REVIEW ARTICLE

The most effective and economic method of reducing death and disability associated with falls

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: Within 20 years (1990-2010) a fall rose on a global scale high in the rankings comprising causes of years lived with a disability as well as years lost to premature death. This study aims to argue for the hypothesis that the most effective and economic method to reduce death and disability caused by fall is common teaching of safe falling techniques. During 2003–2007, there were 79,386 falls fatalities (rate: 40.77 per 100,000 population) reported among the US elderly; it rose from 13,800 to 18,000 between 2003 and 2007. For the US health care, costs due to falls were estimated to be about $5.7 billion in 2002 and are predicted to reach $43.7 billion in 2020. Safe Fall Kalina Methods (SFKM) is partially modelled on judo methodology and is based mainly on amusement forms, simulations imitating balance loss in various circumstances of everyday life (not on the mat) and individually created algorithms of motor adjustment.

Conclusions: Monitoring for decades of the effects of unintended falls reminds a vicious circle. Further research reports only reveal the growing scale of a problem in numerous aspects – health, mental, economic, organisational, scientific, etc. Perhaps, only the most prestigious scientific journals may put effective pressure on people and institutions that have the authority to accelerate the simplest and the most economical solution of the problem, i.e. teaching each person about safe falling as early as possible in their lives.

Keywords: health economic • health prophylactic • injuries prevention • safe falls theory

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The study was conducted within the research project of the Academy of Physical Education in Katowice (Poland): "Reducing vulnerability to body injuries during the fall of people categorized as group being at high risk of losing balance and falling" (Resolution No. 04/2013)

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Fall – is unintentional, a sudden change from vertical to horizontal posture [13]. Falling often leads to injury; that is why it is qualified in the International Classification of Disease (ICD). Codes include falls on the same or upper level, as well as others, unspecified falls. Falls results with a collision with walls, furniture, ground or other objects or obstacles [13, 53].

Fall (in sport) **–** ***noun*** in wrestling, a scoring move in which a wrestler forces the opponent's shoulders to the floor for a specific period ■ ***verb*** to drop or be dropped or lowered [54].

Disability – ***noun*** a condition in which part of the body does not function in a usual way and makes some activities difficult or impossible [54].

INTRODUCTION

Within 20 years (1990-2010) a fall rose on a global scale high in the rankings comprising causes of years lived with a disability as well as years lost to premature death. Among 25 causes of those negative phenomena, the fall is ranked tenth. The highest positions in the ranking are occupied by Europe (Western and Central – third position, Eastern – ninth position). Central and Eastern Sub-Saharan Africa (25) and Western Sub-Saharan Africa (23) [1] occupy the lowest positions in the ranking. In Saharan Africa, a fall is usually cushioned by a soft ground (sand). The climate, infrastructure, lifestyle, numerous high-risk groups of balance loss, etc. result in the fact that the effects of fall of people residing in Western and Central Europe (mainly in the European Union) are much more serious.

An extended life span of people is related to affluence, medical progress and improvement of life quality. Unfortunately, longevity means for many life with a disability caused by seemingly trivial reason, that is balance loss, fall, collision with the ground or vertical obstacle. Life expectancy and disability due to falls are significantly correlated (Figure 1). For European Union countries r = 0.720. Thus, there is 52% certainty confirming the fact as mentioned above and 48% variance of fall cause can be explained by other phenomena (a type of professional activity and during leisure time, specific circumstances, etc.).

This study aim to argue for the hypothesis that the most effective and economic cheapest method to reduce death and disability caused by fall is common teaching of safe falling techniques and the most significant factor limiting the implementation is the accumulation of the effects of barriers of mental and organisational nature as well as scientific, administrative and cultural ones.

THE INEFFECTIVE PROPHYLAXIS

Recommended methods of fall prevention are not effective enough. The competitive hypothesis suggests that in a longer perspective, the current paradigm of fall prophylaxis may become counterproductive. Counterproductive in praxeology means that the subject of action instead of achieving its goal attains its negation.

The shortest justification of this hypothesis is as follows: a postulate on the possibility to eliminate falls from life of a given person is a semantic misuse and proves naivety; neither set of prohibitions and recommendations nor any exercise programme would change the law of gravity; fall is inevitable and integrated into everyday motor activity of creatures moving in an upright posture (invariably 35% to 40% of healthy older people usually fall in the apartment or the vicinity of home [2, 3]); it is advisable to make people aware of the risks (including life loss) which are unintended consequence of fall and collision with the ground (obstacle), however, dazzling especially the older people with prohibitions and imperatives as well as suggesting that physical activity is the most effective prophylaxis method of unintended falls will finally become an onerous therapy; each person will eventually fall (it was experienced by John Paul II and fall of Fidel Castro was a news on global media, etc); even if numerous falls do not cause serious injuries, such experiences will intensify with age the fear of subsequent fall and result in reduction of physical activity; affluence and progress in countless fields do not compensate for negative effects of falls; the US, the leader in prosperity and progress, unfortunately, leads in disgraceful epidemiology ranking of unintentional falls mortality among the elderly.

EMPIRICAL ARGUMENTATION

During 2003–2007, there were 79,386 falls fatalities (rate: 40.77 per 100,000 population) reported among the US elderly; it rose from 13,800 to 18,000 between 2003 and 2007. The annual mortality rate varied from a low of 36.76 (rate) in 2003 to a high of 44.89 in 2007. Falls constituted 43.8% of total unintentional injury mortalities (181,065) during these five years. Of the 79,386 fall fatalities, 38,111 (48.0%) were among aged 85+ years (rate: 149.94). The relative attribution of falls mortality among all unintentional injury mortality increased with age (23.19% for 65–69 years and 53.53% for 85+ years) [3].

Alamgir et al. based on the data of the Centres for Disease Control and Prevention [4] claim that: "(…) for each fall mortality event, there are 136 other fall injuries that require treatments in hospital emergency (9,241,452 emergency department visits and 79,386 fatalities in 2003–2007)" [3]. The scale of the phenomenon is comparable among large populations, e.g. in China, India, Great Britain, Germany [5-8]. From frailty to hyperactivity there are different falls and fallers profiles [9].

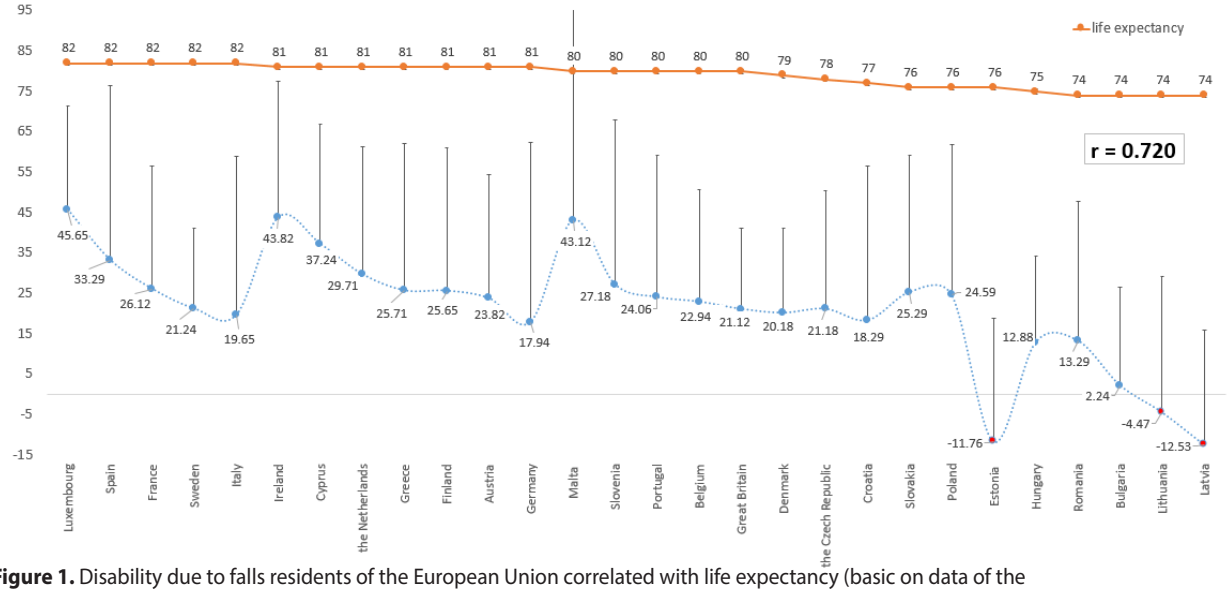

Figure 1. Disability due to falls residents of the European Union correlated with life expectancy (basic on data of the Institute for Health Metrics and Evaluation, USA).

Months of verbal impact on the elderly cause periodical decline in falls only by 30-40% [7]. Despite a tailored intervention programme minimal improvement in participants' psychological adjustment to falls was noted [10]. Some scientists determine the development of effective falls prevention strategies with an elucidation of the underlying mechanisms linking impaired cognition and falls in seniors [11]. Some empirical proofs exist that epilepsy patients were identified as high risk at admission, despite which falls were not prevented. It is necessary to develop suitable preventing falls programme for epilepsy patients [12]. There are numerous issues concerning fall prevention strategies. Since 2007 three pillars of the WHO Falls Prevention Model are recommended [13]. None does directly recommend the necessity to teach the techniques of safe fall.

HEALTH ECONOMIC

For the US health care, costs due to falls were estimated to be about $5.7 billion in 2002 and are predicted to reach $43.7 billion in 2020 [14]. Fractures of the hip cost the National Health Service of Great Britain 1.7 billion pounds each year [7]. „In England, the number of people aged over 65 is due to rise by a third by 2025. In the same period, the number of people over 80 will double, and the number over 100 will increase fourfold (...) A significant rise in falls and associated fractures is therefore likely unless specific preventative interventions (...) become widespread" [15, p. 3]. A similar conclusion of Heinrich et al. conveys the sense of all reports to the subject: "Falls are a relevant economic burden to society. Efforts should be directed to economic evaluations of fall-prevention programmes aiming at reducing fall-related fractures, which contribute substantially to fall-related costs" [16].

THE PARADOX OF JUDO AND INCREASED AMOUNT OF PHYSICAL ACTIVITY

Since half of the century, there is empirical evidence proving the fact that the majority of injuries is caused by a judoka throwing a competitor off balance and causing his fall, who at the same time ignores safety measures rules and falls on the competitor [17]. Thus, humane and health principles of judo (close to the first rule of medicine – *primum non nocere*) are belittled.

In 2003-2010 in Japan the outcomes of head injury were as follows: 15 judokas died; 5 were in a persistent vegetative state; 6 required assistance because of higher brain dysfunction, hemiplegia, or aphasia; and 4 had a full recovery. Among neck injuries: 18 were diagnosed with a cervical spine injury, 11 of whom had fracture-dislocation of the cervical vertebra; there was also 1 case of atlantoaxial subluxation; 7 had complete paralysis, 7 had incomplete paralysis, and 5 had full recovery[18]. The problem is global [19].

The paradox of judo is peculiar. If listed incidents of mortalities and injuries being characteristic properties of judo as a sport are left aside, adaptative effects are unrivalled on a global scale in falls

prevention strategies. Training of judo and other martial arts has a significant impact on the improvement of postural stability, whereas judo training on elementary level starts from learning safe falling techniques (*ukemi waza*). In Japan, the three *budo arts*: judo, kendo and sumo were included in physical education subject in 1998 [20]. In 2011 we formulated the hypothesis: "Thus Japan is one country where currently the youngest part of the population is covered with body injuries prevention based on safe falling education. From the perspective of a tendency towards prolonging the population age, Japan has the best-developed prevention system. In the future – when the current youth is of retirement age – the number of deaths and body injuries caused by fall and collision with the ground or another obstacle among elderly will be considerably reduced" [21]. Careful analysis of the data of the Institute for Health Metrics and Evaluation (USA) empirically proves this hypothesis (Figure 2). The results of small Baltic countries – Latvia, Estonia and Lithuania (Figure 1) are distinguishable and induce to perform in-depth analysis of physical education programmes, the lifestyle of the residents, etc.

In the eighties of the previous century, several judo schools in Austria implemented a programme of "Sicheres Fallen" (safe fall) in agreement with a large insurance company [22]. There is no scientific data on the effects.

Another paradox lies in the fact that numerous recommendations on fall prevention advise to train those sports that stimulate balance. Meanwhile, epidemiological data leaves no illusions. For example, Yamauchi et al. analysed the information obtained from 1918 patients with fractures or dislocations of the upper extremity (excluding fingers and scapula) sustained during snowboarding/sliding between 2000 and 2008. Eighty-eight percent had not received instruction from licensed instructors. Diagnoses included wrist fractures (53.7%), upper arm fractures (16.8%), shoulder dislocations (11.5%), and elbow dislocations (9.8%) [23]. The only reasonable conclusion justifies learning of safe falling techniques at first.

SAFE FALLS THEORY IN BRIEF

Ewaryst Jaskólski (the professor of sport sciences) and Zbigniew Nowacki (the doctor of physics) published in Polish safe falls theory ('soft fall' theory) in a local journal in 1972. Basing on the laws of physics, the authors defined key concepts of the theory and developed suitable mathematical models of: „energy of base deformation" „heat released during friction", „human body strain energy", strain energy of distortion", „strain energy of volume change".

A falling individual may decrease the unit deformation energy by (a) increasing body area in contact with the base during fall; (b) increasing time of braking or braking distance during the collision itself. Calculations show that only a double increasing in those two values decreases a unit deformation energy by 16 times, while its five-fold increase allows reducing the ***„e"*** value (*strain energy of volume change*) as many as 625 times. On the basis of those well-justified premises, authors tend to associate the sense of preventing body injury in cases of loss of balance, fall and collision with the base with the ability of loosing falling energy or that of a foreign body in collision with the human body (e.g. when hit by a car, boxer blow, etc.). They argue in a just way that the muscles are appropriate amortisation means for shocks that a human body is submitted to. During a fall the muscles tend to play the amortising role best, if the joint system, which they run, is set at the most convenient angle [24].

Andrzej Mroczkowski (PhD promoted by Ewaryst Jaskólski) added new biomechanical determinants of motor safety of a man during a fall [25]. Mroczkowski has developed a rotating training simulator which among other things is applicable in simulating falls imposed by internal force [26]. The suitability of the simulator was verified during the validation procedure [27].

SAFE FALL KALINA METHODS (SFKM) AND BARRIERS LIMITING THE IMPLEMENTATIONS

Since 1971 (when he took first professional work), the author (Roman Maciej Kalina) officially and constantly has been teaching safe falling according to his method. SFKM is partially modelled on judo methodology and is based mainly on amusement forms, simulations imitating balance loss in various circumstances of everyday life (not on the mat) and individually created algorithms of motor adjustment. His first students were commandos, then students of military academy and children, youths and adults participating in judo and self-defence courses. First publications of this method in Polish were published in 1976 [28]. First

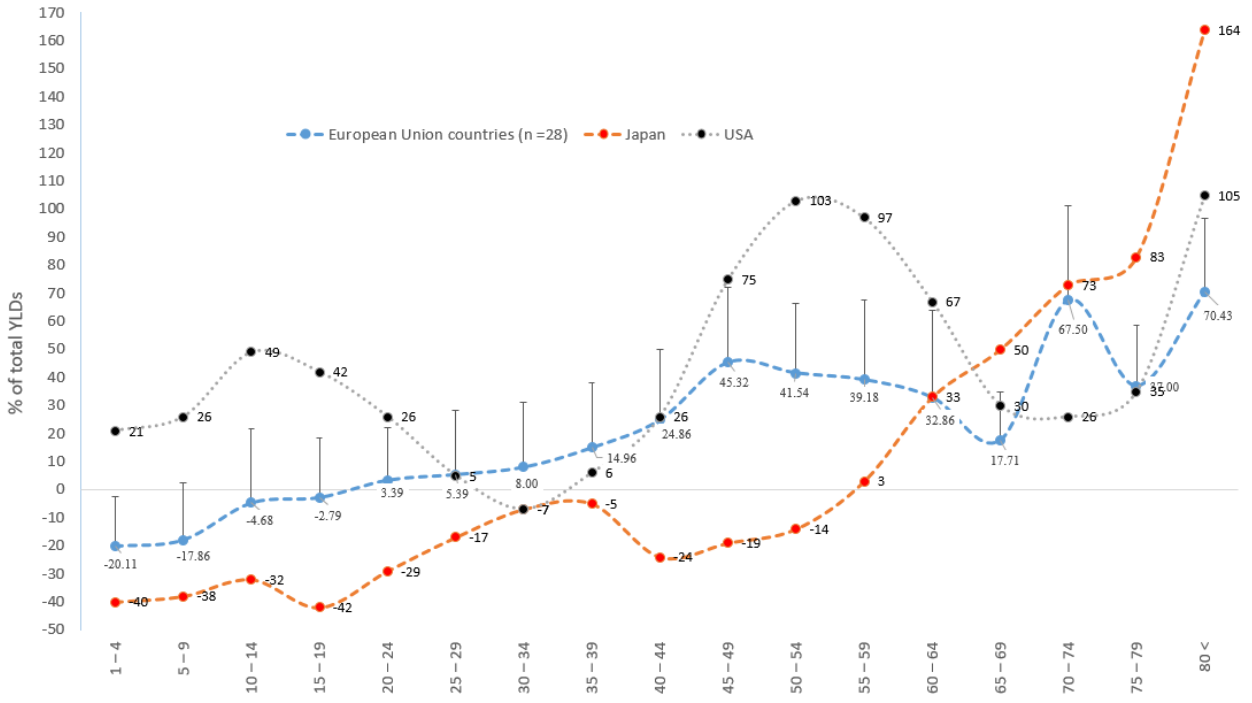

Figure 2. Basic on data of the Institute for Health Metrics and Evaluation: only in Japan years lived with disability (YLDs) caused by the fall decreased in the period 1990-2010 among people up to 54 yrs.

international applications (1978-1979) happened during "Judosommerschule" in Austria. The martial law in Poland (1981-1989) interrupted the possibility to popularise subsequent variants of SFKM for many years. Twenty-one years after the first publication dedicated to this method [28] Artur Kalina provided empirical evidence for a universal character of exercises safe falls [29].

Even though the RM Kalina for 45 years of his academic career has had no problems with implementation of various types of SFKM at several Polish universities, it is people and institutions who fail and who should seek implementations. Overcoming the barriers is the most difficult [30]. Publications and presentations during international congresses, seminars, workshops (including those in UNIPAC University in Brazil in 2003) on the one hand obtain the approval of the scientists (orthopaedists, neurologists, gerontologists, psychologists, biomechanics) and bioethical committees do not question the legitimacy of implementation of scientific projects on this subject. On the other hand, the reactions of people from the circles with the highest decision-making capabilities shock with extreme ignorance. One of the advisers of the Polish Ministry of Education was so impressed with the presentation in 2007 that he suggested to include safe fall into the core curriculum of physical education. The argumentation of his opponent: "a fall of the pupil (!) – it can be badly associated" won in the vote.

However, sometimes situations occur that motivate and provide irrefutable evidence that teaching people of safe falling techniques is the only rational way to reduce mortalities and disability caused by fall and to improve life quality especially of the disabled and people qualified to high-risk groups of balance loss and fall. During the study visit in 1996 in a large rehabilitation clinic in Pretoria (RSA) inhabited by numerous patients after limb amputations, the author of SFKM demonstrated balance loss and dynamic safe falls (the performance took place on a parquet floor). After having demonstration, soldier about 20 years old, who lost both lower legs by stepping on a mine, got up from rehabilitation-figure, clumsily made a few steps using modern prostheses (the first ones since amputation) and with tears in his eyes stated: "I would like to learn such techniques" [31].

Published in 2003, theoretical and methodological postulates of teaching lower extremity amputees to fall safely [31] have been implemented into the teaching programme of physiotherapy students in two Polish universities no until 6 years after [32]. The pace of implementations is still slow. However, the results show that sex, age, type of body build, health and motor experience are not factors preventing or significantly limiting the learning process of how to safely control the body during sudden balance loss, fall and collision with the ground [33-35].

Moreover, there are some empirical data that students attending basic course of safe fall were able to protect their life and did not suffer from any injury in extreme situations (one has fallen backwards from a ladder on the concrete floor, the other was unexpectedly hit by a car), while a female student was able to skillfully catch an older man who was falling on a bus due to sudden braking of the vehicle [21]. Many judokas underestimate this activity (!)

Continuation of proprietary programs with the implementation of SFKM provides empirical evidence that following diseases do not limit preventing or significantly limiting the learning process of how to safely control the body during sudden balance loss, fall: *people with eye diseases* [36, 37]; people after amputation or with abnormalities of lower limb [38]; patients with mental impairment [39, 40].

Important elements of the SFKM are two original achievements of RM Kalina, non-apparatus tests: „the susceptibility test of the body injuries during the fall" (STBIDF) [41]; safe fall preparations test (N-ASFPT) [42]. In the current research, the most applications and recommendations concern STBIDF (see the monograph [43] and review paper [35]). The conclusion from the discovery of Mroczkowski et al. is important: "Knowledge about assessment criteria of STBIDF has a significant influence on the results of the test. STBIDF can detect motor habits during its performance to some degree because a significant part of participants commits error despite knowing how to perform the test correctly. High persistence of committing the error of controlling head during test indicates its diagnostic value in detecting susceptibility to head injuries during a fall." [44, p. 60]. Another recommendation by Mroczkowski and Hes is also important: "The result of (…) STBIDF should become one of the criteria used to qualify a candidate to a trampoline. Regardless of the STBIDF result, preliminary training should involve the course about safe falling" [45, p. 63].

The wide SFKM program also includes collision with a vertical obstacle and avoiding collision with an object in motion. The effectiveness of the techniques is proven by the latest research using sophisticated technology (respectively [46, 47]).

The best recommendation

The best recommendation of SFKM is cited above constituted by research results and current clinical observations of patients with eye diseases, neurological disorders and limb amputees (also reflecting the improvement of their life quality). However, one result is of particular significance. Several hundreds of physiotherapy students (currently, paradoxically, unemployed graduates) unanimously confirm in anonymous surveys the sense of teaching everyone without exception about safe falling, especially people belonging to high-risk groups of balance loss and fall. Willingness to undertake the mission of teacher of safe fall after a basic course of safe fall has been declared only by 16%, but after the next higher level course by 35% [48].

This result does not belittle the value of SFKM. On the contrary, students emphasise the importance of large responsibility of a teacher (therapist) and the necessity of having in-depth knowledge from several fields (kinesiology, functional anatomy, neurophysiology, pedagogy, psychology, etc.), and in a sense a vocation to be a teacher. This result reveals that the methodology and pragmatics of safe fall, which is still underestimated by science and medicine, are too important aspects of life to become just an ephemeral fashion for falling. Repeating in this area the prophylaxis and therapy of the expansion model of various types of martial arts or the algorithm of promotion of easy, in a motor sense, fitness forms may bring more harm than good. Safe fall is a serious specialisation on the border of sports medicine, health prophylactic and injuries prevention, or in a wider sense – the science of health.

Attractiveness and sense of security during the practice SFKM adds the appropriate equipment (helmets, orthopaedic belts, etc.) – see photos 1-4. The similarity of the method of diagnosing susceptibility to bodily injury during the fall is evident in the latest work of Spanish researchers dedicated to the safe fall program on children's [49].

CONCLUSIONS

Monitoring for decades of the effects of unintended falls reminds a vicious circle (not to belittle the significance of conducted research and the effort of the scientists). Further research reports only reveal the growing scale of a problem in numerous aspects – health, mental, economic, organisational, scientific, etc. The postulate of Alamgir et al. „Time for action" [4] is an evident demonstration of helplessness. Confident suggestions made by Kagan and Puppione „To reduce fall-related injury, we need (…) learn to tolerate

Photo 1

Photo 2

Photo 3

Photo 4

Source: Images from a private collection of Bartłomiej Walczak-Gąsiennica.

risk for falls (...) and better able to avoid injury if they do fall" [50] are, on the other hand, the example of accurate intuition.

Perhaps, only the most prestigious scientific journals may put effective pressure on people and institutions that have the authority to accelerate the simplest and the most economic solution of the problem, i.e. teaching each person about safe falling as early as possible in their lives. The role of the scientists is still to publish the methods and study results so that the others could accept them or at first, subject them to the secondary verification process.

HIGHLIGHTS

SFKM – regardless of the time of publication of the work – provides simple tools for diagnosing (non-apparatus and quasi-appliances tests [53]), which apply according to the following rating algorithm: safe falls preparations test [42]; the susceptibility to injuries during the fall [41, 21]; motor competence from the scope of safe falling [33] and alternatively modified test of safe fall – applications in diagnosing of blind people [51], also patients after amputations in the limbs, the elderly, etc. [48]. Motor competences in the field of collision with stationary objects and avoiding collision with objects in motion are based on expert assessments during exercises (motor simulations).

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