Fall as an extreme situation for obese people

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

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Abstract

Background and Study Aim: Global obesity rates have tripled in many countries of the World Health Organization (WHO) European Region since the 1980s, and the numbers of those affected continue to rise at an alarming rate. Based on the latest estimates in European Union countries, overweight affects 30%-70%, and obesity affects 10%-30% of adults. In the USA 70% of the population are now affected by excess weight or obesity. The cognitive purpose of this paper comprises two issues, namely a general review of available papers on the risk of falls and body injuries in the population of obese persons due to such incidents as collisions with stationary objects (e.g. a wall) or moving objects (throwed objects, vehicles, etc.); the second issue relates to the effect of safe falling training in persons with third degree obesity.

Material and Methods: The review focuses on manuscripts published since 2001, describing obesity issues associated with greater risk of falling, and the risk of injury from a fall. The main result (conclusion) of the article analyses pertains either to theoretical studies or empirical studies, or both types of the aforementioned studies combined. The study participant was a woman (age 21 year, body height 168 cm, body mass 118 kg, BMI 41.81), a third year physiotherapy student participating in specialist courses on the theory and methodology of safe falling. Clinical assessments were performed using the: Rotational Test (RT); the susceptibility test of the body injuries during the fall (STBIDF); test for safe falls (TSF); standing broad jump; bent arm hang; sit ups; trunk bend.

Results: There are more papers on the risk of falls in obese persons and fewer papers on body injuries in this population due to collisions with the ground during falls. SBIDF indicators obtained before the experiments (11 total points) have shown that the obese female participant was characterized by a very high level of susceptibility to body injuries during falls. The reduction of the score corresponding to errors committed while controlling the distal body parts to 3 points (average level) is the evidence for a high effectiveness of safe fall courses. The score obtained from the RT was 7 points (which indicates 61% of adequate test performance according to result decomposition criteria in T scale) before and after safe fall courses is the evidence of an average level of body balance disturbance tolerance. Reduction of test performance duration from 16.41 to 11.81 seconds (by 28.01%) confirms a favourable adaptive effect. The obese student perfectly performed TSF (100 points) within 20 seconds, providing an empirical evidence for acquiring the ability of safe falling at a very high level. The methods training resulted in upper limb muscle strength increase by 36%, that means 0 points before and 36 points after the experiment and 28% increase in lower limb muscle strength namely: 33- before and 61 points (raw data corresponding to standing long jump 120 cm before and 185 cm after the experiment). The obese student's flexibility deteriorated as indicated by the values obtained prior to and following the experiment: 50 and 44 points and by the raw data of 10- and 5 cm respectively.

Conclusions: The aforementioned (although isolate) adaptive effects are important arguments for implementation of health related training for overweight and obese persons, based on safe falling workouts. There is no need to organize special safe falling and collision avoidance courses for overweight and obese persons; a competent application of the pedagogic rule of individualization during training sessions is sufficient.

Key words: body injuries • fall • safe fall course • soft fall theory

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ICSPFT – the Test of Physical Fitness development by the International Committee on the Standardisation of Physical Fitness Test [25].

INTRODUCTION

Obesity is defined as an abnormal or excessive accumulation of fat that may impair health, and it is a chronic disease that is increasing in prevalence [1]. Global obesity rates have tripled in many countries of the World Health Organization (WHO) European Region since the 1980s, and the numbers of those affected continue to rise at an alarming rate [2]. Based on the latest estimates in European Union countries, overweight affects 30%-70%, and obesity affects 10%-30% of adults. In the USA 70% of the population are now affected by excess weight or obesity [3, 4].

Clinically, obesity is defined on the basis of the body mass index (BMI), calculated as weight in kilograms divided by height in square meters [5]. The WHO states that for adults, the healthy range for BMI is between 18.5 and 24.9. Overweight is defined as a body mass index of 25 to 29.9, and obesity is defined as a body mass index of 30 or higher [2]. For clinical and research purposes, obesity is classified into three categories: class I (30-34.9), class II (35-39.9), and class III (>40) [5, 6].

Health-related characteristics pertaining to overweight and obese populations include information that these persons are at risk of balance loss, falls and consequences of the aforementioned risk factors, leading to further health impairment (body injuries [7], years lived with disability (YLDs) [7, 8], death [9]). Conversely, there are no empirical data on adaptive capabilities of such persons to overcome the category of extreme (falls) and other incidents (avoiding collisions with vertical obstacles and moving objects) [10, 11].

There available reports on the methodological aspect of our interest (preparing overweight and obese individuals for safe falls and collision avoidance), concerning either simulated studies in healthy participants or patients with specific disabilities (visually impaired [12, 13], amputees [14] or mentally impaired [15, 16]). There are also papers presenting studies on samples including persons who, due to their participation in sports (combat sport and martial arts [17, 18]) or their profession (soldiers, anti-terrorists, stuntmen or policemen) develop their skills of safe collisions with surface which are due to intentional or unintentional falls and learn to avoid and/or cushion collisions with vertical obstacles or moving objects. In a broader context of this issue, we should mention papers reporting on susceptibility to fall-related body injuries in persons belonging to specific risk groups as well as in healthy individuals [19]. The authors do not mention overweight and obese persons.

The cognitive purpose of this paper comprises two issues, namely a general review of available papers on the risk of falls and body injuries in the population of obese persons due to such incidents as collisions with stationary objects (e.g. a wall) or moving objects (throwed objects, vehicles, etc.); the second issue relates to the effect of safe falling training in persons with third degree obesity.

MATERIAL AND METHODS

Review of the literature

The review focuses on manuscripts published since 2001, describing obesity issues associated with greater risk of falling, and the risk of injury from a fall. The main result (conclusion) of the article analyses pertains either to theoretical studies or empirical studies, or both types of the aforementioned studies combined.

Assessment of motor effects of safe fall courses

Participant

The study participant was a woman (age 21, body height 168 cm, body mass 118 kg, BMI 41.81), a third year physiotherapy student (2009/2010) at the Podhale State College of Applied Sciences in Nowy Targ (PSCAS), participating in specialist courses on the theory and methodology of safe falling. The following inclusion criteria were applied: presence at training sessions (90% to 100%) and the body mass index (BMI) value confirming obesity. In the entire sample of students only one female student met both criteria: her BMI was BMI 41.81, indicating class III obesity (extreme obesity).

Motor test were applied at the beginning of October 2009 (Tables and Figures IA) and at the end of May 2010 (Tables and Figures IB).

The tests were carried out in a specially equipped room where the floor was covered with puzzle mats and some mats (1m x 1m) were used as pads during special motor simulations. The aids included orthopaedic wedge cushions, slings, sleeping pads, judo belts and eye bands. The classes were carried out as two separate courses. The first safe fall course (SFC-1) comprised training rear falls and falls to the side as part of methodology for teaching persons with vision impairment. It consisted of 10 training and methodology sessions including: 5 minutes of workout; 45 minutes of methodological tasks, comprising the total of 10 units, 90 minutes long each. Moreover, it comprised 5 90 minutes long lectures. The second safe fall course (SFC-2) included methodology of safe falls in limb amputees and included learning rear falls and falls to the side, as well as front falls and front falls with turn over the shoulder. The structure of the course was the same as that of the previous one.

Motor potential and testing

The body balance disturbance tolerance skills (BBDTS) – Rotational Test (RT)

BBDTS was measured by the Rotational Test (RT) [20]. The movie is available at the website of the Archives of Budo journal in the section: ArchBudo Academy under link Rotational Test (http://www.archbudo.com/ text.php?ids=351). Each set of 'jump-landing-posture correction' should last about two seconds and the principal investigator of research starts a stopwatch while pronouncing "r" during the first command, i.e. 'right' and stops it during the pronunciation of "t" in the last command, i.e. "left". The main test consists of 6 tasks, starting with the jump with a 360° rotation to the right.

Evaluation method: An assistant provides documentation for motor effects of the test: landing after the jump on the designated line with both feet and maintaining balance means the lack of the mistake (the result is recorded as "0"), no contact of one foot with the line after landing is assessed as "1" (first degree mistake), "2" means the lack of contact with the line after landing or not maintaining this contact while correcting the posture (second degree mistake), "3" records leaning against the ground with a hand/hands or a fall (third degree mistake).

Evaluation criteria for both versions of the test (quasi-apparatus and non-apparatus). The overall result is the sum of the six tasks (consecutive jumps with body rotation) and includes 0 to 18 stipulated points. "0" indicates a very high ability to tolerate imbalances, while "18" means the exact opposite of that assessment. Criteria of an individual level assessment determined by the 'Rotational Test' (RT) are as follows: very high (0-1), high (2-3), average (4-9), low (10-12), very low (13-15), insufficient (16-18) [20].

During decomposition of the raw data on T-scale we accepted that one point of the Rotational Test result means 5.56 points in T-scale.

Susceptibility to injuries during the fall (SBIDF) – the susceptibility test of the body injuries during the fall (STBIDF)

The student individually performed „*the susceptibility test of the body injuries during the fall*" (STBIDF) [21, 22]. The test consists of three motor tasks, which should be performed on a soft surface (such as tatami mat). The criterion for evaluation is the way of protection (or lack) of those parts of the body, which during the fall are most exposed to injury (head, hands, hips, legs). Each incorrect collision of such body parts with the ground – simulated by the fastest possible change of vertical posture to the horizontal one (lie down on the back) – should be recorded in the worksheet STBIDF by circling number "0" (no error), "1" (first degree error) or "2" (second degree error).

The total score is a general indicator of susceptibility to injuries during the fall (SBIDF): low (0), average (1–3), high (4–8), very high (9–14). The measure of susceptibility of the predetermined parts of the body to injuries (SBPIDF) is the sum of the points obtained from all tasks (summarized points from the rows of the worksheet) analysed separately for each part of the body: low (0), average (1), high (2–6).

Marginal values of SBPIDF (as a result of adding errors made during the tasks) for different parts of the body include between: legs 0–2; hips 0–3; hands 0–6; head 0–3. However, the marginal values obtained by adding points estimated after completing Tasks 1 and 2 are in the range of 0 and 4 points, and those obtained from Task 3 are in the range of 0 and 6 points. For this reason, a comparative analysis (for the parts of the body and each tasks) takes into account the indicator of proportion of errors (expressed in percentage) applied to the possible maximal value of estimated points (SBPIDF%max). For example, for the hands this value is 6 points and 2 points for legs [21].

The ability to safe fall (ASF) – test for safe falls (TSF).

The student performed the test for safe falls (TSF) in its full basic version, which consists of four consecutive tasks – the second one-element, the remaining two-element – which are series of seven falls: (1) rear fall and rear fall with turn; (2) front fall; (3) fall to the side (left and right); (4) front fall with turn over the shoulder (left and right).

Instruction for test execution and evaluation criteria: At the command „ready" the tested individual assumes the fighting stance; at the examiner's signal, who simultaneously starts the stop watch, the participant? executes test tasks (1 to 4); the examiner prompts the defined sequence and switches off the stop watch once the participants have finished task 4 (time of test implementation 20 s excellence and 40 s sufficient). Each task, from the motor viewpoint, is subject to evaluation in a 4-level scale: **25-, 20-, 15-, 0** points, taking into account the following criteria: **25** points for a perfect and dynamic execution of a particular task (of all its elements); **20** points for a faultless and fluent execution of tasks, but not a dynamic one; or for a dynamic execution with minor technical errors; **15** points for execution of the task in an insufficiently dynamic way and with mistakes, which nevertheless do not affect a change in the type of movement; **0** points, the essential type of movement is not maintained, moreover, the tested person is unable to assume the defence stance during the execution of tasks or move in a way accepted for behaviour in defence fights.

The way of carrying out the test out is available (in text and video) on the website of the journal Archives of Budo (www.archbudo.com) in the top-left window under link Safe Falls Academy (www.archbudo.com/text.php?ids=263) [23, 24].

Muscle strength and tests (according to criteria **The Test of Physical Fitness development by the International Committee on the Standardisation of Physical Fitness Test – ICSPFT** [25]):

- ***the strength of the lower limbs –*** standing broad jump (result: jump length in cm);
- ***the strength of the upper limbs –*** bent arm hang /chin over the bar/ (result: seconds);
- ***the strength of the abdominal muscles –*** sit ups (result: number of repetitions performed in 30 seconds).

Flexibility

Trunk bend (result: it is constituted by a deeper bend obtained in two consecutive attempts and measured in cm).

RESULTS

Analysis of the literature review

There are more papers on the risk of falls in obese persons (Table 1) and fewer papers on body injuries in this population due to collisions with the ground during falls (Table 2). The synthesis of the analysis of literature dedicated to body injuries in obese population is included in "Discussion" section. There are no papers containing information on the consequences of collisions with vertical or moving objects.

Table 1. The risk of falls in obese population – literature review (ordinal variable – year of publication).

Year & Author(s)	Material	Study design	Results, conclusion, recommendations
2001 Corbeil P, Simoneau M, Rancourt D, Tremblay A, Teasdale N. [26]	A 15-segment humanoid was used. To create the obese humanoid, anthropometric measurements were taken for a male subject having a BMI of 43.0 kg/m^2.	In the present experiment, a model of postural control was used to examine the impact of an abnormal distribution of body fat in the abdominal area upon postural stability. Obese and lightweight humanoids were destabilized by imposing a small initial angular speed from a neutral standing position.	When submitted to daily postural stresses and perturbations, obese persons may be at a higher risk of falling than lightweight individuals.
2008 Fjeldstad C, Fjeldstad AS, Acree LS, Nickel KJ, Gardner AW. [27]	The subjects participating in this study consisted of 91 males and 125 females. Subjects who had a body mass index (BMI) greater than 30 kg/m^2 were classified into an obese group (n = 128) while those with BMI between 18.5 and 24.9 kg/m^2 were included into a normal weight group (n = 88).	Functional tests were performed to assess balance, and questionnaires were administered to assess history of falls, ambulatory stumbling, and health-related quality of life.	In middle-aged and older adults, obesity was associated with a higher prevalence of falls and stumbling during ambulation, as well as lower values in multiple domains of health-related quality of life.
2012 Himes CL, Reynolds SL. [7]	Ten thousand seven hundred fifty-five respondents aged 65 and older in 31,602 person-intervals.	Falls within any 2-year interval (9,621 falls). Injuries requiring medical attention (3,130 injuries). Increased ADL disability after a fall within any 2-year interval (2,162 events). Underweight and three classes of obesity (body mass index BMI).	Obesity appears to be associated with greater risk of falling in older adults, as well as a higher risk of greater ADL disability after a fall. Obesity (BMI 40 kg/m^2) may reduce the risk of injury from a fall.
2012 Rosenblatt NJ, Grabiner MD. [28]	All subjects were community dwelling women, aged 55 years and older. Eighty six subjects (42 obese) reported falls occurring during the previous year (retrospective falls), and over the following year	The current study relied on data from a larger study considering the influence of a fall-prevention intervention on reducing falls in the community.	Taken together data suggest that obese women aged 55 years and older may not be at an overall increased risk of falling or stumbling but may experience a greater rate of trip-related falls. Therefore, the previously reported increased risk of fall-related injury, which may partly be supported here, may be due to a predisposition to injury after falling.
2012 Wu X, Lockhart TE, Yeoh HT. [29]	Ten healthy young male adults participated in the study	The purpose of this study was to investigate the influence of gait adaptations of the obese individuals and its implication on risk of slip initiations as measured by friction demand characteristics.	In conclusion, young obese adults walked similarly as their lean counterparts except for exhibiting greater step width and higher transversal friction demand characteristics, suggesting that slip induced fall risks are similar along the horizontal direction, but increased risks along transversal direction under certain floor conditions.
2014 Lin HW, Bhattacharyya N. [30]	Among 216.863 five million adult Americans, 26.3% +0.4% were obese.	With demographic information, data for balance and dizziness problems, reported falls, injuries from falls, and body mass index were extracted.	The addition of obesity to dizziness was associated with a higher rate of falling but was not associated with a significantly higher rate of fall-related injury. Balance problems in conjunction with obesity need to be targeted in fall-prevention efforts.
2014 Madigan M, Rosenblatt NJ, Grabiner MD. [31]	Articles	research approach: analysis of data, in-depth analysis. The focus of this paper is the potential of task-specific training to improve compensatory stepping responses and reduce falls by obese people given the individual-specific anthropometric and functional consequences of obesity.	Fall-prevention interventions have not been designed to specifically address the significant issue of falls by obese older adults. The anthropometric and functional consequences of obesity may impose constraints on motor performance that limit compensatory stepping responses and increase fall risk.
2014 Mitchell RJ, Lord SR, Harvey LA, Close JCT. [32]	A representative sample of 5,681older people (at least 65 years of age) living in the community, with a private telephone, was surveyed across New South Wales regarding participants' falls experience, knowledge and perception of falls, participation and awareness of physical activity and health status.	To determine whether overweight and obese individuals have higher reported fall and fall injury risk than individuals of healthy weight, and to examine the influence of BMI on health, quality of life and lifestyle characteristics of fallers.	Older obese individuals have an increased risk of falls and obese fallers have a higher prevalence of pain and inactivity than fallers of a healthy weight.
2015 Mitchell RJ, Lord SR, Harvey LA, Close JC. [33]	A representative sample of 5,681 older people (aged 65+ years) living in the community, with a private telephone, were surveyed across NSW regarding their falls experience, knowledge and perception of falls, participation and awareness of physical activity and health status.	Research examines whether specific diseases, sedentary behaviour, mood, pain, and medication use mediate the association between obesity and falls.	Among older people, obesity has been associated with an increased risk of falling and this study has identified a number of mediating factors for the association between obesity and falls.

Year & Author(s)	Material	Study design	Results, conclusion, recommendations
2017 Handrigan GA, Maltais N, Gagné M, et al. [34]	Study sample consisted of 15,860 adults aged 65 years or older (6,399 men and 9,461 women).	Falls, fall-related injuries, and BMI measures were self-reported. For both sex, dose-response curves presenting the relationship between BMI, falls, and fall related injuries were first examined.	The relationship between BMI and prevalence of falls showed that underweight and obese individuals reported falling more than normal and overweight individuals; this being more apparent in men than women. Obesity is associated with self-reported falls, and there appears to be a sex-specific difference in elderly persons.
2019 Gadelha AB, Neri SGR, Vainshelboim B, Ferreira AP, Lima RM. [35]	A total of 201 older women (67.97 ±6.02 years; 27.70 kg/m²)	Waist circumference measurement, and had handgrip strength assessed using a hydraulic dynamometer. Dynapenia was classified using the lower tertile of handgrip strength, while abdominal obesity was considered as a waist circumference > 88 cm.	Dynapenic abdominal obesity is more closely related to falls than either dynapenia or abdominal obesity alone, and is independently associated with an increased incidence of falls in older women.
2019 Lockhart TE, Frames CW, Soangra R, Lieberman A. [36]	One hundred healthy older adults (age 74.0 ±7.6 years, range of 56–90 years) living independently in a community participated in this study.	Study investigates if obesity (Body Mass Index: BMI>30 kg/m²) influenced gait and standing postural characteristics of community dwelling older adults leading to increased risk of falls.	The key finding of this study are: 1) postural and gait stability is compromised in obese fallers; 2) acceleration-based gait and postural parameters are able to distinguish between obese fallers and non-fallers.
2020 Ercan S, Baskurt Z, Baskurt F, Cetin C. [37]	Individuals aged 40-60 years who were divided into obese and non-obese groups based on their body mass index values. Of the 251 subjects, the obese group had 125 (49.8%) subjects.	Data was recorded before collecting target data using Tinetti Falls Efficacy Scale, Activities-Specific Balance Confidence Scale, History of Falls Scale, Single Leg Stance Test, Functional Reach Test and the New York Posture Rating Test.	A high restriction in activity was determined in obese females because of fear of falling (p<0.05). Obese males, did not experience fear of falling. Fear of falling was high in obese females and confidence in daily activities was low (p<0.05). No fear of falling obese males and a deceptive sense of confidence, prevented prediction of the risk of falling.
2020 Lee JJ, Hong DW, Lee SA, et al. [38]	317 participants were categorized based on their body mass index.	Clinical balance assessments were performed using the Berg Balance Scale, Timed Up and Go test, and Short Physical Performance Battery.	The logistic regression analysis of study showed that BMI-based obesity can be an independent fall risk as well as age and balance.
2020 Neri SGR, Harvey LA, Tiedemann A, Gadelha AB, Lima RM. [39]	246 female participants underwent obesity screening (BMI≥30 kg/m²)	Incident falls were recorded at the end of the 18-month follow-up period via participant recall.	Lower-limb muscle quality and foot loads mediate the relationship between obesity and falls in older women. Being flatfooted was related to increased risk of falls in obese participants, but not in non-obese participants.

Table 2. Body injuries due to falls in obese population literature review (ordinal variable – year of publication).

Year & Author(s)	Material	Study design	Results, conclusion, recommendations
2011 Compston JE, Watts NB, Chapurlat R, Cooper C, Boonen S, Greenspan S et al. [40]	A total of 60,393 women aged ≥55 years were included.	Multinational, prospective, observational, population-based study. Data were collected using self-administered questionnaires that covered domains that included patient characteristics, fracture history, risk factors for fracture, and anti-osteoporosis medications.	Body mass index (BMI) and fracture history were available at baseline and at 1 and 2 years in 44,534 women, 23.4% of whom were obese (BMI ≥30 kg/m²). Results demonstrate that obesity is not protective against fracture in postmenopausal women and is associated with increased risk of ankle and upper leg fractures.
2011 Nielson CM, Marshall LM, Adams AL, LeBlanc ES, Cawthon PM, Ensrud K et al. [41]	5,995 US men 65 years of age and older. 27% of men had normal BMI (18.5 to 24.9 kg/m²), 52% were overweight (25 to 29.9 kg/m²), 18% were obese I (30 to 34.9 kg/m²), and 3% were obese II (35 to 39.9 kg/m²).	Standardized measures included weight, height, and hip bone mineral density (BMD) by dual-energy X-ray absorptiometry (DXA); medical history; lifestyle; and physical performance.	Overall, nonspine fracture incidence was 16.1 per 1000 person-years, and hip fracture incidence was 3.1 per 1000 person-years. In age-, race-, and BMD-adjusted models, compared with normal weight, the hazard ratio (HR) for nonspine fracture was 1.04; for overweight, 1.29; for obese I, and 1.94; for obese II. Obesity is common among older men, and when BMD is held constant, it is associated with an increased risk of fracture. This association is at least partially explained by worse physical function in obese men.

Year & Author(s)	Material	Study design	Results, conclusion, recommendations
2012 Prieto-Alhambra D, Premaor MO, Fina Aviles F, Hermosilla E, Martinez-Laguna D, Carbonell-Abella C et al. [42]	1,039,878 women aged ≥50 years were eligible, of whom 832,775 (80.1%) had a BMI measurement. These were categorized into underweight/normal (302,414 women), overweight (266,798), and obese (263,563).	Fractures were ascertained using the International Classification of Diseases, 10th revision (ICD-10) codes. Multivariate Poisson regression models were fitted to adjust for age, smoking, high alcohol intake, type 2 diabetes, and oral corticosteroid use.	The association between obesity and fracture in postmenopausal women is site-dependent: in cohort, obesity was protective against hip and pelvis fractures but was associated with increased risk of proximal humerus fractures.
2013 Premaor MO, Compston JE, Fina Aviles F, Pages-Castella A, Nogues X, Diez-Perez A et al. [43]	In 2007, 186,171 men ≥65 years were eligible, of whom 139,419 (74.9%) had an available BMI measurement. For this analysis men were categorized as underweight/normal (BMI<25 kg/m^2), overweight (25>BMI<30 kg/m^2), and obese (BMI ≥30 kg/m^2).	Incident fractures were ascertained using International Classification of Diseases, 10th edition (ICD-10) codes.	Obesity in men was protective against hip, wrist/forearm, pelvic, and clinical spine fractures but appeared to increase the risk of multiple rib fractures. Tibia and proximal humerus fracture rates were not related to BMI.
2014 Caffarelli C, Alessi C, Nuti R, Gonnelli S. [44]	Articles	Research approach: analysis of data, in depth analysis	The search for better methods for the identification of fragility fracture risk in the growing population of adult and elderly subjects with obesity might be considered a clinical priority which could improve the prevention of fracture in these patients.
2014 Premaor MO, Comim FV, Compston JE. [45]	Articles	research approach: analysis of data, in depth analysis	The proportion of fractures occurring in obese people is considerable, and is likely to increase with the progressive rise in obesity in the world population. Subjects with higher BMI are at higher risk of fractures at some sites such as the humerus, lower leg and ankle.
2017 Acosta-Olivo C, Gonzalez-Saldivar JC, Villarreal-Villarreal G, et al. [46]	114 patients with distal radius fracture were examined in across-sectional, observational study. 20.2% patients had a normal BMI (<25), 34.2% were overweight (BMI 25–30), and 45.6% were obese (BMI > 30).	Was observed no correlation between the types of fracture and the degree of obesity. The patients were divided into three groups, with average ages of 43 years, 53 years, and 65 years, and the frequency of distal radius fracture in these groups were 26.3%, 24.6%, and 49.1% of patients, respectively.	Based on the results of this study obesity and severity of distal radius fractures do not correlate.
2017 Sotiriadi-Vlachou S. [47]	Articles	A review of all current literature on the topic was carried out based on systematic searches of electronic databases using the key words of obesity, elderly, body mass index, postmenopausal woman, fractures.	The prevention of fall related injury in obese elder women needs a multifaceted approach to public health, by heightened awareness for the assessment, education, referrals, and recommendation.
2019 Bryant MK, Parrish M, Roy S et al.[48]	Results of the 333 patients with femur fractures included in the study, the majority were male (57.4%). The study cohort was divided amongst normal weight, overweight, and obese with frequencies of 35.4%, 34.8%, and 9.7%,	Bivariate correlations and multiple regression models were used to examine the relationship between BMI and outcomes.	Higher BMI puts patients at risk for longer hospital stays and increased rate of systemic complication following femur fracture, which should influence counselling of obese patients after femur fracture.
2019 Court-Brown CM, Duckworth AD, Ralston S, McQueen MM. [49]	During the study period data on 6818 fracture patients aged ≥16 years were prospectively recorded. A total of 4886 (71.7%) patients had BMI data available. For the purposes of analysis the BMI was conventionally divided into underweight (< 18.5), normal weight (18.5–24.9), overweight (25–29.9) and obese (>30).	Epidemiological analysis of all patients presenting to the Royal Infirmary of Edinburgh in a one-year period between mid-2010 and mid-2011.	There is a positive relationship between obesity and proximal humeral, finger phalangeal and ankle fractures in males and with humeral diaphyseal, carpal and ankle fractures in females. There was no relationship found between open or multiple fractures and obesity.

Motor effects

The level of body balance disturbance tolerance skills

The score obtained from the Rotational Test was 7 points (which indicates 61% of adequate test performance according to result decomposition criteria in T scale – see methods) before and after safe fall courses is the evidence of an average level of body balance disturbance tolerance. Reduction of test performance duration from 16.41 to 11.81 seconds (by 28.01%) confirms a favourable adaptive effect, however, in this paper this result is not presented in figures.

The level of susceptibility to injuries during the fall

SBIDF indicators obtained before the experiments (11 total points) have shown that the obese female participant was characterized by a very high level of susceptibility to body injuries during falls. The reduction of the score corresponding to errors committed while controlling the distal body parts to 3 points (average level) is the evidence for a high effectiveness of safe fall courses. The body parts responsible for the most serious errors committed during distal body part control by the obese participant prior to the experiment included the lower limbs, hips and the head (each result was 100%) while the value corresponding to upper limb control was 50%. During safe fall courses, the student managed to reduce all leg and hip control errors while performing simulated falls, and to reduce the arm and head control errors by 50% and 33.33% respectively (Figure 1).

Skill level safe falling

The obese student perfectly performed TSF (100 points) within 20 seconds, providing an empirical evidence for acquiring the ability of safe falling at a very high level.

Muscle strength and flexibility

The methods and training techniques used during safe fall courses resulted in upper limb muscle strength increase by 36% according to ICSPFT scale, that means 0 points before and 36 points after the experiment (raw data, 0- and 0.54 seconds) and 28% increase in lower limb muscle strength according to ICSPFT scale, namely: 33- before and 61 points (raw data corresponding to standing long jump 120 cm before and 185 cm after the experiment). The above mentioned methods and techniques proved sufficient to support abdominal muscles (identical results before and after the experiment 45 points ICSPFT, raw data, 20 repetitions). Conversely, the obese student's flexibility deteriorated as indicated by the values obtained prior to and following the experiment, as reflected by the scores: 50 and 44 ICSPFT points respectively, and by the raw data of 10- and 5 cm respectively.

Synthetic visualization of adaptive effects

The most important result concerns acquisition of safe fall skill (100% effectiveness) and reduction of distal body part control errors during simulated falls by 57.14%. The student reduced the duration of Rotational Test performance while generating identically evaluated errors according

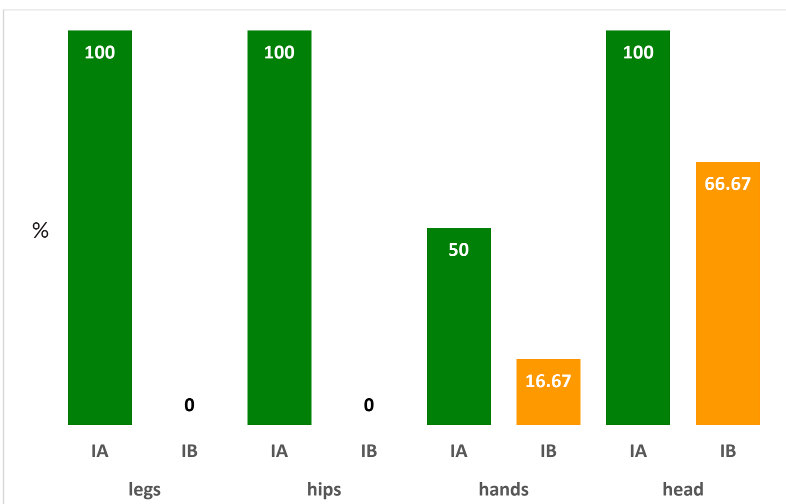

Figure 1. Indicators of the proportion (%) of committed distal body part control errors during a simulated rear fall, estimated using SBPIDF%max indicators in the obese female participant before and after the experimental safe fall courses.

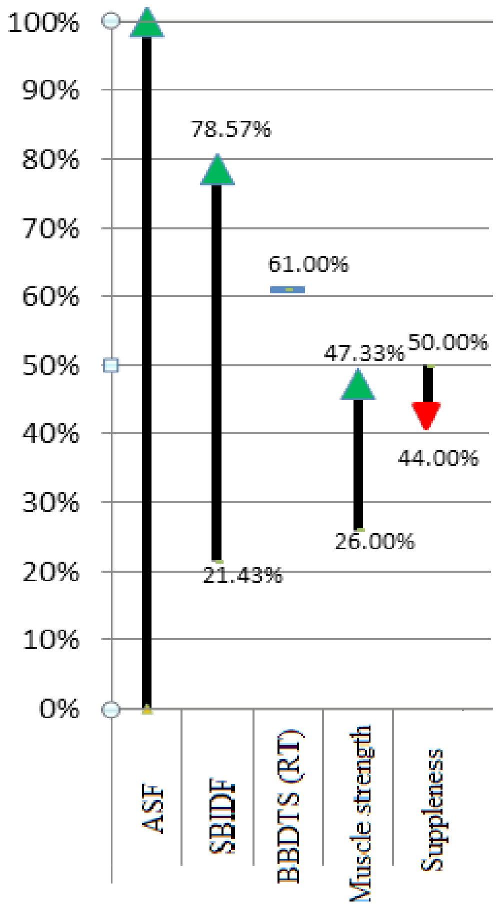

Figure 2. Adaptive effects obtained by the female student with morbid obesity after 20 training sessions of two safe fall courses (the result obtained from the Rotational Test, reduced by 28.01%, is not monitored).

to scoring criteria). Her muscle strength increased by 21.33% which was revealed by the mean value obtained from the three above mentioned tests (Figure 2). Her flexibility deteriorated, evidently due to the excessive increase in body mass during the experiment.

DISCUSSION

In the above presented context of an obese person's motor functioning under extreme conditions (loss of balance and an unintended collision with the ground), the issue of the validity of tests assessing individual motor skills is interesting from the cognitive and applicative viewpoints. The female student with III° obesity (according to BMI) was unable to perform bent arm hang prior to the course. After the first course, despite the increase in body mass, she performed a front fall with turn and rear fall with turn (Figure 3), and the value corresponding to the duration of workout performance was similar to that obtained in the fittest man in the group (Figure 4).

This finding indicates that the speed of specific fall technique performance with turns and an optimal muscle tone of the upper limb over which the student effectively rolled [50], compensated strength deficit in the upper limbs, measured by the recommended flexed arm hang test. Prior to the first attempt to perform a front fall with turn (with the professional specialist's aid), the participant was conscious that muscle strength in the upper limbs did not guarantee maintaining body mass during supported bent down performance, even within a second, when the gravity center is shifted towards the arms. Since then, she was performing this workout by herself. On completion of both courses (SFC-1 and SFC-2) the time obtained by the participant during hang performance was 0.54 s. Her muscle strength (the averaged value obtained from the above mentioned test and 2 consecutive tests measuring muscle strength in legs and the abdomen) increased from 25% to 47% and her ability to tolerate body balance disturbances was maintained at a similar level (61%, the score obtained from RT = 7 points), however, after RT training, the time of her task performance was reduced by 4.6 seconds. The issue of general validity of physical fitness tests clearly arises in a detailed analysis of the student's adaptive effects. There should be no doubts that the 6% decrease in body flexibility revealed by the test on completion of the courses was related to body mass increase.

Prior to the training, the student with III° obesity showed a very high susceptibility to body injuries during falls. The 11 point value of STBIDF indicator translates into abilities to protect distal body parts against injuries during collisions with the ground. Since the student reduced the STBIDF score to 3 points after 2 courses, the value corresponding to the adaptive effect, based on the difference between the 2 measurements, was 57% (Figure 2). The 100% TSF value indicates that prior to the training the student was unable to fall safely in a professional way. For this category, professionalism means an optimal use of all amortizing functions of the limbs, soft tissues, motor adaptation ability and control of each body segment under laboratory conditions during performance of the test suitable for the subject's health state (these phenomena

Figure 3. The way of front fall performance with turn and rear fall performance by the female student with III° obesity.

Figure 4. The way of front fall performance with turn and rear fall performance by the fittest physiotherapy student.

are explained in soft fall theory by Jaskólski and Nowacki [51]), supported by the papers written by Kalina et al. [22] and Mroczkowski [50]. The student perfectly performed basic TSF (7 falls in 4 directions), developed for healthy persons, not qualified for any group of increased risk.

The epidemiologic knowledge on health problems among obese population is broad. The study by Gardner et al. [52], conducted within a 5 period (from 2007 Jan 1 to 2011 Dec 31) provided evidence that during that period about 20% with III class obesity experienced falls. Research results [7, 32, 53] have shown a directly proportional relation between the risk of fall (the bigger the body mass the higher the risk), Mitchell et al. [33] indicate that obesity entails a higher by 25% risk of falls as compared with non-obese persons. Ercan at al. [37] examined the effect of obesity on the perception of health, quality of life and risk of falling, and found that the risk of falling in obese individuals aged >65 year was 31% higher than that of non-obese subjects. Epidemiological studies have reported a higher rate of all cause falls among individuals who are obese [7, 26, 27]. The reported prevalence of falls among obese subjects (n = 128) is 27 percent [27].

Obesity appears to be associated with an increased risk of falling in older adults [28, 30, 32-35, 38, 39, 54, 55], as well as a higher risk of greater ADL disability after a fall [7]. The results for a fall-related injury were slightly different. Age, female sex, and white race remained significantly related to the risk of experiencing a fall-related injury. Only obese people in the most extreme BMI category, Class 3 (>40.0 kg/m^2) were significantly less likely to be injured in a fall [7, 42, 43, 44]. There are epidemiological studies showing no relation between the risk of fractures and the BMI, which is the most common indicator used for obesity [56-58]. Some authors have proposed that high BMI is protective against fractures in women (but not in men), because fat mass increases the amount of estrogen, which then prevents the demineralization of bone tissue. Greater BMI values could provide padding that protects against fractures during falls [56, 58]. The relationship between BMI and the prevalence of fall-related injuries suggest that only obese men seem more likely to have sustained a fall-related injury [34]. These studies, however, do not provide an indication of the risk of falling related to obesity [29, 56, 58]. High BMI values do 31 not protect people against falls. A large body mass may prevent trunk injuries, however, the lower and upper limbs and the head are exposed to injuries. Obesity is responsible for a high incidence of falls mainly because an obese subject is less well able to protect him/herself against a fall [47]. Fall-prevention interventions have not been designed to specifically address the significant issue of falls by obese older adults [31]. Balance problems in conjunction with obesity need to be targeted in fall-prevention efforts [32].

The results of our study indicate the lack of empirical data on adaptive capacity during falls in overweight and obese persons. The general effects of motor adaptation in the obese student indicated a high-level safe falling ability. The period when we start safe falling training is essential. The progressive increase in body mass will have a marked effect on acquisition of adaptive effects. According to innovative agonology approach [59], if we start education in initial phases of the disease, it will be focused on prevention while education during later stages will be treated as therapy. Another issue concerns the development of collision avoidance and fall impact cushioning methodology [10, 11, 60]. Kalina et al. [24] maintain that safe falling is a most effective element of personal injury prevention in people, regardless of gender, age and type of body build. This finding is further confirmed by Dobosz et al. [61]. If teaching safe techniques of collisions with the ground or moving objects is based on pro-health training sessions, it will bring multiple benefits. Instead of running or jumping, safe falling workouts may be applied during the training, also at different moments of intense or slow running, after jumps with turning and in numerous combined exercises and motor simulations.

CONCLUSIONS

The aforementioned (although isolate) adaptive effects are important arguments for implementation of health related training for overweight and obese persons, based on safe falling workouts. There is no need to organize special safe falling and collision avoidance courses for overweight and obese persons; a competent application of the pedagogic rule of individualization during training sessions is sufficient.

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