PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Reliability and objectivity of the susceptibility test of the body injuries during a fall of physiotherapy students

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Abstract

Background and Study Aim Falling is an increasingly frequent problem. Assessment of the ability to control the body parts that are most susceptible to injury during a fall is the primary goal of prevention of fall-related injuries. The susceptibility test of the body injuries during a fall (STBIDF) is of note. To date, investigations of the STBIDF have been limited to validity assessment. Aim. Verify the reliability and objectivity of the STBIDF test.

Material and Methods Thirty-five female physiotherapy students participated in this study voluntarily. The sample was selected from 45 males and females undertaking their first-degree studies during the fifth semester of 2017–2018 at Podhale State College of Applied Sciences (PSCAS) in Nowy Targ, Poland. The STBIDF questionnaire was applied. Each student was recorded during STBIDF test performance. The STBIDF reliability assessment was performed using the test-retest method. The STBIDF objectivity assessment was performed using the Delphi method, with a panel consisting of three experts.

Results A significant correlation ($r_s = 0.865$, $p < 0.001$) between the $Index_{SBIDF}$ scores for the test and retest was observed. The Wilcoxon signed-rank test result did not reveal any significant differences between the test and retest.

Conclusions The STBDIF is characterized by reliability and objectivity; therefore, it is a good tool for analysis of the susceptibility to injury of the body parts most exposed during falls in people from different risk groups. This non-apparatus test is a reliable and easy to use tool, available for experts dealing with falls and their consequences, and preventive approaches. It can also be used in medical, pedagogical, and athletic environments.

Keywords: safe fall, concordance of assessments, motoric simulations, different risk groups

Introduction

Falls are a growing social [1-3] and economic [4, 5] issue. According to the World Health Organization (WHO), every year 646, 000 people die due to falls and 37.3 million require medical care [6]. The global rankings of injuries from 2017, that compares causes of death, years lived with disability (YLDs), and disability-adjusted life years (DALYs), classifies falls as the first to third most frequent cause of these incidence [7]. Dobosz et al. [8] identified that the surface on which people fall determines the consequences of falling. According to this ranking [7], Central and Eastern Europe are the leaders, with the rate of falls lowest in sub-Saharan Africa.

The Fall Prevention Model developed by the WHO is composed of three pillars. The first pillar involves building awareness of fall prevention. The second pillar involves improvement of recognition and assessment of risk factors for falls. The third pillar involves the development and implementation of realistic and successful interventions [9]. The second pillar is based on the paradigm that it is possible to eliminate falls from one's life or maximally limit their incidence, and this criterion is dominant in preventive programs. In our opinion, combining the programs aimed at fall limitation with the programs aimed at teaching safe fall techniques is the most optimal solution [10].

Jaskólski and Nowacki [11] have developed the theory of "soft falling". Thanks to their well-justified premises, they combine the sense of body injury prevention in cases of balance loss, falls and contact with the surface, with the ability to lose energy during falls. Mroczkowski [12] has extended this theory by analyzing human body deformation energy during rotational movement performance on the surface. Empirical studies [8, 13] provide evidence for the effectiveness of the so-called Kalina's methods. These methods, verified many times, are based on teaching how to overcome the consequences of balance loss and contact with the surface. An optimal level of muscle strength, flexibility and balance (developed for the circumstances and motor activities to ensure protection of distal body parts and the entire organism, or to minimize the destructive consequences of falls and body contact with the surface) is fundamental [10].

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Effective prophylaxis of fall-related body injuries for individuals begins with an accurate assessment of the quality of control over the body parts that are most exposed to injury. Granhed et al. [14] reviewed the papers on fall-related body injuries. The most exposed body parts included: hips and the upper limbs in people who fell at the same level; lower limbs in persons who fell from heights; the spine and the head; the chest (especially in people who fell from height); and the abdominal cavity (in falls from extreme heights).

The reference sources recommend different approaches to fall risk assessment. These include the Berg Balance Scale [15]; the Falls Efficacy Scale [16]; the Aachen Falls Prevention Scale [17]; and the Short Falls Efficacy Scale International [18]. The motoric tests include the Timed "Up & Go" Test [19] and the Functional Reach Test [20], as well as tests using biomechanical devices [21, 22]. Other good examples of the limited usefulness of these sorts of tools in the prognosis of falls in older people, especially the consequences of such incidents, are the conclusions pertaining to the externally validated accuracy of Fall Risk for Older People in the Community (FROP-Com) [23].

Therefore, the susceptibility test of the body injuries during a fall (STBIDF) is of note [24, 25]. It belongs to the non-apparatus test category, and is safe and easy to apply in clinical and population screening studies. A simple motor simulation of a backward fall on a soft surface enables observation of the body parts that are most exposed to injuries after contact of the body with the surface. The quantified results of this observation (scores) are a simple measure of injury risk for single or multiple body parts in cases of falls during everyday physical activities. The Information Scale on Safe Ways of Falling (INFOSECA) developed by Toronjo-Hornillo et al. [26] assesses motor activities in people during backward falls. Although the approach to identification of the body parts that are most exposed to fall-related injuries is very similar to the STBIDF, the authors of the above mentioned scale cite the review paper presenting test results [27] without mentioning the reference sources [24, 25].

To date, the STBIDF validation procedure has been limited to validity assessment [25]. According to the highest standards of research methodology, the author of a motoric test should not verify its reliability personally. This condition is fulfilled by the results obtained in our study. Among the approaches to reliability assessment, the test-retest approach is most often applied [28-30]. Moreover, the rule is "a trial is objective when it is performed by (at least) two experts using the same human material and its results are identical or very similar" [31]. Therefore, the aim of the present study was to verify the reliability and objectivity of the STBIDF.

Material and methods

Participants

The sample included 35 female physiotherapy students (21.3 ± 0.8 years of age). The sample was selected from 45 males and females undertaking their first-degree studies during the fifth semester of 2017–2018 at Podhale State College of Applied Sciences (PSCAS) in Nowy Targ, Poland. The following inclusion criteria were applied: an adequate health state, voluntary participation, and gender (female). The exclusion criteria were: a lack of consent for participation in the study, pregnancy, and dysfunctions making it impossible to undergo the test. All participants were informed in detail about the aim of the study prior to participation. The study was accepted by the Bioethics Committee at the Regional Medical Chamber in Gdansk, Poland, Resolution KB – 17/17.

Procedures

Assessment of the susceptibility to body injuries during a fall

The STBIDF was applied [24, 25]. Each student was recorded during test performance in such a way that the camcorder was recording the required motor activities in the sagittal plane. The participants waiting for the test were in another room, and they could not contact those who had already performed the test.

The structure of the STBIDF included three motoric tasks performed on tatami (martial arts) mats. The manner of protecting body parts that were most exposed to injuries during a fall (head, hands, hips, legs) was assessed. Any incorrect collision, as indicated by the fastest possible change of posture from vertical (standing) to horizontal (lying on the back), was recorded as a first ("1") or second grade ("2") error, with no errors recorded as "0". The total score is used as general indicator of the susceptibility to body injuries during a fall (i.e., the $Index_{SBIDF}$), with scores classified as low (0), average (1–3), high (4–8), and very high (9–14). The scores obtained for individual body parts were classified as low (0), average (1), and high (2–6) [24, 25].

Assessment of the reliability of the STBIDF using a test-retest approach

The test was recorded twice. The second measurement (i.e., retest) was taken seven days after the first test (i.e., test). Each participant performed the test and retest on their own. The test and retest were performed at the same time of the day, in the same room, and using identical procedures.

Assessment of the objectivity of the STBIDF using the Delphi method (expert panel)

The method of direct secondary observation with the possibility of multiple replays was applied. The assessment procedure involved observation of video recordings of the two stages of the study (i.e., test and retest) by three experts experienced in using the STBIDF. First, the experts independently assessed the recordings and did not share their views. In the case of discrepancies between the scoring, the experts assessed the recordings together (multiple times if required), and verbalized their opinions before reaching a consensus on the final result.

$Index_{RC}$ is the number (expressed in %) of consensus ratings made by experts (independently) in a test and retest.

Statistical analysis

Normality was assessed using the Shapiro-Wilk test. The obtained scores were not normally distributed; therefore, further analyses were conducted using nonparametric methods. Differences between test and retest scores were analyzed using the Wilcoxon signed-rank test, with the alpha level set at < 0.05. Spearman's rank correlation coefficient was used to analyze associations between variables (for example test $Index_{SBIDF}$ and retest $Index_{SBIDF}$). Arithmetic means ($\bar{X}$), standard deviations (SD), minimal (min) and maximal (max) scores (i.e., range), and skew (g1) and kurtosis (g2) were calculated.

Results

The difference between the $Index_{SBIDF}$ scores obtained in the test and those obtained in the retest was 0.2 points according to expert A, and 0.14 points according to expert B, with no difference observed by expert C (Table 1). The biggest difference 0.26 points (calculated on the basis of the data in Table 2) in the mean STBIDF scores was found between expert B's and expert C's assessments for the test.

The experts' mean scores for the test $Index_{SBIDF}$ and retest $Index_{SBIDF}$ were similar for their analyses carried out together at the same time (in the case of discrepancies between the scoring, the experts assessed the recordings together). The differences obtained for the first, second, and third tasks were 0.03 points, 0.08 points, and 0.08 points respectively, and the difference for the $Index_{SBIDF}$ was 0.02 points. A significant correlation between the $Index_{SBIDF}$ test and retest scores was observed ($r_s = 0.865$, $p < 0.001$). The Wilcoxon signed-rank test did not reveal any

Table 1. Mean scores obtained for STBIDF (test-retest) assessment by three independent experts (A, B, C).

Expert statistics		STBIDF test result (score)						$Index_{SBIDF}$ (score)	
		1		2		3			
		test	retest	test	retest	test	retest	test	retest
A	$\bar{X}$	2.69	2.63	2.54	2.57	3.66	3.49	8.89	8.69
	SD	1.02	0.88	0.92	0.7	1.08	1.01	2.56	1.98
	min	1	0	1	1	2	1	4	4
	max	4	4	4	4	6	6	14	12
B	$\bar{X}$	2.74	2.66	2.57	2.63	3.66	3.54	8.97	8.83
	SD	1.01	0.91	0.81	0.69	1	0.95	2.33	2.01
	min	1	0	1	1	2	2	4	4
	max	4	4	4	4	6	6	14	14
C	$\bar{X}$	2.63	2.6	2.49	2.6	3.6	3.51	8.71	8.71
	SD	0.84	0.91	0.82	0.77	0.85	1.09	1.84	2.27
	min	1	0	0	1	2	1	5	3
	max	4	4	4	4	5	6	13	14

Table 2. Differences in mean $Index_{SBIDF}$ scores and rating compatibility index $Index_{RC}$ (%).

Stages and expert assessments		Test		
		$\bar{X}$ $Index_{SBIDF}$ / $Index_{RC}$	$\bar{X}$ $Index_{SBIDF}$ / $Index_{RC}$	$\bar{X}$ $Index_{SBIDF}$ / $Index_{RC}$
	Expert	A	B	C
Retest	A		0	0.06
			77.14	74.29
	B	0.05		0.06
		94.29		80
	C	0.02	0.03	
		88.57	82.86	

significant differences between the test Index$_{SBIDF}$ and retest Index$_{SBIDF}$ scores (Table 3).

The concordance of assessments between expert A and expert B for the retest was 94.29 % (Table 2), and no significant differences between the results were observed.

All correlations between test and retest scores as determined by the experts together were significant ($p < 0.001$). The highest correlation coefficient was observed for Index$_{SBIDF}$ scores, while the lowest correlation coefficient was observed between the scores obtained from the third task (Table 3). However, the lack of significant differences in the results of individual body part assessment by each expert is the most convincing empirical evidence, indicating that the evaluation criteria are precise and that they did not change during the period between the test and retest (Table 4).

High correlation coefficients between the test and retest Index$_{SBIDF}$ scores and between-expert Index$_{SBIDF}$ scores were observed. For the test, differences were found between the experts' scores: between experts A and B and experts A and C = 0.942 ($p < 0.001$); and between experts B and C = 0.937 ($p < 0.001$). Differences between the experts were also observed for the retest: between experts A and B = 0.992 ($p < 0.001$); between experts A and C = 0.963 ($p<0.001$); and between experts B and C = 0.945 ($p < 0.001$).

Discussion

The STBIDF improves identification and assessment of the risk factors highlighted by the WHO in the second pillar recommendations [9]. The STBIDF can be used by anyone who has read the description and adheres to the methodological recommendations [24]. However, only experienced

Table 3. Mean scores of STBIDF (test-retest) after all experts' corrections.

Statistic Indicator	Scores obtained from STBIDF (points) 1		2		3		Index$_{SBIDF}$ (score)	
	test	**retest**	**test**	**retest**	**Test**	**retest**	**test**	**retest**
$\bar{X}$	2.66	2.63	2.49	2.57	3.57	3.49	**8.71**	**8.69**
SD	1.03	0.88	0.85	0.7	1.01	1.01	**2.38**	**1.98**
min	1	0	1	1	2	1	**4**	**4**
max	4	4	4	4	6	6	**14**	12
g1	−0.6	−1.39	−0.05	−0.27	0.07	−0.05	**−0.17**	**−0.5**
g2	−0.44	1.69	0.49	0.04	−0.25	0.58	**−0.13**	**0.26**
Spearman rank correlation	0.816***		0.772***		0.572***		**0.865*** **	
Wilcoxon test p value (exact)	0.82		0.46		0.49		**0.87**	

***$p < 0.001$

Table 4. Mean score and standard deviation corresponding to susceptibility of the predetermined parts of the body to injuries in physiotherapy students (n = 35).

Stages	Body parts in STBIDF tasks (score) 1			2			3			
	hips	**arms**	**head**	**hips**	**arms**	**head**	**legs**	**hips**	**arms**	**Head**
Expert A										
Test	0.23±0.43	1.51±0.82	0.94±0.24	0.2±0.41	1.57±0.56	0.77±0.43	0.94±0.84	0.2±0.41	1.63±0.49	0.89±0.32
Retest	0.14±0.36	1.60±0.77	0.89±0.32	0.11±0.32	1.6±0.5	0.86±0.36	0.74±0.7	0.2±0.41	1.63±0.55	0.91±0.28
Difference	0.09	0.09	0.05	0.09	0.03	0.09	0.2	0	0	0.02
Expert B										
Test	0.29±0.46	1.51±0.82	0.94±0.24	0.17±0.38	1.6±0.5	0.8±0.41	0.83±0.82	0.31±0.47	1.63±0.49	0.89±0.32
Retest	0.17±0.38	1.6±0.77	0.89±0.32	0.14±0.36	1.6±0.5	0.89±0.32	0.8±0.72	0.2±0.41	1.63±0.55	0.91±0.28
Difference	0.12	0.09	0.05	0.03	0	0.09	0.03	0.11	0	0.02
Expert C										
Test	0.17±0.38	1.51±0.82	0.94±0.24	0.2±0.41	1.6±0.6	0.69±0.47	0.8±0.83	0.26±0.44	1.63±0.49	0.91±0.28
Retest	0.11±0.32	1.6±0.77	0.89±0.32	0.17±0.38	1.6±0.5	0.83±0.38	0.74±0.7	0.23±0.43	1.63±0.55	0.91±0.28
Difference	0.06	0.09	0.05	0.03	0	0.14	0.06	0.03	0	0

experts have numerous opportunities to track individuals' behavior and activities to find out whether these (namely conscious behavior during different formal exercises, motoric simulations, and some forms of play fighting [32]) lead to errors or optimal actions. The STBIDF has been frequently applied [27] in samples of athletes (e.g., judoka or karateka) [33], individuals who do not train [34], individuals with disabilities [35, 36] and visual impairments [37, 38], and limb amputees [39].

Kalina et al. [25] first applied the STBIDF in 2010 for the assessment of female physiotherapy students who completed motoric simulations of falling by blind people and limb amputees. The obtained scores were used in the validation procedure (test validity assessment) for the STBIDF. The STBIDF was observed to be a very sensitive tool, able to verify changes in body susceptibility to fall-related injuries in physiotherapy students, patients with visual impairment, and footballers after limb amputation or with malformed limbs (AMP football players) [40]. There was only one case of a patient with morbid obesity [41]. An extended analysis of the STBIDF results revealed opportunities for simple brain plasticity assessment [38]. This conclusion is in agreement with the opinions presented by, amongst others, Bennett et al. [42].

Due to the multiple motoric elements repeated at potentially high speeds (the requirement of fall dynamics simulation), three experts highly experienced in athlete observation during training and competition (especially combat sports and games) assessed the recordings. This approach is very effective. The recording can be replayed several times, and in case of any doubt's playback can be slowed or stopped when necessary. On completion of the tests, the experts recommended recording task performance from both sides of the participant. It was noted that assessment of head-to-surface contact can be problematic if a participant has a hair bun (as in the case of one participant in our study), and that assessment of hip control may be biased if a participant wears oversized clothing that prevents observation of the moment of contact with the surface. In our opinion, the observer's perception is also an important factor. During observer training it is important to note how many times a candidate has to replay a recording to see the details required for the final assessment.

This study has shown a high concordance of assessment. The mean level of the difference obtained from Index$_{SBIDF}$ scores was lower for the first-grade error. According to the quote that states "the trial is objective when it is performed (at least) by two different persons with the same human sample and its results are identical or very similar"[31], the STBIDF should be regarded as objective, whilst high and significant correlation coefficients obtained using the test-retest approach indicate its reliability. This conclusion is further supported by the lack of significant differences between test-retest scores.

Assessment of a fall under laboratory conditions is often performed using state-of-the-art programs based on biomechanics and computer systems that enable multiplane analyses. Unfortunately, this instrumentation is expensive [21, 22] and the scale of fall consequence phenomenon [6] requires the use of simple approaches to observation that are quick and, most importantly, cheap. A special application for smartphones that facilitates documentation of observations and assessment of results would be beneficial. Our study results confirm the finding that the STBIDF, as a simple tool of participant observation during simulated falls, provides empirical data that enables valid, reliable and objective analysis of susceptibility to injuries that may be sustained by older people who fall whilst undertaking everyday physical activities in their apartments, gardens, and houses [43].

Conclusions

The STBDIF is characterized by reliability and objectivity; therefore, it is a good tool for analysis of the susceptibility to injury of the body parts most exposed during falls in people from different risk groups.

This non-apparatus test is a reliable and easy to use tool, available for experts dealing with falls and their consequences, and preventive approaches. It can also be used in medical, pedagogical, and athletic environments.

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Conflicts of interest

The authors declare no conflicts of interest.

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