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Relationships between susceptibility to injury during falls and physical fitness and functional fitness of musculoskeletal system. Pilot study

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: The opinions on the role of physical fitness and physical on the effects of falls on health are, however, divided. The purpose of the study was the relationship between the ability to fall safely and physical fitness and the functional state of the motor organ.

Materials & Methods: Ninety-four women and men aged 19-24 were studied. The ability to fall safely was tested using Kalina's non-apparatus the susceptibility test to the body injuries during the fall (STBIDF, Polish: TPUCPU). Physical fitness was determined using the International Committee on the Standardisation of Physical Fitness Test: ICSPFT. The functional limitations to the motor organ were determined using the Functional Movement Screen (FMS) by Gray Cook and Lee Burton.

Results: The studied the overall susceptibility to injury during falls test result (average: men 5.61-, women 4.76-; weighted arithmetic mean 5.04 points) that demonstrates an high proneness to bodily injuries (SBIDF). The most errors were made with an incorrect position of the head (men 1.87-, women 1.68-; weighted arithmetic mean 1.74 points) and hands (men 1.81-, women 1.62-; weighted arithmetic mean 1.68 points). A statistically significant negative correlation was observed between the overall SBIDF Index and the FMS Index demonstrating that persons that made fewer errors in the STBIDF tasks achieved better results in the functional trials. No significant correlations were noted for the SBIDF test results and the overall ICSPFT, as well as biometric data.

Conclusion: Persons who high FMS scores made the fewest errors in the STBIDF. This might prove an interdependence between the motor organ functional limitations and specific motor abilities, such as the ability to self-regulate.

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INTRODUCTION

Fall prevention is a difficult task due to their complex root causes. Increasing awareness of the consequences of falls, the importance of balance and physical fitness and adapting the environment in which a given person operates may constitute an element of prevention. However, such form of prevention is unsatisfactory, although it helps preventing about 30-40% of falls [1]. Teaching self-regulation and protecting the body during the fall to minimise the risk of bodily injuries caused by the impact with the ground [2] or an vertical object [3] may constitute a solution. When learning to walk, upon the first attempts to get into an upright position, toddlers of a few months are able to fall safely [4]. For an adult, this simple motor task often presents a considerable difficulty. Therefore, teaching safely falling should involve particular motor abilities (muscle strength, stamina, coordination level), mental attitude and exercise goal awareness [5-8].

Most methodologies developed so far concentrates on risk assessment, risk factors elimination, ameliorating the functioning of organs and systems as well as supplementation with calcium and vitamin D. Training muscle strength and balance are especially recommended as prevention [6]. These activities, however, most often aim at preventing falls without tackling the question of preventing or reducing the resulting bodily injuries, e.g. by learning safe falling, self-regulating and preventing impacts. The ability to protect one's own body might be the most effective method of preventing the negative consequences of falls. Developing a habit of correct falling might, in consequence, minimise the number of bodily injuries and the resulting mortality, especially in the populations of senior citizens and people with disabilities.

Healthy lifestyle, especially physical activity, helps maintaining independence and functioning. Physical exercises improve posture stability, balance, increase or maintain the levels of strength and stamina [9-13]. The opinions on the role of physical fitness and physical on the effects of falls on health are, however, divided. The purpose of the study was the relationship between the ability to fall safely and physical fitness and the functional state of the motor organ.

Non-apparatus test – that motoric test (exercise endurance test) of the required reliability (accurate and reliable), which use does not require even the simplest instruments [40].

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [39].

Balance – the ability maintaining an upright body posture (position), i.e in equilibrium.

Balance – *noun* **1.** the act of staying upright and in a controlled position, not stumbling or falling **2.** a state of emotional and mental stability in which somebody is calm and able to make rational decisions and judgments **3.** the proportions of substances in a mixture, e.g. In the diet [40].

Calcium – *noun* a metallic chemical element that is a major component of bones and teeth and is essential for various bodily processes, e.g. blood clotting (note: the chemical symbol is **ca**.) [40].

Vitamin D – *noun* a vitamin which is soluble in fat, and is found in butter, eggs and fish (NOTE: It is also produced by the skin when exposed to sunlight. Vitamin D helps in the formation of bones, and lack of it causes rickets in children) [40].

Preventive – *adjective* used for describing an action taken to stop something happening, especially to stop a disease or infection from spreading [41].

Muscle strength – essential and basic physical capacity in combat sports by which the body moving status is modified [42].

Stamina – *noun* enduring physical or mental energy and strength that allows somebody to do something for a long time [41].

Coordination – *noun* the ability to use two or more parts of the body at the same time to carry out a movement or task [41].

Disability – *noun* a condition in which part of the body does not function in the usual way and makes some activities difficult or impossible.=> **learning disability** [41].

MATERIAL AND METHODS

Participants

Ninety-four women and men aged 19-24 were studied. Study group entrance criteria were: no health contraindications (diseases or motor organ injuries preventing to perform the functional tests), not doing sport.

Study design

The ability to fall safely was tested using Kalina's non-apparatus the susceptibility test to the body injuries during the fall (STBIDF, Polish: TPUCPU) – the smaller the number of body control errors during a simulated fall, the greater the likelihood that a person is able to fall safely [4, 14]. The test consists of three motor tasks performed on a gymnastic mat.

Task 1 is to move from vertical (upright) position (posture) to horizontal posture (lying on the back) on the mat as fast as possible, so that the lower limbs, buttocks, the back, upper limbs and the head hold to the ground.

Task 2 is a modification of task one, to move from vertical to horizontal posture, additionally holding a gymnastic pouch with the chin to the sternum and clapping hands while performing the task.

Task 3 is a modification of task 2, while transiting into the horizontal posture is preceded by the highest possible jump up.

The assessment criterion is protecting the body parts that are the most prone to injury (legs, hips, hands and head). All errors (an incorrect contact

Table 1. Characteristics of research group.

Group	Number of people [n]	Age [years]	Body mass [kg]	Body height [cm]	BMI [kg/m^2]
Women	63	20.92 ±1.09	59.29 ±7.78	167.16 ±5.96	21.22 ±2.49
Men	31	21.34 ±1.56	77.29 ±8.18	180.48 ±5.05	23.75 ±2.52

of a given body part with the ground) are noted in SBIDF observation sheet as one point. The sum of points acquired during the three motor tasks expresses a general indicator of the susceptibility to bodily injuries during the fall (SBIDF Index). A conventional classification of proneness to bodily injuries was used: 0 low, 1-3 average, 4-8 high, 9-14 very high. Relatively for particular body parts (SBPIDF): low (0), average (1), high (2-6) [4, 14].

The Test of Physical Fitness (development by the International Committee on the Standardisation of Physical Fitness Test: ICSPFT – based mainly on quasi-apparatus motoric trials) was used in the study [15]. It consists of eight tests: of stamina (an 800 m run for women and 1000 m for men), pace (a 50 m run), agility (4 × 10 m shuttle run), jumping (long jump from standing position), arm muscle strength and stamina (active hang on bar for women and pull-ups on a bar for men), palm strength (dynamometer squeeze), abdominal muscles strength (upper body crunches from horizontal position) and flexibility (a bend forward). Results of particular tests are recalculated into points. An overall result determines a global level of the subject's physical fitness (ICSPFT Index) [15].

The functional limitations to the motor organ were determined using the Functional Movement Screen (FMS) by Gray Cook and Lee Burton [16, 17]. It was developed to provide an objective analysis of the human motor patterns in relation to functional performance and to predict and prevent injuries in athletes. Thanks to a tridimensional movement analysis, it is possible to detect anomalies in kinetic chains, as well as to have a comprehensive assessment pointing out the asymmetry and important functional limitations, which are a result of incorrect mobility and motor system stability FMS is comprised of seven exercises that test basic movement patterns: 1. Deep squat, 2. Hurdle step, 3. In-line lounge, 4. Shoulder mobility, 5. ASLR – active straight leg raise, 6. Trunk stability push up, 7. Rotation stability. Performing each of the seven aforementioned tests is evaluated on a 4-point scale, in accordance with the set assessment criteria. For each movement pattern, once can be granted from 0 to 3 points (3 points are granted to a person that performed the movement pattern correctly, 2 points to a person that performed the movement pattern with compensation, 1 point to a person that is not able to perform a movement pattern, 0 to persons who experience pain while performing the pattern or during a provocation test). On the whole, a studied person can score 21 points (FMS Index) [16, 17].

The studied subjects also filled in an original survey, providing information about, among others, the number of falls and the type of bodily injuries caused by the fall.

Statistical analysis

The data were processed using standard methods of statistical analysis, arithmetical means ($\overline{x}$) or weighted arithmetic mean, including standardised deviations (SD or ±). Dependencies between particular variables were described with Pearson's correlation. The reliability of differences between women and men was evaluated with the Mann–Whitney U test. The minimal reliability level was adopted at $p<0.05$. The results were calculated in MS Excel and Statistica 10 computer packages, with license owned by Warsaw Medical University.

RESULTS

The studied subjects the overall result (average SBIDF: men 5.61-, women 4.76 points) that demonstrates an high proneness to bodily injuries. The most errors of SBPIDF were made with an incorrect position of the head (men 1.87-, women 1.68-; weighted arithmetic mean 1.74 points) and hands (men 1.81-, women 1.62-; weighted arithmetic mean 1.68 points). No significant differences were observed between men and women in each error category (Table 2).

Among the following points of ICSPFT trials, the highest score (recalculated into points) was noted for the palm strength test on average: women 62.27 ±10.08 points; men 58.86 ±18.52 points), and the lowest in the stamina run (on average: men 38.94 ±11.38 points; women 43.81 ±9.83 points). Women are characterized by significantly higher scores in all three tasks, assessing stamina, agility and flexibility. No significant differences were noted between the result of the remaining tests and the overall result obtained by women and men (Table 3).

The average overall Functional Movement Screen result for all (15.98 points) obtained by the studied persons demonstrate an average proneness to bodily injuries. The highest result was noted in

Learning disability – *noun* a condition that either prevents or significantly finders someone from learning basic skills or information at the same rate as most people of the same age [41].

Physical activity – *noun* exercise and general movement that a person carries out as part of their day [41].

Dystonia – *noun* a neurological disorder that causes involuntary muscle spasms and twisting of the limbs [41].

Table 2. Results (in points) of susceptibility to particular body parts injuries during fall (SBPIDF).

Group	Results of SBPIDF				SBIDF Index [total points]
	legs	hips	hands	head	
Women (n = 63)	0.63 ±0.76	0.83 ±1.06	1.62 ±1.66	1.68 ±1.11	4.76 ±3.01
Men (n = 31)	0.84 ±0.89	1.10 ±1.08	1.81 ±1.47	1.87 ±0.92	5.61 ±2.54
Weighted arithmetic mean	0.70	0.92	1.68	1.74	5.04

Table 3. Results (in points) of ICSPFT.

Group	Results of ICSPFT trials								ICSPFT Index [total points]
	800/1000 m run	50 m sprint	long jump	30 s sit-ups	4 x 10 m shuttle run	hand grip	bent arm hang/ pull-ups	trunk flexion	
Women (n = 63)	43.81 ±9.83	50.22 ±8.94	49.50 ±10.82	57.44 ±9.69	52.36 ±7.85	62.27 ±10.08	40.55 ±22.32	57.29 ±9.15	406.45 ±62.93
Men (n = 31)	38.94 ±11.38	50.39 ±8.06	46.90 ±11.99	58.11 ±11.06	48.73 ±7.89	58.86 ±18.52	48.31 ±22.39	51.93 ±9.49	381.68 ±88.92
Differences	**0.048**				**0.043**			**0.014**	

task 4 (shoulder mobility) and the lowest, in the 7th (rotation stability). Women obtained a significantly higher score in the active straight leg raise test, and men, in the trunk stability push up. The remaining results did not differ significantly (Table 4).

A statistically significant negative correlation was observed between the overall results of STBIDF and FMS (SBIDF Index and the FMS Index) tests, demonstrating that persons that made fewer errors in the SBIDF tasks achieved better results in the functional tests (Figure 1). A significant positive correlation was noted for the STBIDF results and the number of bodily injuries (Figure 2). No significant correlations were noted for the STBIDF results (SBIDF Index and trials) and the overall ICSPFT Index and trials, as well as biometric data.

Taking into consideration the particular FMS tests (exercises), significant negative correlations were noted between the SBIDF Index and the deep squat scores and push up for women and in-line lounge for men (Table 5). The only ICSPFT trial that had significant correlations with the SBIDF Index was the palm strength test (hand grip trial) for women and for the entire group (Table 6).

Table 4. Results of Functional Movement Screen.

Group	Results of FMS tests (exercises)							FMS Index [total points]
	deep squat	hurdle step	in-line lunge	shoulder mobility	ASLR	trunk stability – push-up	trunk rotation stability	
All (n = 94)	2.02 ±0.59	2.27 ±0.55	2.51 ±0.62	2.72 ±0.56	2.50 ±0.68	1.98 ±0.86	1.99 ±0.43	15.98 ±1.97
Women (n = 63)	1.98 ±0.61	2.27 ±0.54	2.52 ±0.62	2.76 ±0.56	2.63 ±0.63	1.75 ±0.84	1.94 ±0.35	15.86 ±1.75
Men (n = 31)	2.10 ±0.59	2.23 ±0.57	2.45 ±0.63	2.65 ±0.55	2.23 ±0.72	2.45 ±0.72	2.10 ±0.54	16.19 ±2.38
Differences					**0.009**	**0.000**		

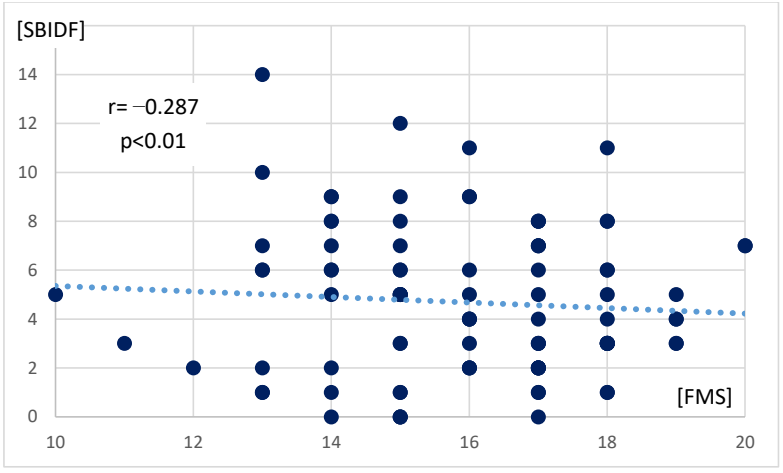

Figure 1. Correlation between results of STBIDF (individual SBIDF Index) and individual FMS Index.-

DISCUSSION

Falls can happen at every period of life, yet children and elderly people are the most at risk. Risk groups also include people with disabilities, especially those with vision [18] and locomotor apparatus impairment. Injuries that result from falls may lead to permanent incapacity, or even death [19-21]. It is estimated that among people aged 65 or older, around 40% fall at least once a year. This percentage grows with age [22]. Falls happen three times as often to persons who are weak and undertake minimal physical activity than to those active and physically fit [23, 24]. Most often, falls are a result of dysfunctions of many organs and systems, as well as external factors. Most people have at least two health reasons, accompanied by an environmental factor [19]. The main health factors include, among others, balance disorders, restriction of joint movement, muscle strength weakening, walking disorders, vision disorders, memory disorders, weakening of cognitive functions, decreased daily activity, orthostatic fainting, age over 80 [25-28].

Fall prevention is difficult, mostly due to their complex root causes. Physical activity, recreation and rehabilitation may play an important role in preventing falls. Nevertheless, research conducted by Sterkowicz et al. [29] and Syska and Bógdał [30] prove that the ability

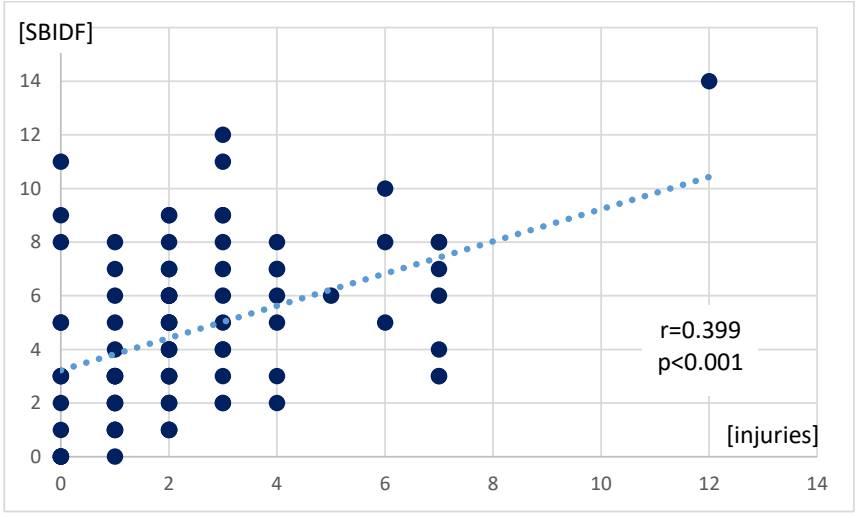

Figure 2. Correlation between results of STBIDF (individual SBIDF Index) and number of injuries.

Table 5. Correlation between results of STBIDF (SBIDF Index) and indicators of FMS.

Group	Indicators of FMS							FMS Index
	deep squat	hurdle step	in-line lunge	shoulder mobility	ASLR	trunk stability – push-up	trunk rotation stability	
All (n = 63)	**–0.235***	–0.190	**–0.266***	0.095	–0.022	–0.146	–0.157	**–0.287****
Women (n = 63)	**–0.266***	–0.166	–0.226	0.119	0.030	**–0.266***	–0.166	**–0.337****
Men (n = 31)	–0.216	–0.249	**–0.361***	0.089	–0.005	–0.083	–0.240	–0.270

*p<0.05, **p<0.01

Table 6. Correlation between results of SBIDF Index and Indicators of ICSPFT.

Group	Indicators of ICSPFT (trials)								ICSPFT Index
	800/1000 m run	50 m sprint	long jump	30 s sit-ups	4 x 10 m shuttle run	hand grip	bent arm hang/pull-ups	trunk flexion	
All (n = 94)	–0.056	–0.167	0.033	–0.103	–0.117	**–0.279****	–0.012	0.077	**–0.059**
Women (n = 63)	0.106	–0.173	0.072	–0.125	–0.092	**–0.274***	0.006	0.077	–0.031
Men (n = 31)	–0.296	–0.160	0.001	–0.076	–0.101	–0.302	–0.159	0.227	–0.055

* p<0.05, ** p<0.01

to self-regulate and positioning the body correctly during a fall is not related to the level of overall physical fitness, therefore, even very fit people may not be capable of absorbing the impact of their own body with obstacles or the ground, and therefore are vulnerable to bodily injuries. Czerwiński et al. [6] and Tinetti et al. [31], in turn, demonstrate that physical activity should be the basis of fall prevention as it leads to bone mass increase, ameliorated cardiopulmonary system functioning, as well as increased movement scope in joints and muscle mass. Therefore, thanks to the activity, their level of fitness increases, thus minimising the risk of falls and bodily injuries they provoke [6, 31, 32]. Analysis of the study results within this paper leads to similar conclusions. Although no correlation was proven between the proneness to bodily injuries on falls and physical fitness, but the degree of functional limitations to the motor organ may have an effect on the ability to fall safely. It was also proven that an appropriately led sports and health training may have a positive effect on the functional state of the motor organ (lack of prominent asymmetries and muscular dystonia, physiological scope of movement in joints) [33-35].

Combat sports and martial arts seem the most appropriate form of activity, as they enable the practitioner in a string of abilities and movement habits helpful in fall prevention and moreover, they support balanced motor skills development and minimising the functional limitations of the motor organ [36-38].

Apart from teaching self-regulation and protecting the body during the fall, functional training might be one of the methods supporting fall prevention. Developing a habit of correct falling and maintain a high level of functional fitness might decrease the number of bodily injuries, mostly in elderly people and those more physically vulnerable (the sick, persons with disabilities), where the risk of falls is much higher [26, 27, 39].

Sedentary lifestyle and a low level of physical activity in a large part of the society will make falls

a more and more prominent issue, This is why it is very important to create an effective programme of preventing falls and their consequences, and the safe falling learning programme based on functional training and combat sports and martial arts training might constitute an important part of it.

CONCLUSIONS

Persons who achieved high Functional Movement Screen scores made the fewest errors in the STBIDF. This might prove an interdependence between the motor organ functional limitations and specific motor abilities, such as the ability to self-regulate.

Proneness to bodily injuries on falls measured with the STBIDF was higher the more bodily injuries a given person sustained. It might prove that incorrect motor habits revealed in a dangerous situation might be one of the causes of bodily injuries.

The results obtained may constitute a cause for further randomised prospective studies on larger groups, using advanced research appliances.

REFERENCES

1. Kalina RM. Bezpieczny upadek. Medical Tribune 2009; 12: 30-31 [in Polish]
2. Michnik R, Jurkojć J, Wodarski P et al. Similarities and differences of body control during professional, externally forced fall to the side performed by men aged 24 and 65 years. Arch Budo 2014; 10: 233-243
3. Michnik R, Jurkojć,J, Wodarski P et al. Similarities and differences of the body control during professional collision with a vertical obstacle of men aged 24 and 65. Arch Budo 2015; 11: 27-39
4. Kalina RM. Miękkie lądowanie. Medical Tribune 2009; 13: 28-29 [in Polish]
5. Sherrington C, Lord SR, Finch CF. Physical activity interventions to prevent falls among older people: update of the evidence. J Sci Med Sport 2004; 7(1 Suppl): 43-51
6. Czerwiński E, Borowy P, Jasiak B. Current guidelines for using physiotherapy for prevent falls. Ortopedia Traumatologia Rehabilitacja 2006; 8(4): 380-387
7. Kalina RM, Barczyński B, Jagiełło W et al. Teaching of safe falling as most effective element of personal injury prevention in people regardless of gender, age and type of body build – the use of advanced information technologies to monitor the effects of education. Arch Budo 2008; 4: 82-90
8. Dobosz D, Barczyński BJ, Kalina A et al. The most effective and economic method of reducing death and disability associated with falls. Arch Budo 2018; 14: 239-246
9. Metel S. The influence of Tai Chi and sensorimotor exercises on balance in the elderly. Med Rehab 2003; 7(3): 55-63
10. Mraz M, Mraz M, Sipko T et al. Assessment of the influence of motor coordination on maintaining body balance in young and elderly people. Acta Bio-Opt Inform Med 2006; 12(3): 145-149
11. Famuła A, Nowotny-Czupryna O, Nowotny J et al. Movement activity and body stability as part of life style in different life periods. J Orthop Trauma Surg Relat Res 2009; 3(15): 22-27
12. Witkowski K, Maśliński J, Remiarz A. Static and dynamic balance in 14-15 year old boys training judo and in their non-active peers. Arch Budo 2014; 10: 323-331
13. Maśliński J, Witkowski K, Jatowtt A et al. Physical fitness 11-12 years boys who train judo and those who do not practise sport. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 41-46
14. Kalina RM, Barczyński B, Klukowski K et al. The method to evaluate the susceptibility of injuries during the fall – validation procedure of the specific motor test. Arch Budo 2011; 7(4): 201-215
15. Pilicz S, Przewęda R, Dobosz J et al. Physical Fitness Score Tables of Polish Youth. Criteria for Measuring Aerobic Capacity by the Cooper Test. Warszawa: Studia i Monografie Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie; 2005
16. Cook G, Burton L, Hoogenboom BJ et al. Functional Movement Screening: the use of fundamental movements as an assessments of function – part 1. Int J Sports Phys Ther 2014; 3: 396-409
17. Cook G, Burton L, Hoogenboom BJ et al. Functional Movement Screening: the use of fundamental movements as an assessments of function – part 2. Int J Sports Phys Ther 2014; 4: 549-563
18. Gąsienica Walczak B, Barczyński BJ, Kalina RM. Evidence-based monitoring of the stimuli and effects of prophylaxis and kinesiotherapy based on the exercises of safe falling and avoiding collisions as a condition for optimising the prevention of body injuries in a universal sense – people with eye diseases as an example of an increased risk group. Arch Budo 2018; 13: 79-95
19. Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. Clinics in Geriatrics Medicine. Clin Geriatr Med 2002; 18(2): 141-145
20. Scuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. J Epidemiol Commun H 2003; 57(9): 740-744
21. Stevens JA, Corso PS, Finkelstein EA et al. The costs of fatal and non-fatal falls among older adults. Injury Prev 2006; 12: 290-295
22. Czerwiński E, Białoszewski D, Borowy P et al. Epidemiology, Clinical Significant, Cost and Fall Prevention in Elderly People. Ortop Traumatol Rehab 2008; 10(5): 419-428
23. Skalska A, Walczewska J, Ocetkiewicz T. Age, gender and physical activity in persons declaring falls and the falls circumstances. Med Rehabil 2003; 7(3): 49-53
24. Bączkowicz D, Szczegielniak J, Proszkowiec M. Relations between postural stability, gait and falls in elderly persons – preliminary report. Ortop Traumatol Rehab 2008; 10(5): 476-480
25. Czerwiński E, Kumorek A, Milert A et al. Causes of falls in women in Krakow population. Ortop Traumatol Rehab 2008; 10(5): 429-440
26. Boguszewski D, Zabłocka M, Adamczyk JG et al. Evaluation of susceptibility to injuries resulting from falls of children with visual impairment. Eur J Adap Phys Activ 2013; 6(1): 7-16
27. Gąsienica-Walczak B, Kalina A. Susceptibility of body injuries during a fall of people after amputation or with abnormalities of lower limb. In: Kalina RM, editor. Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17-19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 193-195
28. Mosler D. Changes of susceptibility of body injuries during a fall of patients with mental impairment participating for several months in special cognitive-behavioural therapy. In: Kalina RM, editor. Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17-19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 196-198

29. Sterkowicz S, Chwała W, Ambroży T. Zdolności motoryczne warunkujące rezultat w teście podstawowej umiejętności samoobrony. In: Korzeniowski L, editor. Kształcenie pracowników ochrony. Kraków: Liport LFK; 2001: 154-169 [in Polish]

30. Syska JR, Bógdał D. Związek umiejętności bezpiecznego upadku z wszechstronną sprawnością fizyczną. In: Dąbrowski A, Jasiński T, Kalina RM, editors. Sporty walki w edukacji dzieci i młodzieży – perspektywa metodyczna. Płock: Szkoła Wyższa im. Pawła Włodkowica w Płocku; 2002: 211-218 [in Polish]

31. Tinetti M, Gordon C, Sogolow E et al. Fall-risk evaluation and management: challenges in adopting geriatric care practices. Gerontologist 2006; 46(6): 717-725

32. Mroczkowski A, Sikorski MM. The susceptibility to body injuries during a fall and abilities related to motor coordination of children aged 10 to 12. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 65-71

33. Parchmann CJ, McBride JM. Relationship between functional movement screen and athletic performance. J Strength Cond Res 2011; 25: 3378-3384

34. Adamczyk JG, Boguszewski D, Białoszewski D. Functional assessment of male track and field runners through Functional Movement Screen test. Med Sport 2015; 68(4): 563-575

35. Zalai D, Panics G, Bobak P et al. Quality of functional movement patterns and injury examination in elite-level male professional football players. Acta Physiol Hung 2015; 102(1): 34-42

36. Boguszewski D, Adamczyk JG, Kerbaum K et al. Susceptibility to injury during falls in women practicing combat sports and martial arts. Pol J Sport Tour 2015; 22: 15-24

37. Boguszewski D, Jakubowska KJ, Adamczyk JG et al. The assessment of movements patterns of children practicing karate using the Functional Movement Screen test. J Combat Sports Martial Arts 2015; 6(1): 21-26

38. Boguszewski D. Zdrowotne aspekty sportów i sztuk walki. Warszawa: Warszawski Uniwersytet Medyczny; 2017 [in Polish]

39. Black A, Wood J. Vision and falls. Clin Exp Optom 2005; 88: 212-222

40. Kalina RM. Applying non-apparatus and quasi-apparatus tests in a widely understood concept of health promotion – an example of flexibility measurement and assessment. Arch Budo 2012; 8(3): 125-132

41. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006

42. Calvo Rico B, García García JM, Monteiro LF et al. Kinematic indicators in combat sports athletes in a pre-competitive dehydrated status. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 181-188

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