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Selected factors influencing the risk of falls in the elderly

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Abstract
Introduction: Falls concern 1/3 of people aged >65 years and every second person aged >80, leading to seniors' disability and dependence on other people's care. The unmodifiable causes for falls are age, sex, marital status, and place of residence. The modifiable causes include involutional changes in all body systems, multimorbidity, polypharmacy, as well as living and environmental conditions.
Aim: To determine the risk factors of falls in the elderly.
Material and methods: The study involved 220 hospitalized patients aged >65 years who had experienced a fall. An anonymous questionnaire was applied that referred to the medications taken, diagnosed diseases, factors predisposing to falls, and the frequency of falls. The Mini-Mental State Examination was performed to qualify the subjects, and Tinetti test to assess gait and balance.
Results: In the Tinetti scale, 48.2% of the subjects were characterized by a rise in the risk of fall 5-fold higher than average; the risk increase less frequently concerned people undertaking physical activity and those who were younger (65–70 years) ($P<0.05$). The Tinetti test analysis revealed a statistically significant relation ($P<0.05$) between brain stroke, Parkinson's disease, orthostatic hypotonia, gait disorders, and falls. The decrease in the number of falls was influenced neither by dizziness, declared by 70.4% of the patients ($P=0.092$), nor by the number of medications taken ($P=0.072$). It was influenced, however, by the usage of orthopedic equipment ($P<0.001$).
Conclusion: The risk of falls in the elderly rises with age. Physical activity decreases the risk; it is increased, though, by gait and balance disorders, Parkinson's disease, past brain stroke, and orthostatic hypotonia.

Keywords: elderly; falls; risk factors; quality of life

Introduction
The involutional changes progressing in senility add to the worsening of the whole body function. Difficulties in maintaining balance, as well as problems with moving manage to hamper performing everyday activities and dynamic partaking in the social life [1]. These disorders are often accompanied by falls, which belong to the so-called geriatric giant syndromes. They contribute to the occurrence of senile disability, and their incidence increases with the patients' age, considerably worsening their quality of life.

Falls, beside cardiovascular diseases, are one of the causes for premature deaths. They are experienced by ca 30% of people aged over 65 and 50% of those aged over 85 in a year [2]. Most often falls happen as a result of balance loss during walking. Consequences are faced by seniors in all spheres of their lives (physical, psychological, social and economic).

Falls most often concern nursing home residents (50%–70%) and hospitalized people (20%), less frequently those living in their own homes. About one third of seniors experience falls each year, and more than a half are subjected to the incidents repeatedly [2,3].

Among the most significant risk factors of falls, there are age over 75 years, female sex, living alone, and past falls (history of falls) [4], including iatrogenic ones, resulting mainly from polypharmacy, overlapping adverse effects of the medications taken, and changes regarding absorption of the therapeutic substances [2]. Medications especially

contributing to the occurrence of falls include benzodiazepines, hypotensive, antiarrhithmic, antidiabetic, analgesic, and antidepressant agents; as well as diuretics and neuroleptics [5].

The cause for falls is complex. Most often, gradual and progressive worsening of the function of particular tissues and organs is observed with aging, and the changes result from many overlapping reasons (multimorbidity, polypharmacy, senile changes within the body systems). Less frequently, falls are brought about by a single factor [6]. Of significant importance here, among others, is the musculoskeletal system, as a factor responsible for maintaining balance, where lowering the muscle mass (sarcopenia) and bone mass (osteopenia, osteoporosis) progresses with age [2], as well as the nervous system, where the degenerative processes consist in the loss of neurons supporting muscles and in the slowdown of information processing. The frequency of falls is also influenced by changes in the sense organs, particularly those of vision (cataract, glaucoma, homonymous anopsia, macular degeneration) and of hearing [7,8].

The risk of falls in seniors is increased by chronic diseases, mainly those of the cardiovascular system. These include heart rhythm disorders, atherosclerosis of carotid arteries and lower limbs, myocardial infarction, orthostatic hypotonia incidents, and vasovagal reactions impairment (fainting on coughing, miction, defecation or hyperventilation).

Another group of diseases that impact on balance problems in the elderly are metabolic disorders (e.g. hypothyroidism, hypoglycemia, malnutrition, diabetes, anemia). Moreover, there are water-electrolyte (e.g. dehydration, hypokalemia, hyponatremia, hypo- or hypercalcemia), urogenital (e.g. nycturia, urinary incontinence, urge incontinence), and gastrointestinal (e.g. gastrointestinal bleeding, diarrhea, constipation) disorders.

Among the reasons for falls in the elderly, the environment should also be mentioned. The majority of incidents occur in nursing homes, then in hospitals, and in seniors' own homes, where so-called external factors seem the most important issues (slippery floors, steps, carpets, improper lighting, bathrooms not adjusted to the needs of an elderly person, etc.); the least frequent site is the general space, with problematic curbs or stairs [9].

Usually, several factors lead to a fall. Determining each of them is significant for assessing the incident risk. An estimation of a fall threat should be performed in each senior, as it allows to discover mobility disorders relatively early and to undertake preventive measures. Orthopedic equipment can be applied in the suitable time in order to decrease the frequency of falls and protect the elderly against the negative consequences of falls [1]. The aim of the paper was to determine the risk factors of falls in the elderly.

Material and methods

Procedures

The study was performed between January and June, 2017. The total of 220 patients were invited, all of whom were hospitalized in the geriatric wards. Exclusion criteria were: below the age of 65, significant cognitive impairment (achievement of the Mini-Mental State Examination (MMSE) below 24 points), stroke transition. Only people who experienced a fall were analyzed and expressed their informed consent to participate in the study. The initial qualification rejected 27 candidates; therefore, 193 seniors were finally enrolled.

An anonymous questionnaire of own authorship was applied in the study. It consisted of 31 questions, referring to the medications taken, diagnosed diseases, internal and external factors predisposing to falls, as well as the frequency of falls occurrence. The responders could provide the "yes" or "no" answers to the questions. In order to assess gait and balance, the Tinetti test was performed, in which a result of < 19 points indicates a high risk of fall (5-fold increased), a result ranging 19–24 points suggests that the subject is prone to falls, and

that of > 24 points reflects a low risk of fall or no risk at all. The scale is divided into the gait-related and balance-related part.

The study was approved by the Bioethics Committee of the Wroclaw Medical University.

Study group characteristics

The presented study involved 193 patients aged ≥65 years, mostly women (74.1%). Seniors aged >80 years were the most numerous (49.2%), then there were those aged 65–70 years (33.4%), and 75–80 years (17.4%) (mean, 75.7±6.3 years). The subjects were most often widowed (48.1%) or married (42.7%). The majority came from a city (86.1%). The biggest part of the responders had secondary education (44.0%), then primary (30.0%), and higher (26.0%). The mean length of stay in the ward equaled 23.0±7.1 days.

Taking into account the research problems, the authors collected information regarding the subjects' physical characteristics, which could be of considerable importance when indicating factors that determine the susceptibility to falls (Table 1).

Table 1. The study subjects' physical characteristics

Feature	***N***	***M***	***Me***	***SD***	***Min***	***Max***
Height	193	163.11	160.0	7.651	150	188
Body mass	193	73.26	73.0	13.673	44	113
Body mass index	193	26.98	26.08	4.472	17.34	36.78

Abbreviations: ***N*** – number of participants; ***M*** – mean value; ***Me*** – median value; ***SD*** – standard deviation; ***Min*** – minimum value; ***Max*** – maximum value

Statistical analysis

For the results obtained in the Tinetti scale in both domains (gait and balance), a reliability analysis based on Cronbach's alpha coefficient was performed. Statistical analysis was carried out with the use of Mann-Whitney U, Kruskal-Wallis (H), and chi-square tests (χ^2), with the value of $P<0.05$ as the assumed level of significance.

Results

The study participants obtained the mean MMSE result of 28.1±4.2 points. There were 146 seniors who received 27–30 points (the correct result), 47 who reached 24–26 points (mild cognitive disorders without dementia), 19 with 19–23 points (mild dementia), and 8 who scored 11–18 points (moderate dementia).

Among the patients who met the study criteria and were included (N=193), the majority declared to have experienced a fall within the previous year (61.1%). Within this group, most subjects had faced 3 incidents (22.9%), then 5 (21.2%), 2 (20.3%), 1 (16.9%), 10 (11.9%), 6 (3.4%). There were single participants who had gone through 4, 7, 12, or even 28 falls (3.4%).

More than a half of the study subjects declared to undertake physical activity every day (50.7%); 18.1% did it 3–5 times a week, 11.9% twice a week, 10.9% once a week, and 8.4% were not involved in any physical activity.

The majority of the participants maintained not to use any orthopedic equipment when moving (60.1%). Those who apply some most often indicated a walking stick (26.8%), crutches (8.6%), a walking frame (3.7%), or a wheelchair (0.8%).

More than a half declared that they had not experienced any fall caused by difficulties in maintaining balance (51.8%). The most frequent reason they suggested was sight issues (92.7%).

The diseases diagnosed in the study subjects were numerous. The majority (59.2%) suffered from at least three coexisting diseases. These were, in the order of frequency, arterial hypertension (92.7%), ischemic heart disease (50.8%), heart rhythm disorders (43.0%), diabetes mellitus (27.9%), cardiac failure (18.1% each), Parkinson's disease and hypothyroidism (15.0% each), labyrinth diseases (7.2%), asthma bronchiale (5.2%), rheumatoid arthritis (4.1%), depression and kidney transplant status (2.1% each), as well as others, including prostatic hyperplasia, gout and urate lithiasis, cerebellum diseases, atherosclerosis, and alcoholism (23.8%). Because of the diagnosed diseases, the patients received various medications. The biggest group of responders (57.0%) reported taking >6 therapeutic agents every day, 24.9% took 5–6 agents, 15.0% were administered 3–4 agents, and the remaining 3.1% – 1–2. These were mainly hypotensive (97.8%), diuretic (50.4%), antiarrhithmic (29.0%), antidepressant (20.2%), analgesic (17.1%), and sleep-inducing (14.0%) medications. Every fifth patient (22.8%) claimed that they had depressive disorders diagnosed and therefore received antidepressant agents; 12.9% of the subjects declared that in spite of the diagnosis they did not take medicaments of this group.

Problems with performing everyday activities were declared by 19.1% of the subjects. These difficulties concerned dressing and undressing (66.7%), getting up from the bed (27.8%), bathing (19.3%), preparing meals (16.7%), and using the toilet (5.6%).

At the same time, almost all responders reported problems with regard to memory (96.9%), as well as concentration and focusing attention (46.1%), bradyphrenia (39.9%), delayed reaction to situations (19.2%), and speech difficulties (12.9%).

In nearly all studied patients, problems with walking were observed (87.0%), which consisted in slowing of gait (94.3%), moving with small steps (54.0%), limping (26.4%), shuffling the feet (25.3%), and unstable, wide-basis walking (10.3%). Also, the majority reported arthrosis (70.9%), as well as fear and anxiety bound with the possibility of another fall occurrence (61.1%).

Most responders (64.2%) pointed at dizziness, which appeared every day in 40.3%, once a week in 31.6%, once a month in 15.5%, and less frequently in 12.6%. Additionally, almost every third patient suffered from orthostatic hypotonia (29.0%), and every second reported urinary incontinence (49.7%), forcing them to use the toilet frequently. Every fifth senior (20.2%) used the toilet 5 times a day, 16.1% did it 6–8 times, and the remaining 13.4% more than 8 times a day.

According to the study subjects, the most frequent factors leading to falls in their home environment are steps (41.7%), unadjusted furniture (26.3%), slippery floor (18.8%), lack of stair banisters (11.2%), and carpets (2.0%). In turn, among external conditions, uneven sidewalks (47.6%), slippery street surfaces (31.3%), high curbs (10.8%) and steps in means of transportation (6.4%), as well as unsuitable shoes (3.9%) were enumerated. Only 27.8% of the responders had not experienced a fall in external conditions. Falls most often occurred in the morning hours (83.5%).

The majority of patients (66.4%) maintained that falls were not bound with their health status or diseases. The rest indicated a connection with fainting (25.5%) and, much less frequently, pneumonia (2.6%), influenza (1.9%), urinary tract infection or heart failure (1.8% each).

More than a half of the responders (50.7%) did not perceive everyday activities as a factor contributing to a fall. The rest indicated using the toilet at night (15.5%), a shower or a bath (11.8%), changing position from sitting to standing (10.2%), entering the house (9.1%), turning round (1.8%), and walking (0.9%).

In the study, the Tinetti scale was applied; in both domains (referring to balance and gait), high reliability was obtained (α=0.861 and α=0.908, respectively), as well as extreme results possible to achieve. The results of the scale in total were within the range of 1–28,

which indicates a considerable heterogeneity of the group with reference to the risk of fall. The value of *Me*=19 should be emphasized, meaning that at least half of the subjects obtained a result ≤19, thus, they represent a rise of the risk of fall 5-fold higher than the average (Table 2).

Table 2. Tinetti scale results

Tinetti scale	***N***	***M***	***Me***	***SD***	***Min***	***Max***
Balance	193	10.06	10.60	3.561	0	16
Gait	193	7.42	9.00	3.527	0	12
Total result	193	17.48	10.00	6.705	1	28

Abbreviations: ***N*** – number of participants; ***M*** – mean value; ***Me*** – median value; ***SD*** – standard deviation; ***Min*** – minimum value; ***Max*** – maximum value

The high risk of falls in the study subjects can also be concluded from data calculated in categories allowing to interpret the result. Quantity data were encoded into three categories: a very high risk of fall (> 19 points), a risk of fall (< 26 points), and lack of a risk of fall. In 48.2% of the participants, a very high risk of fall was observed, in 43.0% there existed a risk of fall, and merely in 8.8% there was no risk of fall.

As revealed in the balance domain of the Tinetti scale, the biggest problems concerned a turning by 360°; the majority presented discontinuous and unsafe movement in this aspect. Nudge trial with eyes closed also appeared challenging. In turn, in the gait domain, the most serious issues referred to maintaining position when walking (Table 3).

Table 3. Detailed Tinetti scale results in both domains

Tinetti scale		***N***	**%**
The balance domain			
Sitting balance	leans or slides in chair	8	4.2
	steady, safe	185	95.8
Arising	unable without help	15	7.8
	able but uses arm to help	143	74.1
	able without use of arms	35	18.1
Attempts to arise	unable without help	14	7.3
	able but requires more than one attempt	46	23.8
	able to arise wit one attempt	133	68.9
Immediate standing balance (first 5 s)	unsteady	17	8.8
	steady but uses walking frame or walking stick, or grabs other object for support	56	29.0
	steady without any support	120	62.2
Standing balance	unsteady	14	7.3
	steady but on a wide basis, or supporting with with a walking stick	120	62.2
	narrow stance without support	59	30.5
Nudge trial	begins to fall	17	8.8
	staggers, grabs objects but maintains position	81	41.9
	steady	95	49.3

Nudge trial with eyes closed	unsteady	97	50.2
	steady	96	49.8
Turning by 360°	discontinuous movement	170	88.1
	continuous movement	23	11.9
	unsafe	81	41.9
	safe	112	58.1
Sitting down	unsafe	15	7.8
	uses arms or movement is not smooth	164	84.9
	safe, smooth movement	14	7.3
The gait domain			
Initiating gait (after a command)	any hesitancy or multiple attempts to start	33	17.1
	start with no hesitancy	160	82.9
Step length and height: range of right foot step forward	does not pass left foot standing point	56	29.0
	passes left foot	137	71.0
	right foot does not lift off completely	54	27.9
	right foot completely lifts over floor	139	72.1
Step length and height: range of left foot step forward	does not pass right foot standing point	56	29.0
	passes right foot	137	71.0
	left foot does not lift off completely	54	27.9
	left foot completely lifts over floor	139	72.1
Gait symmetry	right and left step length not equal	58	30.0
	right and left step length seems equal	135	70.0
Gait continuity	stops between steps or other discontinuity	69	35.7
	gait seems continuous	124	64.3
Path of gait	marked deviation	6	3.1
	mild or moderate deviation or uses orthopedic equipment (walking stick etc)	131	67.9
	straight path without support	56	29.0
Trunk	marked sway or uses orthopedic equipment	52	26.9
	no sway but flexes knees or back, or spreads arms during gait	98	50.8
	no sway, no knee or back flexion, no use of arms or any orthopedic equipment	43	22.3
Walking stance	heels apart	156	80.8
	heels almost touching during gait	37	19.2

Abbreviations: ***N*** – number of participants

Undertaking physical activity as combined with the risk of fall was also analyzed in the study. Here, the total Tinetti test score was applied, as well as the responders' indications concerning the frequency of undertaking physical activity (Table 4).

Table 4. Risk of fall and physical activity

Group according to the frequency of undertaking physical activity	***Me***	***Min***	***Max***	**Kruskal-Wallis test result**
Once a week	19.00	9	28	*H*=20.232 *df*=4 *P*<0.001
Twice a week	11.00	2	24	
3–5 times a week	17.50	10	27	
Every day	21.00	2	27	
Never	9.00	1	23	

Abbreviations: ***N*** – number of participants; ***Min*** – minimum value; ***Max*** – maximum value; ***H*** – Kruskal-Wallis test; ***df*** – degrees of freedom; ***P*** – statistical significance

The study proved that people undertaking physical activity once a week were less prone to falls than those who did not take any exercise at all ($P<0.05$). It was also observed that patients who exercised twice a week were more vulnerable to falls than those exercising every day ($P<0.05$) and that seniors who exercised every day were less threatened with falls than those not exercising at all ($P<0.05$).

The authors also verified if the risk of fall increased with age in the study subjects (Table 5).

Table 5. Risk of fall and age

Age group	***Me***	***Min***	***Max***	**Kruskal-Wallis test result**
65–70 years	21.50	12	28	*H*=19.899 *df*=3 *P*<0.001
71–74 years	24.00	20	27	
75–80 years	16.00	2	27	
>80 years	17.00	1	27	

Abbreviations: ***N*** – number of participants; ***Min*** – minimum value; ***Max*** – maximum value; ***H*** – Kruskal-Wallis test; ***df*** – degrees of freedom; ***P*** – statistical significance

As it turned out, there were statistically significant differences between the groups ($P<0.05$), the Bonferroni test was additionally performed in order to determine them precisely. The test proved that the youngest subjects (aged 65–70 years) were less vulnerable to falls than those aged 75–80 years ($P<0.05$) and >80 years ($P<0.05$). There were also differences between patients aged 71–74 years and those from the two oldest age groups. Therefore, participants from the two youngest age groups (65–74 years) turned out threatened with falls to a smaller degree than those from the two oldest age groups (75 years and older).

Further analyses, employing the total Tinetti test score, aimed at verifying if the incidence of falls was influenced by sex, body mass index, as well as selected diseases, such as visual disorders, arthrosis, heart rhythm disorders, Parkinson's disease, gait disorders, or orthostatic hypotonia. In the case of Parkinson's disease, orthostatic hypotonia, and gait disorders, a statistically significant correlation was observed ($P<0.05$), unlike in the remaining situations ($P>0.05$) (Table 6).

Table 6. Total Tinetti test score

Variable	Variable occurrence	*Me*	*Min*	*Max*	Mann-Whitney test result
Sex	female	18.0	1	28	*U*=835.0 *P*=0.196
	male	20.0	1	27	
Body mass index	normal	17.0	1	28	*U*=976.0 *P*=0.509
	overweight	19.0	2	27	
Visual disorders	yes	19.0	1	28	*U*=195.0 *P*=0.167
	no	13.5	2	26	
Arthrosis	yes	17.0	1	28	*U*=816.0 *P*=0.071
	no	20.0	1	27	
Heart rhythm disorders	yes	19.0	1	28	*U*=1194.0 *P*=0.802
	no	19.0	1	27	
Parkinson's disease	yes	11.0	2	24	*U*=385.0 *P*=0.007
	no	19.0	1	28	
Gait disorders	yes	18.00	1	28	*U*=193.5 *P*<0.001
	no	23.00	19	27	
Orthostatic hypotonia	yes	17.00	3	24	*U*=731.5 *P*=0.012
	no	20.00	1	28	

Abbreviations: ***N*** – number of participants; ***Min*** – minimum value; ***Max*** – maximum value; ***U*** – Mann-Whitney U test; ***P*** – statistical significance

The study revealed that lowering the number of falls was not influenced by dizziness, declared by 70.4% of subjects (χ^2=2.862, *df*=1, *P*=0.092), or the number of medications taken (χ^2=6.986, *df*=3, *P*=0.072); it was influenced, though, by using orthopedic equipment (*t*=–7.166, *df*=57, *P*<0.001). External factors, such as steps and uneven sidewalks, also contributed to a higher number of incidents (Table 7).

Table 7. Risk of fall and the factor of steps and uneven sidewalks

			A fall within the previous year		Chi-square test result
			Yes	**No**	
Steps in home conditions	Yes	*N*	48	31	χ^2=0.000 *df*=1 *P*=1.000
		%	25.0%	16.1%	
	No	*N*	69	45	
		%	35.7%	23.2%	
Sum		*N*	117	76	
		%	60.7%	39.3%	
Uneven sidewalks in external conditions	Yes	*N*	73	21	χ^2=9.741 *df*=1 *P*=0.002
		%	37.8%	10.9%	
	No	*N*	44	55	
		%	22.8%	28.5%	
Sum		*N*	117	76	
		%	60.6%	39.4%	

Abbreviations: ***N*** – number of participants; χ^2 – Mann-Whitney U test; ***df*** – degrees of freedom; ***P*** – statistical significance

Discussion

According to epidemiological data, about 33% of people aged over 65 years' experience a fall at least once a year. The phenomenon most often occurs among nursing home residents, then among hospitalized seniors [2,3,11] and least frequently in the home environment. Moreover, the risk of an incident increases with the passage of time, which has been proved by numerous studies [12,13] and by the analyses performed within the present research. The observed high proportion of people experiencing falls may be bound with the fact that seniors' mobility continuously decreases with age.

As literature indicates, an unmodifiable factor contributing to an increase of the risk of falls is sex (gender) [14]. Some researchers claim that women are more characterized by disorders bound with maintaining gait and balance [15,16]. In turn, own studies suggest that women are subject to falls to a degree comparable with men. The discrepancies of the collected data most probably result from the characteristics of the analyzed groups and the considerable range of the subjects' age.

In almost half of the responders, the Tinetti test results (with regard to both gait and balance) indicated an increased risk of fall. Arising and turning by 360° were the most problematic for the participants. The achieved outcomes support the analyses performed by other researchers, who proved that activities such as arising, sitting down, initiating gait, and turning round were burdened with the highest rise in the risk of fall [17]. Smaller danger was observed with standing, provided that the senior kept their feet wide apart or used orthopedic equipment, e.g. a walking stick [18].

Sarcopenia often negatively influences the seniors' health status. It is caused by limiting physical activity of an elderly person, as well as the presence of other diseases contributing to loss of muscle strength, and therefore leading to gait impairment. Also, degenerative changes in tendons and ligaments become evident, which can be signs of inflammatory diseases if muscles or joints (e.g. foot deformations, osteomalacia) [2].

Some researchers point at a correlation between arthrosis and the frequency of falls in the elderly. Changes that occur in the osteoarticular system with age are mainly bone mass

losses (osteopenia, osteoporosis) and atrophy of articular cartilages or soft tissues (damages, lowered content of collagen and elastin in tendons and ligaments, thinning and dehydration of cartilaginous tissue), which contribute to degenerative changes resulting in deformation [6]. All the occurring changes lead to the emergence of so-called senile posture, with the characteristic deepening of thoracic kyphosis and decreasing lumbar lordosis. This brings about a forward shift of the center of gravity and limiting mobility in the joints of the spine and limbs [19]. Also, specific gait is observed (feet do not lift completely off the ground, upper limb swings are neglected), as well as shortened step length, unsymmetrical feet load, hampered hip joint rotation, and significantly lower gait speed. Moreover, wide-basis walking impedes changing body position and overcoming obstacles, and significantly impacts on reducing the senior's agility, increasing the risk of fall, which most often occurs while walking or arising from the sitting position [20,21]. All the enumerated signs were observed in the studied group, although they did not concern the majority of patients. This was the probable reason why the study did not reveal statistically significant differences between the increase of the risk of fall and the presence of osteoarticular system diseases. These discrepancies may result from properly applied prophylaxis and suitable treatment.

Among the consequences of sarcopenia, osteoporosis, and falls, there are fractures, mainly of the humeral bone, forearm bones, pelvis, spine, and especially of the proximal epiphysis of the femoral bone. Another complication can be cranial injuries (brain concussions, intracranial hemorrhages), which may be asymptomatic at the initial stages. Symptoms often occur later on and usually are indicative of the reason of the fall; the results frequently lead to hospitalization of the elderly person. Immobilization gives rise to such complications as deep vein thrombosis, pulmonary embolism, bedsores, contractures, hypothermia, respiratory tract infections, or urinary tract infection. These contribute to worsening of the seniors' quality of life, to the post-fall syndrome development, and, often enough, to premature death [22]. A vicious circle arises, as the reduction of functional agility leads to muscular strength loss; motor difficulties appear, as well as those concerning balance maintenance, disorders within the respiratory tract, circulatory and motor system, accompanied by general weakness. This situation adds to worsening of the psychical status, to depression development, and to increasing the already existing anxiety [5,22].

The own research indicates that undertaking physical activity by elderly people significantly reduces the risk of falls. The studied groups turned out to differ significantly in the risk of fall depending on the frequency of physical activity practiced. Body mass index is also a key factor; its slightly higher values in the elderly than among younger people increases their survival rate [23].

The influence of physical effort on lowering the frequency of falls remains in line with a study by Otremba [15], who proves that taking care of physical condition allows to reduce the risk under discussion. One can therefore presume that maintaining motor activity exerts a positive influence on the better mobility of the elderly. Intervention should be based on individually matched exercises referring to, among others, gait and balance maintenance [1,24], and affecting especially hip extensors and abductors as key muscles for the elderly people motion, walking, and arising from the sitting position. Numerous studies prove that the application of exercises strengthening the muscle force and balance and influencing endurance decreases the frequency of falls [25,26].

As revealed in own research, the risk of falls is bigger in people having problems with walking than in the remaining seniors. The main reason is the unsteady gait in the elderly. This is supported by the fact that falls most often occurred during walking, which was bound with a change in the movement pattern. Other authors also indicate that moving with small steps, limping, and shuffling the feet, which appear with age, are among the factors of high risk of falls. Additionally, the individual factors, referring to seniors themselves, can lead to a

fall. Therefore, appropriate choice of clothing and shoes (not too high heels, no slippery sole) is of significant importance [27].

Interestingly, in spite of the walking problems declared by the majority of seniors, most of them did not use any orthopedic equipment, and those who did were vulnerable to falls to a higher degree. In people with a risk of fall, applying rehabilitation equipment at a suitable moment can reduce the number and consequences of falls [28].

Another group of changes influencing the frequency of falls in the elderly refer to the nervous system. Parkinson's disease is one of the neurological disorders commonly observed in elderly people, significantly contributing to the occurrence of falls [29]. This is supported by research performed by Stolze et al. [28] or Szczerbińska and Topór-Mądry [30], who indicate that incidents of fall are bound with Parkinson's disease more often than with any other nervous system disease and that half of the patients even with moderate Parkinson's disease signs experience a fall within a year. Moreover, such parkinsonism-accompanying signs as gait pattern change, passive tremor, or muscular rigidity increase the risk of fall incidents 10-fold [12]. Own research proves that diagnosed Parkinson's disease considerably raises the risk of fall. The main reason can be one of the disease symptoms, namely difficulty in maintaining postural control, specifically contributing to loss of balance and to falling.

Sense organs disorders are another factor that can lead to falls in elderly people. Among them, vision problems are dominant, which is reported by many authors who emphasize a close relationship between these variables [31,32,33]. Studies point mainly at visual acuity impairments, influenced by commonly observed diseases typical of old age, such as cataract, glaucoma, macular diseases, or dry eye syndrome [34]. Of considerable importance is the atrophy of tissues surrounding the eye, bound with decreased production of tears, and therefore with a higher risk of vision organ infections. Also, pupil diminution is observed, as well as lowering lens transparency, vision acuity impairment, presbyopia, peripheral vision impairment, and difficulty in adapting to sudden lighting changes, in accommodation or in contrast perception.

The conducted analyses indicate, however, that vision organ diseases do not differentiate the study subjects with reference to the risk of fall. This observation remains in line with a study by Nevitt et al. [35], who did not reveal such relationships; moreover, they assumed those described in previous studies as not statistically significant. When dealing with vision disorders as a factor influencing falls in the elderly, one should consider cases in which patients wear glasses or undergo surgery to correct vision defects; this factor was not analyzed for the needs of the present paper but still significantly contributes to improving the patients' everyday functioning.

According to literature, the higher incidence of falls is also influenced by the dizziness occurring in seniors [15]. This may be caused by senile changes in the hearing organ, as well as by abnormalities of the balance apparatus. With age, and because of the involutional changes taking place, seniors come across problems with hearing clear sounds; moreover, impairment of higher sounds perception appears, having a great significance in understanding of speech. As a result, in a situation of continuous speech or constant noise, elderly people's hearing becomes much worse.

The performed studies, however, do not confirm the relationship between dizziness and falls. The obtained percentage differences are not sufficient to recognize the data as statistically significant. Nevertheless, a tendency can be assumed whose approval demands further analyses. It should be noted that Pothula et al. [36] and Whitney et al. [37] observed an influence of vestibular system disorders on the occurrence of unexplained falls and the frequency of reporting them by people aged over 65 years.

The literature also enumerates cardiovascular diseases – because of the decrease in the cardiac output and arterial blood pressure – as a risk factor of falls. These conditions are often

observed in the elderly. As Jansen et al. [38] confirmed in their study, a higher risk of fall concerns mainly seniors with heart rhythm disorders, heart failure or murmurs. Own research, however, did not reveal a higher risk of falls in seniors suffering from the mentioned disorders, which can be an effect of an insufficient size of the study group.

Another factor that can increase the risk of falls is orthostatic hypotonia, commonly observed in the elderly [39]. The own research proves this relationship with statistically significant data. Sudden drops in the arterial blood pressure occur principally in situations of changing the body position. Studies point at a high risk of fall especially with shifting the center of gravity, which most often takes place when arising from a sitting or lying position [40,41].

It also seems that polypharmacy and multimorbidity, phenomena frequently seen in elderly people, can impact on the incidence of falls in this age group [42]. Taking many medications, including the over-the-counter (OTC) products, which may cause drug interactions, as well as their lower absorption surface, characteristic of age, increased distribution volume for fat-soluble pharmaceuticals and decreased distribution volume for water-soluble ones, slower metabolism of the applied medications, and disorders of their removal caused by reduced renal elimination can lead to numerous adverse reactions [2].

However, the performed study does not allow to draw conclusions concerning the relationship between polypharmacy and the incidence of falls. What is also similar is the lack of a statistically significant difference between the rise of a threat with an incident of a fall and the group of medications conducive to its occurrence, or the number of medications applied and the occurrence of a fall, in spite of the fact that more than half of the subjects took over six pharmaceuticals a day. Almost all participants received hypotensive agents, and 1/5 of them also took antidepressant agents, which induce a higher risk of falls [28,43]. According to the literature, the risk is especially high when the patient receives four or more medications [44]. The observed discrepancies in the results may be caused by well-adjusted treatment, with reduced adverse reaction occurrence.

External factors play a significant role in the risk of fall assessment. These include slippery, wet, or waxed floors, as well as high steps and carpets. Another external factor is lighting; if too strong and dazzling or too weak, it constitutes a serious threat to a senior's security, especially if there is no switch within their reach. In turn, the room in which elderly people are especially vulnerable to falls is bathroom [9]. The threat results from a slippery bed of a tub or a shower-tray, lack of banisters or holders, low-settled toilet bowl, or lack of anti-slip mats. The external factors also include stairs: the steps can turn out too high, and lack of banisters effectively contributes to a higher risk of falls. Also, unadjusted furniture – highly located shelves or cupboards, too low or too soft chairs short of arm support – makes it difficult to adopt the vertical body position and may become a reason for an injury.

However, the own research indicates that the presence of steps did not affect an increase of the risk of incidents in the preceding year. The differences in the above-mentioned outcomes can result from a particular care for preventing falls or from a relatively small size of the study group.

The issue of factors located outside the place of residence seems different. A relationship between uneven sidewalks and falls was observed. The thesis was also reflected in the works of other researchers, who enumerate architectural barriers (uneven sidewalks, slopes) among the most frequent reasons for falls [28], and uneven surfaces [19].

All the mentioned causes prove that the environment that seniors live in is abundant in factors exposing to the risk of falls, which may result in injuries, potentially bound with long-term morbidity and sometimes leading to death.

As depicted in the paper, the problem of falls in the elderly is unusually complex and bound with multiple reasons. Because of an experienced injury, 50% of seniors demand

hospitalization. What is crucial, patients not always inform physicians about the past incident. Usually, falls are not indicated until more serious complications occur, most often in the form of a fracture or wound, which are related with 10–15% of incidents [45,46]. In 40% of cases, consequences of a fall lead to the senior's institutionalization. Similarly unfavorable data refer to the fall-related mortality, especially concerning seniors aged over 80 years [3]; therefore, the problem should not be disregarded and the earliest symptoms must be diagnosed with due diligence. This approach will allow to prolong the self-reliance of the elderly and to reduce their dependence on other people's care, perceived as troublesome by seniors.

Conclusions

The results of the study allow for the drawing of the following main conclusions: (1) The risk of falls increases with age in the elderly. (2) Undertaking physical activity decreases the risk of falls in seniors. (3) The most serious problems with regard to maintaining body balance are bound with turning around own axis and adopting the sitting position. (4) Disorders concerning gait and balance, Parkinson's disease and orthostatic hypotonia increase the risk of falls in the elderly.

Conflicts of interest

The authors declared no potential conflicts of interest.

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