The use of a rotational training simulator for increasing safety during forward squat somersault on the trampoline

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

Andrzej Mroczkowski

Department of Sports and Health Promotion, University of Zielona Góra, Zielona Góra, Poland

Received: 24 May 2019; **Accepted:** 19 July 2019; **Published online:** 20 December 2019

AoBID: 13740

Abstract

Background and Study Aim: Jumping on a trampoline involves using its elastic surface for take-offs, the workouts aimed at obtaining complex, usually rotational motion over the trampoline. The cognitive purpose of the paper is the knowledge about the two phenomena: a) the effect of exercise on the rotating training simulator on increasing safety when performing a somersault on a trampoline; b) the impact of academic knowledge of rotational motion mechanics, extended by exercises on the rotating training simulator, on trampolining safety.

Material and Methods: The sample comprised 72 female physical education students aged 20.5 ±2.4 years. The participants were randomly assigned to one of the two groups (with 36 participants each). Within a month the students were taught how to perform a single forward somersault from a squatting position in different ways: group A, before training on a trampoline performed specific motor tasks (workouts) on the rotating training simulator; group B, in turn, performed conventional workouts. After test somersault performance, all the students wrote the test measuring their knowledge on motor safety during jumps on a trampoline. The evaluation was based on "zero-one" criterion (a correct or an incorrect reply). The range of rating involves a continuum from 0 (no correct reply) to 10 (all replies are correct).

Results: In group B it was found that 25% committed a second-degree error, 42% committed a first-degree error and 33% correctly performed the landing. In group A and B, second-degree and first-degree errors were noted in 3% and 28% respectively, while in 69% the landing technique was correctly performed. The mean value obtained in group A students was 7.19 while in group B the corresponding value was 5.25.

Conclusions: Faster learning of safety landing during forward squat somersault training, as compared with conventional methods, ensures a combination of the following elements of intellectual and motor nature, namely: the knowledge of rotational motion mechanics and explanation of the rules while performing workouts on a rotating training simulator.

Keywords: jumping • motor safety • pro-health education • sports-related activities

Conflict of interest: Author has declared that no competing interest exists

Ethical approval: The study was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

Author's address: Andrzej Mroczkowski, Uniwersytet Zielonogórski, Wyspiańskiego 58 Str., 65-178 Zielona Góra, Poland; e-mail : amroczkowski@op.pl

Healthy education / Pro-health education – education using approaches based on taking advantage of the student's movements in teaching subjects at different levels of education. Its aim is to prevent deterioration of the student's health state due to the applied teaching methods, minimizing movements. In students, a limited mobility may lead to neural disorders, postural defects, body injuries, vision disorders etc.

Extreme sport (EFPA) – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [8, p. 19].

Motor safety – is consciousness of the person undertaking to solve a motor task or consciousness the subject who has the right to encourage and even enforce from this person that would perform the motor activity, who is able to do it without the risk of the loss of life, injuries or other adverse health effects [18].

Rotating training simulator – as an apparatus that can exercise three functions: determining the moment of inertia, improving motor habits while performing certain "rotation techniques" in various sports disciplines, simulating the effect of the external force as the cause of losing balance and falling by a man who originally was immobile (standing, sitting, kneeling, etc.) [13].

INTRODUCTION

Jumping on a trampoline involves using its elastic surface for take-offs, the workouts aimed at obtaining complex, usually rotational motion over the trampoline. Due to high g-force values generated during exercising, a trampoline was used for training astronauts and pilots so that they could get used to the forces exerted on their bodies [1]. Exposure to g-forces may result in body injuries due to committed errors. Scientific papers report numerous dangerous accidents on a trampoline, especially children's accidents [2-7], therefore this type of exercise is regarded as an extreme form of physical activity (extreme sport). The health and life risk scores for trampolining exceed the documented mean values for other forms of sports-related activities [8, 9]. The degree of risk is also related to coordination problems during workouts on a trampoline. This is the next criterion of trampolining classification according to the expected number of fatalities per accident (EFPA) [10].

According to coaches and experienced competitors [11], such movements as a somersault (Figure 1) belong to the most dangerous rotational movements, especially for beginners. A single forward somersault from a squatting position (Figures 1 and 2) is presented in biomechanics textbooks 10.11 as an example of retained angular momentum:

$$I\omega = \text{const}$$

Here, the following correlation can be noted: by reducing the distance between the user's body segments and the rotation axis, the moment of body inertia (***I***) decreases and thus, the angular velocity decreases with the increasing distance between the body segments.

During workout performance, after bouncing, the user has to change the moment of inertia (**I**) to obtain the angular velocity value allowing safe landing with the feet touching the surface.

While training rotational elements, athletes use soft mattresses put up for safety purposes by the trainer at the moment of landing, and special rubber ropes to which they are attached [9]. It is important for movement safety that the somersault is adequately **performed**. This term means that the landing must be stable and the force has to be symmetrically distributed on each foot. After performing a somersault, the take-off from the trampoline for performing the next element of the workout should be optimally vertical, so that the user does not fly out, e.g. outside the trampoline. In order to land safely on the feet, the user should be able to intuitively assess to what extent the reduction in the distance between certain body segments and the rotation axis affects (changes) the angular velocity.

In the study presented in this paper, *the rotating training simulator* was used [12] to improve the above mentioned intuitive assessment. According to the principle of maintaining the angular momentum, the device allows the user to observe how angular velocity is affected by the changes in inertia moment. At the same time, as a result of changes in its speed, it allows the user to feel how his/her body reacts to changes in accelerations. It has already been described how the rotating training simulator works in terms of determining the moment of inertia and supports practicing various motor activities during rotational motion and simulating falls resulting from the exerted external force [13, 14]. The equipment was also used for teaching rotating techniques specific to aikido [15, 16].

The cognitive purpose of the paper is to present the two phenomena, namely: a) the effect of exercise on *the rotating training simulator* on increasing safety when performing a somersault on a trampoline; b) the impact of academic knowledge of rotational motion mechanics, extended by exercises on *the rotating training simulator*, on trampolining safety.

MATERIAL AND METHODS

Participants

The sample comprised 72 female physical education students aged 20.5 ±2.4 years. The participants were randomly assigned to one of the two groups (with 36 participants each).

Study design

The approaches to teaching forward somersault technique from the squatting position

Within a month the students were taught how to perform a single forward somersault from a squatting position in different ways: group A, before training on a trampoline performed specific motor tasks (workouts) on *the rotating training simulator*; group B, in turn, performed conventional workouts. Prior to the training of somersault performance (the students belonging to both groups participated in the training), the coaches presented basic obligatory safety measures that should be applied during jumps on a trampoline, described in scientific literature [9].

Training in forward somersault performance from the squatting position was carried out by skilled coaches, experienced in jumps on a trampoline. The workout was performed on two trampolines (Figure 1). The athletes performed take offs on one trampoline and landed on the other one which, for safety reasons, was covered by a thick mattress. In order to increase safety during workouts, the coach protected the athlete, standing on the trampoline in an adequate position (Figure 1: d, e). The students performed take offs several times to achieve a proper height, getting closer and closer, with consecutive take offs, to the trampoline where they landed after somersault performance.

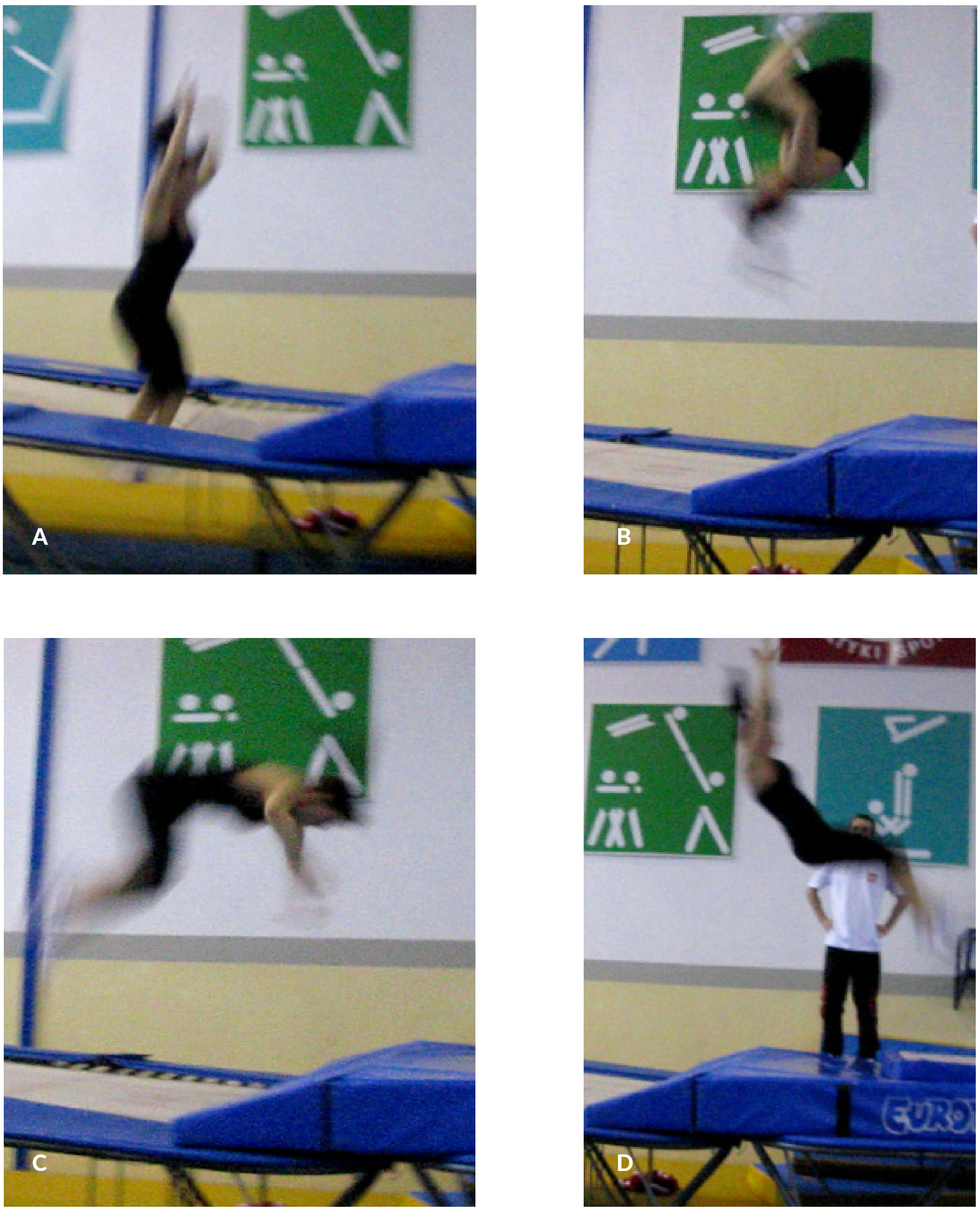

Figure 1. Stages of forward squat somersault performance on the trampoline.

By increasing the takeoff height, the athletes had more time to rotate. Somersaults were assessed based on the estimation of landing safety (and not on performing somersaults according to the strictly defined gymnastic pattern) while the recorded videos were used for the analysis. The rating was based on Rotational Test evaluation criteria [17] adapted to trampolining: the problems with maintaining stability during landing, resulting in an altered distance between the feet when touching the surface, were classified as first degree error; if the problems were due to falling or hand support, the criteria of second degree error would be met; the lack of first and second degree errors (stable landing) indicated that the somersault was correctly performed.

Approaches to knowledge acquisition and specific motor experience

During the lectures, the participants from both groups acquired the knowledge on the mechanics of rotational motion according to the program of biomechanics at physical education departments. Group A students were not only taught by the coach how to perform somersaults; the author of the paper also explained them how to correct their errors, referring to the workouts on the rotational training simulator.

The goal of the workouts on the training simulator in group A students was to verify experimentally the dynamics of the rotational motion. This experiment, however, was not carried out in a form of observation of body movement, but it involved a direct student participation. The students themselves took part in the rotational motion and perceived the consequences of changes in motion. During workout performance, the rules of retaining angular momentum, such as "the movement of each body segment generates acceleration in rotational motion", were explained. The students, exercising on the jumping mat, through the changes in body segment arrangement, assumed positions similar to those noted during forward somersault performance from the squatting position (Figure 1).

Group A students, assuming the position such as that presented in Figure 2, and next, making it a more upright, with their lower limbs spread, perceived changes in g-forces. If, for safety reasons, the stripes supporting the athlete were added to the training simulator, it was possible to move different body segments. Movements on the jumping mat differed from the rotational motion during somersault performance because it was performed on a horizontal plane, demarcated by frame pads. However, when the participant placed her gravity center near the rotational axis of the frame pad, changes in the distance between the body segments and the rotation axis more precisely imitated the G-forces exerted during trampoline jumps.

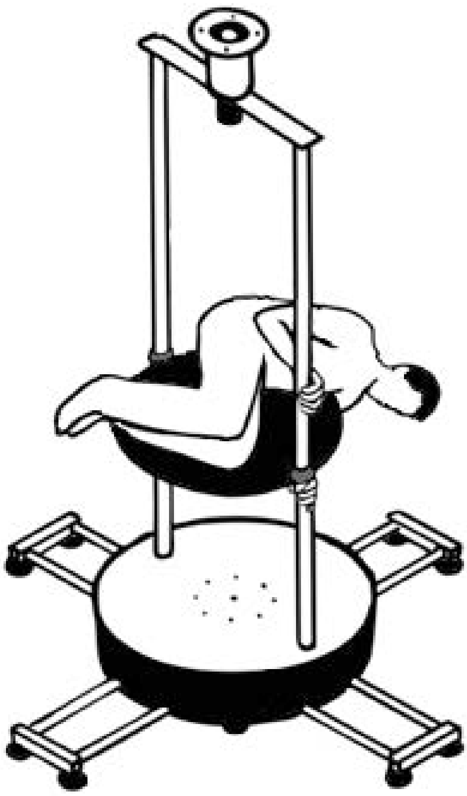

Figure 2. Using a rotational training simulator in the training mode, preparing for forward squat somersault.

The workouts are based on the assumption that the user, exercising under laboratory conditions (simplified motor simulation), learns how to accelerate or delay a single rotation during forward somersault performance from the squatting position.

Knowledge test

After test somersault performance, all the students wrote the test measuring their knowledge on motor safety during jumps on a trampoline (questions Q1-Q6) and rotational motion mechanics (questions Q7-Q10). The first part was not directly related to practical application of this knowledge. The second part included such questions as: "What body movement is the best to compromise the error during backward falling while landing and during forward falling?" (in gymnasts' language it means: what has to be done when the somersault is "overperformed" or "underperformed".

The evaluation was based on "zero-one" criterion (a correct or an incorrect reply). The range of rating involves a continuum from 0 (no correct reply) to 10 (all replies are correct).

Statistical analysis

The analysis of the results was based on aspect ratio (%). The significance of the between-group proportions of correct answers in the knowledge test was based on chi-square tests (which questions made the differences statistically significant) and Student's-t test for independent variables.

RESULTS

In group B it was found that 25% committed a second-degree error, 42% committed a first-degree error and 33% correctly performed the landing. In group A and B, second-degree and first-degree errors were noted in 3% and 28% respectively, while in 69% the landing technique was correctly performed (Table 1).

Statistically significant between-group differences were found only in answers to Q7, Q8, Q9 and Q10 questions which means that the differences were mainly affected by the questions concerning rotational motion mechanics (Table 2).

The mean values obtained from the test of the knowledge on biomechanics including motor safety during trampoline jumps in group A students was 7.194 ±1.261 while in group B ±1.052 the corresponding value was 5.25 (p<0.01).

Table 1. The motor values corresponding to the quality of landing after forward somersault performance from a squatting position in groups A and B.

The type of error	Number (percent) of errors in the groups		p
	A	B	
second-degree	1 (2.78%)	9 (25%)	**0.0064**
first-degree	10 (27.78%)	15 (41.67%)	0.2158
lack	25 (69.44%)	12 (33.33%)	**0.0022**

Table 2. The total number and percentage of correct answers (1) separately for each question of the knowledge test and the probability p for the significance of the differences in proportions between the answers obtained from groups A and B.

Question	Number of errors in the groups		Percent of errors in the groups		p
	A	B	A	B	
Q1	29	31	80.56	86.11	0.5271
Q2	19	18	52.78	50.00	0.8136
Q3	25	24	69.44	66.67	0.8005
Q4	26	26	72.22	72.22	1.0000
Q5	22	22	61.11	61.11	1.0000
Q6	26	24	72.22	66.67	0.6089
Q7	28	9	77.78	25.00	**0.0000**
Q8	29	12	80.56	33.33	**0.0001**
Q9	29	12	80.56	33.33	**0.0001**
Q10	26	11	72.22	30.56	**0.0004**

DISCUSSION

The results indicate that group A students committed the lowest number of errors during forward somersault performance from the squatting position. The additional workouts on *the rotating training simulator* proved effective. The biomechanical knowledge extended this way turned out to be a specific simulator, coding the changes in acceleration during rotational movements so as to lead to stable landing.

Unfinished somersaults may be due to hesitation during rotational motion performance. According to the author, the hesitation may be due to the participant's failure to get used to acceleration achieved during rotational motion. During workouts performed on the *rotating training simulator*, the students got used to accelerations in rotational motion. Such accelerations took place in a different plane than during jumps on the trampoline, however, they turned out completely safe for the participants. Therefore, as confirmed by the results, the workouts on the *rotating training simulator* increased the participants' feeling of safety during repeated forward squat somersaults.

The scores confirming the participants' knowledge on rotational movement mechanics also turned out to be higher in group A. The rating was significantly affected by the answers concerning the practical application of the knowledge on biomechanics in cases of acceleration changes during rotational motion, aimed at safe landing. The results confirm the author's earlier findings [16, 18-20] that understanding the rules of mechanics may advance acquisition of knowledge on motor activities involving rotation. This aspect of understanding may be of particular importance for future physical education teachers as well as coaches teaching sports-related techniques based on rotational motion [9]. This is particularly important when teaching e.g. gymnastic workouts involving highly dynamic rotational movements. The knowledge of biomechanics can help teaching more complicated somersaults and favorably affect students' safety.

The authors of textbooks on biomechanics emphasize that the system based on mimicking the master's movements, without biomechanical analysis is dominant in motor education. The development of biomechanics, however [11], suggests that the conceptions of such an approach to motor ability teaching, referring to the learner's consciousness and understanding the performed activities, is justifiable. This approach to teaching is important for motor safety improvement, understood according to its definition and from the aspects of the learner and the teacher [18].

The results reported in this paper show that understanding and taking advantage of mechanics rules while learning how to perform somersaults on a trampoline, improved the correctness of motor activity performance during landing.

Similar effects involving improvement in motor ability learning during rotational motion, thanks to taking advantage of the aforementioned knowledge, were obtained by the author during aikido and shot put teaching [19]. As for teaching aikido techniques, such effects were obtained both in primary or secondary school children and students [15, 16, 20, 21].

Based on his research results, the author suggests introducing the term: "healthy education" (see glossary). This term does not mean the same as "pro-health education", which deals with healthy lifestyles rather than healthy education process [22]. The education applied this way would aim at activation of a maximal number of senses in the process of teaching, not limited to vision and hearing, most frequently activated in contemporary education.

Activation of the maximum number of senses during learning is recommended in numerous scientific papers [16, 19-21, 23]. The conception of healthy education would be related to child's work ergonomics. According to the author, the computer programs used nowadays may support education, however, in the case of experimental subjects, they are not basic educational tools. Stimulation for movement is essential for children's health. It limits the time of assuming a seated position by a child, reducing, at the same time, the development of postural malformations. Besides, movement would release, at least for a moment, mental tension during learning. From the point of view of ergonomics, this model of education would enable knowledge acquisition by a pupil, requiring least effort and sometimes spontaneous.

Based on the example of aikido [20], the author argues that a child learns without even realizing it. Making the child learn consciously may result in stress associated with traumatic experience at school. The author shows that a child can understand the rules of rotational movement dynamics at the age of 7 to 9 years. Based on this fact, the author concludes that such a form of learning may be last for a long time.

Such healthy education" should, according to the author, include learning physics, and specifically one of its branches, namely mechanics, through movement performance based on the knowledge of biomechanics. In this case biomechanics is a form of the so called "live mechanics" [16, 19] with man participating in it instead of an inanimate object. Other branches of physics could be presented in a similar, more attractive way, based on biophysics [19]. Such kind of education may also include teaching using EDUball balls [24, 25]. It involves using the elements of physical education to teach such subjects as mathematics or Polish language such as balls with letters and figures written on them. According to the authors of the aforementioned method, such education is facilitated by the pupil's motor activity during this type of classes.

CONCLUSIONS

Faster learning of safety landing during forward squat somersault training, as compared with conventional methods, ensures a combination of the following elements of intellectual and motor nature, namely: the knowledge of rotational motion mechanics and explanation of the rules while performing workouts on a *rotating training simulator*.

While using this equipment in training process (teaching and improving) the learner receives information how his or her body reacts to acceleration changes during rotational motion performance. There is no direct evidence, however, that during forward somersault training using a *rotating training simulator* it is possible to understand the laws of biomechanics referring to rotational motion with no academic knowledge of this issue.

REFERENCES

1. http://www.olympic.org/trampoline-equipment-and-history?tab=history (accessed 2019 May 11)
2. Hume PA, Chalmers DJ, Wilson BD. Trampoline injury in New Zealand: emergency care. Br J Sports Med 1996; 30: 327-330
3. Smith GA. Injuries to children in the United States related to trampolines, 1990-1995: a national epidemic. Pediatrics 1998; 101(3 Pt 1): 406-412
4. Trampolines at home, school, and recreational centers. American Academy of Pediatrics. Committee on Injury and Poison Prevention and Committee on Sports Medicine and Fitness. Pediatrics 1999; 103(5 Pt 1): 1053-1056
5. Levine D. All-terrain vehicle, trampoline and scooter injuries and their prevention in children. Curr Opin Pediatr 2006; 18(3): 260-265

6. Sandler G, Nguyen L, Lam L et al. Trampoline trauma in children: is it preventable. Pediatr Emerg Care 2011; 27(11): 1052-1056
7. Council on Sports Medicine and Fitness. Trampoline Safety in Childhood and Adolescence. Pediatrics 2012; 130(4): 774-779
8. Bąk R. Definition of extreme physical activity deter- mined through the Delphi method. Arch Budo Sci Martial Art Extreme Sport 2013; 9: 17-2
9. Mroczkowski A, Hes B. Motor safety during trampolining. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 57-64
10. Grimshaw P, Lees A, Burden A. Sport and Exercise Biomechanics. New York: Taylor & Francis Group; 2006
11. Bober T, Zawadzki J. Biomechanika układu ruchu człowieka. Wrocław; Akademia Wychowania Fizycznego; 2003 [in Polish]
12. Mroczkowski A. Rotating training simulator. Patent P.395584 & 219875, Poland, 2014
13. Mroczkowski A, Rotating training simulator – an apparatus used for determining the moment of iner- tia, assisting learning various motor activities during rotational movements and simulating falls imposed by internal force. Arch Budo Sci Martial Art Extreme Sport 2014; 10: 59-66
14. Mroczkowski A, Mosler D. Diagnosis of Motor Habits during Backward Fall with Usage of Rotating Training Simulator. In: Merc M, editor. Sport and Exercise Science. London: IntechOpen Limited; 2018: 29-53
15. Mroczkowski A. Using a rotating training simulator to train rotational movements in aikido techniques. J Combat Sports Martial Arts 2013; 4: 25-29
16. Mroczkowski A. Teaching selected aikido techniques with the use of a rotating training simulator. Arch Budo Sci Martial Art-Extreme Sport 2018; 14: 55-61
17. Kalina RM, Jagiełło W, Barczyński BJ. The method to evaluate the body balance disturbation tolerance skills – validation procedure of the "Rotational Test". Arch Budo 2013; 9(1): 59-69
18. Kalina RM, Barczyński BJ. EKO-AGRO-FITNESS(c) original author continuous program of health-oriented and ecological education in the family, among friends or individually implemented – the premises and assumptions. Arch Budo 2010; 6(4): 179-184
19. Mroczkowski A. Using the Knowledge of Biomechanics in Teaching Aikido. In: Goswami T, editor. Injury and Skeletal Biomechanics. London: IntechOpen Limited; 2012: 37-60
20. Mroczkowski A. The use of biomechanics in the methodology of teaching aikido to children. Arch Budo 2010; 6(4): 57-61
21. Mroczkowski A. The use of biomechanics in teaching aikido. Human Movement 2009; 10(1): 31-34
22. https://www.who.int/topics/health_education/en/ (accessed 2019 May 11)
23. Karpiński R. Pływanie. Podstawowe techniki. Nauczanie. Katowice: Cebud; 2002 [in Polish]
24. Rokita A. Cichy I. "Edubal" Educational Balls: I Learn While Playing! Glob J Health Phys Educ Peda 2013; 2(4): 289-297
25. Wawrzyniak S, Rokita A, Pawlik D. Temporal-spatial orientation in first-grade pupils from elementary school participating in Physical Education classes using Edubal educational balls. Balt J Health Phys Act 2015; 7(2): 33-34

Cite this article as: Mroczkowski A. The use of a rotational training simulator for increasing safety during forward squat somersault on the trampoline. Arch Budo Sci Martial Art Extreme Sport 2019; 15: 61–68