions 10 minutes each. At the final Tinetti test, after intervention, they noted significant increase in scoring among the study group with walking backwards training. In this group balance in standing position improved about 17,7% and balance during gait 27,9%. Both trainings resulted in increase of speed in the Up&Go Test. In the Functional Reach Test noted statistically significant growth of the distance about 11,4% in the group with

walking backwards. Increase of the torque values of the extensors of the knee joint were showed in both groups. What was interesting was increased values of the torque were higher in the right lower limb by 34,5% and in total values of the torque in both limbs by 30,1% in the backward gait training group.

There are also studies, which examined influence of backward gait training in a group of patients with stroke. These studies showed faster gait, longer step and improvement of lower limbs symmetry in comparison with the forward gait training group (Yang et al., 2005, pp. 264-273).

Backward gait training has positive influence, which results from strong proprioceptive sensory stimulation. At the same time it is strengthening the force and stabilizing head, torso, pelvis muscles and deep dorsal muscles, abdomen and gluteal muscles. It can influence an increase of better gait efficiency and balance.

All of these studies show positive qualitative and quantitative changes effects, which are necessary in safe daily locomotion of seniors. It is important that researchers are incessantly looking for better and better methods, which may be used in falls prevention (Wnuk et al., 2010).

CONCLUSIONS

There are many types of exercises aimed at preventing falls but the results of using them are different and they force the therapist to choose the most suitable ones according to individual needs of each patient, it is a crucial point of every physical therapy as well as physical exercise. The studies that distinguish groups of patients with exercises aiming at primary prevention and those with exercises aiming at secondary prevention deserve special attention. It is necessary to conduct further random studies that will estimate the efficiency of training among a bigger group of patients; it could help to standardise the recommendations for fall prevention.

REFERENCES

- [1] Barnett, A., Smith, B., Lord, S. R., Williams, M., Baumann, A. (2003). Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. *Age and Ageing*, 32(4), 407-414.
- [2] Brzozowski, A., Chomiuk, T., Śliż, D., Folga, A. (2014). Czy należy wprowadzić trening fizjoterapeutyczny ukierunkowany na zmniejszenie ryzyka upadku w populacji pacjentów z przewlekłą niewydolnością serca? [Is there a need to bring a physiotherapy training aimed at reducing the risk of falls in a population of patients with chronic heart failure?]. *Kardiologia w praktyce*, 2(28), 41-44.
- [3] Campbell, A. J., Robertson, M. C., Gardner, M. M., Norton, R. N., Buchner, D. M. (1999). Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. *Age and Ageing*, 28(6), 513-518.
- [4] Debra, J. (2011). Zapobieganie upadkom u osób starszych - brak „uniwersalnej” strategii interwencji [Preventing falls among older adults: No „one size suits all” intervention strategy]. *Rehabilitacja medyczna*, 15(1) 37-48.

- [5] Dzieża-Grudnik, A., Czekaj, D., Wójcik-Bugajska, M., Grodzicki, T. (2014). Upadki w trakcie hospitalizacji – częstość występowania i konsekwencje [Falls during hospitalization – prevalence and consequences]. *Przegląd Lekarski*, 71(10), 537-540.
- [6] Edbom-Kolarz, A., Marcinkowski, J. (2011). Falls of elderly people-causes, consequences, prevention. *Hygeida Public Health*, 46(3), 313-318.
- [7] Gajos, A., Kujawski, S., Gajos, M., Chatys, Ż., Bogacki, P. (2014). Applications of the H-reflex in kinesiology: a systematic review. *Biomedical Human Kinetics*, 6(1), 99-108.
- [8] Gajos, A., Kujawski, S., Gajos, M., Chatys, Ż., Bogacki, P., Ciesielska, N., Zukow, W. (2014). Effect of physical activity on cognitive functions in elderly. *Journal of Health Sciences*, 4(8), 91-100.
- [9] Guccione, A. A., Wong, R. A., Avers, D. (2014). *Fizjoterapia kliniczna w geriatrui* [Geriatric Physical Therapy]. Wrocław: Elsevier Urban & Partner.
- [10] Hackney, M. E., Wolf, S. E. (2014). Impact of Tai Chi Chu'an Practice on Balance and Mobility in Older Adults: An Integrative Review of 20 Years of Research. *Journal of Geriatric Physical Therapy*, 37(3), 127-135.
- [11] Kamińska, M. (2013). Rola pielęgniarstwa rodzinnego w prewencji upadków w grupie pacjentów w wieku geriatrycznym [The role of family nurse in prevention of falls in elderly people]. *Family Medicine & Primary Care Review*, 15(1), 21-26.
- [12] Kujawski, S., Gajos, A., Gajos, M., Stemplowski, W., Ciesielska, N., Kędziora-Kornatowska, K. (2015). Cognitive tests used in examining effects of physical training in elderly people. *Medical and Biological Sciences*, 29(2), 11-16.
- [13] Kupisz-Urbańska, M., Broczek, K., Massakowska, M. (2013). Ryzyko upadków u najstarszych seniorów [The risk of falls in the oldest seniors]. *Magazyn Pielęgniarki i Położnej*, 11, 8-9.
- [14] Lord, S. R., Ward, J. A., Williams, P., Strudwick, M. (1995). The effect of a 12-month exercise trial on balance, strength, and falls in older women: a randomized controlled trial. *Journal of American Geriatrics Society*, 43(11), 1198-1206.
- [15] Mackenzie, L., Clemson, L. (2014). Can chronic disease management plans including occupational therapy and physiotherapy services contribute to reducing falls risk in older people? *Australian Family Physician*, 43(4), 211-215.
- [16] Maritz, C. A., Silbernagel K. G. (2015). A Prospective Cohort Study on the Effect of a Balance Training Program, Including Calf Muscle Strengthening, in Community-Dwelling Older Adults. *Journal of Geriatric Physical Therapy*, 18.
- [17] Nitz, J. C., Choy, N. L. (2004). The efficacy of a specific balance-strategy training programme for preventing falls among older people: a pilot randomized controlled trial. *Age and Ageing*, 33(1), 52-58.
- [18] Pearse, E. O., Redfern, D. J., Sinha, M., Edge, A. J. (2003). Outcome following a second hip fracture. *Injury*, 34(7), 518-521.
- [19] Skalska, A., Żak, M. (2007). Upadki – ocena ryzyka, postępowanie prewencyjne [Falls – risk assessment and prevention]. *Standardy Medyczne*, 4, 167-174.
- [20] Skelton, D. A., Young, A., Greig C. A., Malbut, K. E. (1995). Effects of resistance training on strength, power, and selected functional abilities of women aged 75 and older. *Journal of American Geriatrics Society*, 43(10), 1081-1087.
- [21] Son, N. K., Ryu, Y. U., Jeong, H. W., Yang, Y. H., Kim, H. D. (2015). Comparison of 2 Different Exercise Approaches: Tai Chi Versus Otago, in Community-Dwelling Older Women. *Journal of Geriatric Physical Therapy*, 39(2), 51-57.
- [22] Szot, P., Golec, J., Szczygieł, E. (2008). Przegląd wybranych testów funkcjonalnych, stosowanych w ocenie ryzyka upadków u osób starszych [Overview of selected functional tests used in assessment of the risk of falls of older persons]. *Gerontologia Polska*, 16(1), 12-17.
- [23] Świątek, J., Urodow, W. (2013). Profilaktyka upadków u ludzi w podeszłym wieku [Prevention of Falls of the Elderly People]. *Pielęgniarstwo Zdrowa Publicznego*, 3(2), 195-200.
- [24] Wnuk, B., Walusiak, M., Durmała, J., Kadyjewska, M., Żak, E. (2010). Wpływ fizjoterapii rozszerzonej o różne formy treningu chodu na bieżni ruchomej na sprawność funkcjonalną osób starszych zagrożonych upadkiem [Effects of physiotherapy including various forms of gait exercises on a treadmill on functional efficiency in the elderly at risk of falling]. *Fizjoterapia*, 18(2), 3-9.

- [25] Wolf, S. L., Barnhart, H. X., Kutner, N. G., McNeely, E., Coogler, C., Xu, T. (1996). Reducing frailty and falls in older persons: an investigation of Tai Chi and computerized balance training. *Journal of American Geriatrics Society*, 44(5), 489-497.
- [26] Wrisley, D. M., Kumar, N. A. (2010). Functional gait assessment: concurrent, discriminative and predictive validity in community-dwelling older adults. *Journal of the American Physical Therapy Association*, 90(5), 761-773.
- [27] World Health Organization (2007). *WHO Global Report on Falls Prevention in Older Age*. Geneva: World Health Organization.
- [28] Yang, Y., Yen, J., Wang, R., Yen, L., Lieu, F. (2005). Gait outcomes after additional backward walking training in patients with stroke: a randomized controlled trial. *Clinical Rehabilitation*, 19(3), 264-273.
- [29] Vivrette, R. L., Rubenstein, L. Z., Martin, J. L., Josephson, K. R., Kramer, B. J. (2011). Development of a fall-risk self-assessment for community-dwelling seniors. *Journal of Aging Physical Activity*, 19(1), 16-29.
- [30] Zettergren, K. K., Lubeski J. M., Viverito J. M. (2011). Effects of a yoga program on postural control, mobility, and gait speed in community-living older adults: a pilot study. *Journal of Geriatric Physical Therapy*, 34(2), 88-94.
- [31] Żak, M. (2008). Ocena ryzyka upadków u osób starszych i możliwości prewencji [Assessment of the risk of falls in elderly people and the possibilities of prevention]. *Gerontologia Polska*, 8(3), 18-21.