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Original Article

Literature review on the measurement and effectiveness of the Safe Fall-Safe Schools© program

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Abstract:
Introduction: The World Health Organization (WHO) has pointed out that injuries caused by falls are the second leading cause of death in terms of accidents. The WHO emphasized that, intervention strategies should focus on education, training, creating a safer environment, reducing risks, and on the research of falls.**Material and methods:**A systematic literature review was concluded for screening the data sources of databases.The systematic review was based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria which provides a clear protocol over traditional literature reviews analysing as much of the literature as possible in a non-selective, bias-free, and reproducible way with respect to a given research topic. **Results:**The total number of patients studied in the 6 studies involved in the qualitative study was 4791. In three cases there was a control group and an intervention group and in three articles only one intervention group was examined. Four of the most recent studies used INFOSECA (The Information Scale on Safe Ways of Falling) score system to measure the position of the neck, trunk, hips, knees and hands, as the five basic elements during a backwards fall. These studies applied "Safe Fall, Safe Schools" programme (SFSSP) which is a good practice which can help in the prevention of injuries and resulting good health.The reviewed studies showed significant changes in correct motor responses to backwards falls.**Discussion:**The Safe Fall training program was successful in Physical Education classes in training appropriate motor responses to a fall in young children. The results suggest that the participants in the safe fall program, are at less risk of injury associated with a falls. This approach to prevent the harmful consequences of falls is a novel tool, which coincides with one of the needs raised by the WHO regarding the implementation of educational programmes based on falls research. The proposal for implementation for the safe fall program constitutes a step forward for fall prevention programmes, as it responds in a preventive and proactive way to the problem for public health and safety posed by backward falls in the school population. **Conclusion:**From the selected literature it is visible that by using the„Safe Fall Safe Schools" program proved effective to teach adolescent fall techniques.The program is able to improve motor ability, it can achieve statistically significant development in motor responses of backward fall by adolescents.
Keywords: accidental falls, child, physical education, training, backward falls

Introduction

Numerous studies around the world deal with injuries caused by falls, their number, and the resulting health expenditures(James, Victor, Saghir, & Gentile, 2018; Nauta et al., 2013; Patel, Magnusen, & Sandell, 2017).The World Health Organization (WHO) has pointed out that injuries caused by falls are the second leading cause of death worldwide in terms of unintentional accidents. On an annual basis, this represents 37.7 million cases requiring medical intervention worldwide, and an estimated 646,000 deaths each year, more than 80% of which occur in low- and middle-income countries (WHO, 2018).

The WHO emphasized that, in line with the preventive approach, intervention strategies should focus on education, training, creating a safer environment, reducing risks, and on the research of falls. Age is a major determinant, in the case of fall injuries, the high-risk age group is over 60 years, as well as the group of children. The European Judo Union (EJU), the University of Seville and the Andalusian Federation of Judo and Associated Sports (FANJYDA) have developed the "Safe Fall-Safe Schools" project, which is a research and education program, also supported by the WHO.It is a non-commercial, non-interventional research and education (prevention) activity, which adapted to the school environment and with prevention in mind - seeks to provide an alternative to prevent and also reduce fall injuries in the group of young children. The program was developed by a group of highly qualified scientists in the sport of judo, who worked in the field of science and physical activity in Spain. The program is already running successfully in Spain, with the first pilot study on research results already published (Toronjo-Hornillo, DelCastillo-Andres, Campos-Mesa, Bernier, & Sanchez,

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2018). In order to prove the effectiveness of the program to the WHO, it is necessary to carry out studies according to the protocol that has already been developed in many European countries.

Key factors in maintaining health in the studied context include motor ability development and regular exercise(Padulo et al., 2019)throughout life(Liong, Ridgers, & Barnett, 2015; Tang et al., 2009). Learning to move allows the population to learn about a number of practical examples that can contribute to the prevention of health risks(Giblin, Collins, & Button, 2014).

While moving, a person may lose his balance due to unexpected forces and can fall to the ground, such accidents can cause mechanical damage to the body. The extent of health damage depends on the vulnerability of internal organs to external forces. One of the most dangerous mechanical injuries to the human body is head injury, which affects the human nervous system in particular. An example of this is a rash during a boxing match, which can lead to temporary loss of consciousness and sometimes some damage to health.

Motor safety is defined as the consciousness of a person who performs a physical activity or a subject who has the right to encourage or even force them to perform a certain physical activity that they are capableto do without the risk of death, injury, or other health side effects.

One may consciously perform certain physical activities with a risk of mechanical injury, such as participating in contact sports, serving in police or the military. A defensive reaction to a given force acting on a person causing a certain acceleration may not be sufficient to avoid mechanical damage to the body, for example in a car accident or when falling from a certain height.Under certain conditions, such as when less force is applied to a person, mechanical injury to the human body can be avoided or reduced. As many reports claim, falls often cause damage to health.

According to the WHO, a fall is an event that inadvertently puts the individual to the ground, or in case of a higher starting point, it puts them into a lower position. Some researchers use the judo definition and define a fall as an event in which a sudden, unintentional change in body position is caused, primarily as a result of a disturbance or loss of balance, which results in the person finding themselves on the ground or on another surface lower than the starting point. This definition, given by Żak(Żak, 2009) is based on the research work of Hauer et al. (Hauer, Lamb, Jorstad, Todd, & Becker, 2006)and Feder et al. (Feder, Cryer, Donovan, Carter, & Guidelines Dev, 2000).

Prevention of injuries and fall is a frequently researched topic, especially in the case of association and competitive athletes. However, there's much less research performed in this particular topic, among non-athlete children(De Castro-Maqueda & Amar-Cantos, 2019; de Freitas, Fujisawa, & Macedo, 2020; Pryimakov, Iermakov, Kolenkov, Samokish, & Juchno, 2016). Furthermore, fall prevention is most widely studied in the cases of osteoporotic diseases. Mainly the older age group was examined(Gómez-Miranda, Santiago-López, Chacón-Araya, Moncada-Jiménez, & Ortiz-Ortiz, 2019; Krasilshchikov et al., 2018).

Material and methods

The systematic review was based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria which provides a clear protocol over traditional literature reviews analysing as much of the literature as possible in a non-selective, bias-free, and reproducible way with respect to a given research topic. Although PRISMA is primarily used for the analysis of randomized controlled clinical trials, it can also be used as a basis for reporting other types of studies.

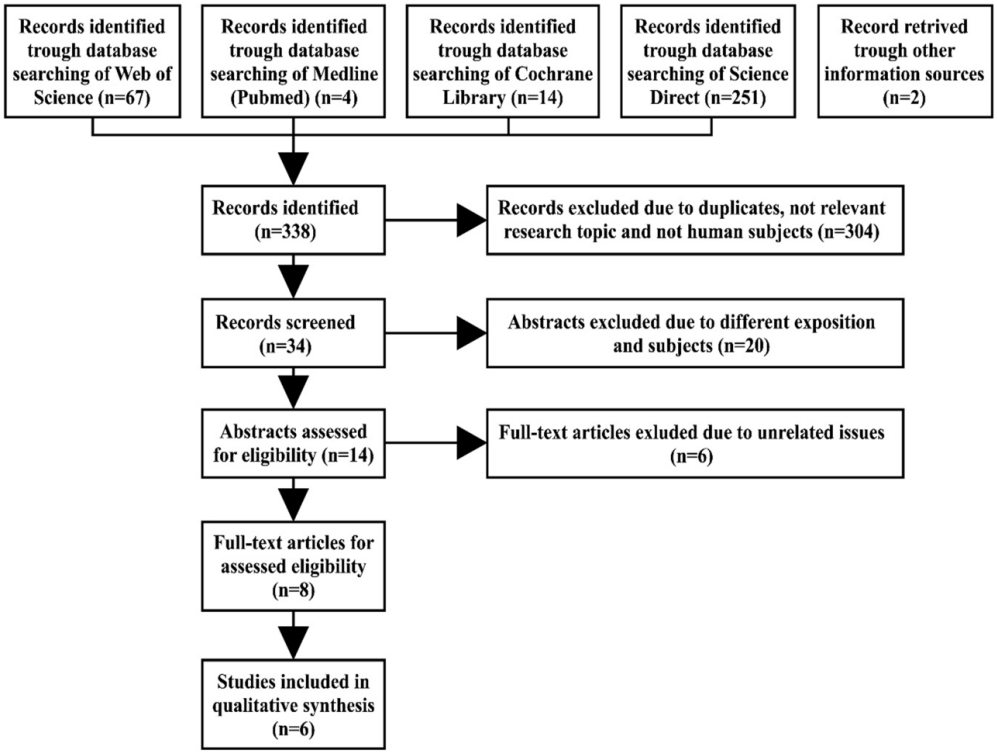
We conducted our research in the Web of Science, Medline (PubMed), Cochrane Library, and Science Direct databases, as well as through additional search. During the search, we focused on the termsaccidental falls, child, physical education. Table 1. showsa detailed definition of MeSH terms. A selection of English-language studies published over the last 5 years was selected for the analysis, with the last search conducted in June 2020.

Table 1: Detailed definition of MeSH terms

Medline (PubMed)	((accidental falls[MeSH Terms]) AND (child[MeSH Terms])) AND (physical education and training[MeSH Terms])
Web of Science	TS=((accidental falls AND child AND physical education OR training AND backward falls))
Science Direct	title-abs-key((Accidental falls AND child AND physical education OR training))
Cochrane Library	"accidental falls" AND "Child" AND "physical education and training"

The 337 related studies found were reviewed by two independent researchers, with a third opinion involved in case of disagreement. After applying the exclusion criteria (non-relevant/different to the research topic), 14results were identified, of which further 6were excluded after reading the abstracts with respect to parallelism, different exposure, and research subject. Finally, 8in extenso publications were examined, and 6of them were relevant and included in the qualitative synthesis (Figure 1). Since “Safe Falls-Safe School” programme is a relatively new educational, research and prevention program, we decided to include 2 articles that were relevant to our studyand were written before 2015.

Figure 2: PRISMA flow diagram



The studies included school aged children regardless of gender and type of body build, who participated in the "Safe Falls, Safe Schools" physical education program for the purpose of preventing fall related injuries.Studies with specific indications were excluded. Our analysis focused on examining the effectiveness of the above mentioned: Safe Falls, Safe Schools program in the group of school aged children.

Results

The total number of patients studied in the 6 studies involved in the qualitative study was 4791. In three cases there was a control group and an intervention group and in three articles only one intervention group was examined(DelCastillo-Andrés, Toronjo-Hornillo, Rodríguez-López, Castañeda-Vázquez, & Campos-Mesa, 2018; R. M. Kalina et al., 2008; Toronjo-Hornillo et al., 2018).Most of the studies were carried out with approximately 100-500 participants, with the exception of the study of Nauta, J., et al. (2013) in which 3317 students participated(Nauta et al., 2013).

Authors measured students' natural response to an unexpected backwards fall with baseline tests, as well as their physical activity level, and their body index. Detailed description of the studied articles can be found in Table 2a and Table 2b.

Four of the most recent studies used INFOSECA (The Information Scale on Safe Ways of Falling) score system to measure the position of the neck, trunk, hips, knees and hands, as the five basic elements during a backwards fall. These studies applied "Safe Fall, Safe Schools" programme (SFSSP) which is a good practicewhich can help in the prevention of injuries and resulting good health. This programme was created for the World Health Organization's call in 2018, because according to their research, they consider falls to be the second leading cause of accidents, unintentional injuries and deaths worldwide. Basic elements were defined by a detailed description. One point was given for each,when the participants correctly performed the backwards fall as described. Zero points were given if the participant could not perform them correctly. The elements were evaluated with one point (correct execution) when the participants: bent the neck, and held the chin down towards the chest (neck); curled up into a ball and rolled while landing on a curved back; kept the hips bent; kept the knees bent; and protected the head(Invernizzi, Signorini, Michielon, Padulo, & Scurati, 2019).

The most recent study was carried out by Invernizzi, P. L., et al. (2019) who also used INFOSECA observation scale which records five basic elements during a backwards fall, in relation to the positions of the neck, trunk, hips, knees and hands.They performed a pre, mid and a post test. Statistical differences were found in the pre-and the mid-time points about SFSSP, except for the knees' values. There were differences found in

all variables in the mid- and the post-time points. The post-time points had a significantly higher score compared to the pre- and mid-time points in all considered variables(Invernizzi et al., 2019).

DelCastillo-Andréset al. (2019) also used The Information Scale on Safe Ways of Falling observation scale, but their scoring system differed from the others. Each of five body parts were scored separately. A score was given in the event of a PHR (potentially harmful responses) and no score was given if there was no PHR observed. The overall score was between 0 and 5. Higher scores suggests higher risk of injury. They applied the SFSS programme on the intervention group. At baseline tests, they found no significant difference in the two groups when studying PHR scores. After the intervention program, control group had no significant changes in their PHR scores, while the intervention group had a significant decrease in their scores (0.79 points, 0.62-0.96 95% CI). After the control group also completed the programme, their average PHR scores decreased significantly (their final score was 0.41)(DelCastillo-Andres, Toronjo-Hornillo, & Toronjo-Urquiza, 2019). DelCastillo-Andrés (2018)also used the regular INFOSECA scale system in a different study, in which they gave points on completing the five essential physical reactions correctly. They applied the SFSS programme on the intervention group. In all variables after the application of the program there was an increase in the correct position. From the pre-test to the post-test the number of those who incorrectly completed neck flexion fell from 76.4% to 9.8%. Those score,who used their upper extremities to stop the fall fell from 98.4% to 9.8%.Those, who incorrectly completed the rolling up fell from 91.9% to 8.9%. Those who incorrectly completed the hip flexion fell from 98.4% to 13%. Lastly, those who incorrectly completed the knee flexion fell from 43.9% to 4.9%. For all five responses,the difference was significant ($p<0.05$). The program was equally effective for both genders, as no significant differences in motor responses were recorded between boys and girls(DelCastillo-Andrés et al., 2018).

Toronjo-Hirnillo, L., et al. (2018) also applied INFOSECA on their own study. They applied the SFSS programme on the intervention group. The proportion of students who bent their neck in a sudden fall was 10.8% before, and 89.2% after the intervention. For the rolling up variable, the proportion of students who completed this correctly was 15% before, and 85% after the program. ($p=0.000$) The bending of knee was completed correctly 1.7% before, and 98.3% after the intervention. ($p=0.013$) The bending of the hip task was performed incorrectly by all students before the intervention, and 100% correctly afterwards. ($p\leq0.001$)The rate of those who used their hands correctly before the intervention was 0.8% and afterwards 99.2%. ($p\leq0.001$)(Toronjo-Hornillo et al., 2018).

Nauta, J., et al. (2013) examined 7 to 12 years old children with the Adolescent Physical Activity Recall Questionnaire, which contained age, gender, ethnicity, injuries (in the preceding 3 months), the regular weekly frequency and duration of sports and leisure time physical activity, as well as their fall-related injury registrations for the following up 8 months, on a weekly basis, which they were asked about by their PE teacher. 33 primary schools that completed both baseline and follow-up questionnaires were included in the analysis. In total, 3317 children completed the baseline questionnaires (intervention group: 17 schools, 1397 children, control group: 16 schools, 1920 children). The intervention group received the 8-week educational programme to improve falling skills. At the start of the study, there were no differences between the intervention and control group with respect to age (mean 10.7 years) and gender. Children in the intervention group were less active significantly (630 min/week SD=326 vs 662 min/week SD=325) and more likely to report an injury in the 3 months prior to the baseline measurement. They found a significant decrease with unadjusted logistic regression in fall-related injuries in the intervention group. However, after adjustment for clustering, no significant differences were found between the intervention and control groups. The educational programme to improve falling skills was more beneficial for children who were least physically active ($p=0.087$)(Nauta et al., 2013).
Kalinaet al. (2008) hypothesised that, if methodical and educational standards are met, gender, factors as age and body build are not limiting the effectiveness of learning safe falling. They used four differently structured programs (with the same content) of Combat Sports Propaedeutics-Basic of Judo (CSP-BJ). CSP-BJ's structure had no influence on the educational effects. At the average similar level of motor competence of safe fall, APE (Academy of Physical Education) students have done these actions the quickest. Significant difference was found compared to the scores of other students ($p\leq0.01$)(R. M. Kalina et al., 2008).

Table 2:Summary of Measurement Methods of Safe Falls Safe Schools effectiveness

Author (year)	Research tool – Efficiency	Findings
Invernizzi, P. L., et al. (2019).	**Test protocol** Participants completed the backwards fall with the help of one researcher **Video analysis** Using the INFOSECA observation scale, which records five basic elements during a backwards fall, the positions of the neck, trunk, hips, knees and hands.	• Statistical differences in the pre-and the mid-time points about SFSSP intervention except for the knees' values (significance: pre- to mid-neckp=0.01; pre-to mid-backp<0.01; pre- to mid-knee p=0.58; pre- to mid-hip p<0.01; pre- to mid-handsp<0.01. • The results showed that the participants started with the same level of ability at falling backwards (32% with a CV of 97%) and after the intervention, each groups scores were raised significantly.

Author (year)	Research tool – Efficiency	Findings
DelCastillo-Andrés, Ó., et al. (2019).	**Baseline test** Baseline test was used to assess the children's natural response to an unexpected backwards fall. **The Information Scale on Safe Ways of Falling observation** To assess the risk of injury. This scale identifies potentially harmful responses (PHR) during a fall.	• There were no statistical differencesbetween the groups at baseline. • At baseline, there was no significant difference found between the two groups when studying PHR scores. After the control program, control group had no significant changes in their PHR scores, while the intervention group had a significant decrease in their results (0.79 points, 0.62-0.96 95% CI)
DelCastillo-Andrés, Ó., et al. (2018).	**The Information Scale on Safe Ways of Falling (INFOSECA)** Ad-hoc observation scale was used for data collection: this scale registers 5 essential physical reactions throughout the process of a safe and protected backwards fall.	• In all variables after the application of the program, there was an increase in the correct position. From the pre-test to the post test the number of those, who incorrectly completed neck flexion fell from 76.4% to 9.8%, usedupper extremities to stop the fall fell from 98.4% to 9.8%, incorrectly completed the rolling up fell from 91.9% to 8.9%, incorrectly completed the hip flexion fell from 98.4% to 13%, incorrectly completed the knee flexion fell from 43.9% to 4.9%. For all five responses $p<0.05$. • No significant differences in motor responses were found between boys and girls. The program was equally effective for both genders.
Toronjo-Hirmillo, L., et al. (2018).	**INFOSECA scale** INFOSECA records the 5 elements, the position of the neck, the trunk, the hips, and the knees during a backwards fall.	• The proportion of students who bent their neck in a sudden fall was 10.8% before, and 89.2% after the intervention. For the rolling up variable, the proportion of students who completed this correctly was 15% before, and 85% after the program. ($p\leq0.01$) The bending of knee was completed correctly 1.7% before, and 98.3% after the intervention. ($p=0.013$) The bending of the hip task was performed incorrectly by all students before the intervention, and 100% correctly afterwards. ($p\leq0.01$) Those who used their hands correctly before the intervention was 0.8% and afterwards 99.2%. ($p\leq0.01$)
Nauta, J., et al. (2013).	**Adolescent Physical Activity Recall Questionnaire** Contained questions on age, gender, ethnicity, injuries (in the preceding 3 months), the regular weekly frequency and duration of sports and leisure time physical activity. **Injury registration** Provided information about the type of the injury, location, severity and activity performed at the time the injury occurred (physical education class, sports or outdoor play).	• At baseline, there were no differences between the intervention and control group with respect to age (mean 10.7 years) and gender. Children in the intervention group were significantly: less active during the week (630 min/week SD=326 vs 662 min/week SD=325) and more likely to report an injury in the 3 months prior to the baseline measurement • Unadjusted logistic regression analyses showed a significant decrease in fall-related injuries in the intervention group. However, after adjustment for clustering, no significant differences were found between the intervention and control groups. The educational programme to improve falling skills was more beneficial for children who were least physically active. ($p=0.087$)
Kalina, R. M., et al. (2008).	**Structure of test for safe falls** -Rear fall and read fall with turn -Front fall -Fall to the side (left and right) -Front fall with turn over the shoulder (left and right)	• At the average similar level of motor competence of safe fall, APE (Academy of Physical Education) students have done these actions the quickest and compered with the other students the difference met the statistical significance($p<0.01$).

Discussion

Falls have been cited as the most common causes of accidental injuries in Italy(ISTAT, 2015). Various studies report the epidemiology of injuries in Italy, where 54.8% of patients experienced accidental injury from a fall(ISTAT, 2015).

It is widely known that along adolescence (14-18 in men and 12-17 years in women) the decrease in time spent on physical activity(Sherar, Esliger, Baxter-Jones, & Tremblay, 2007) and deterioration in coordination skills(Hirtz & Starosta, 2002) is determinative. Furthermore, abilities such as abstract thinking, mental resilience, working memory(Alesi et al., 2015), and attention(De Giorgio et al., 2018) may also be observed in adolescence, reaching the lowest level (Roalf et al., 2014).

In contrast, early adulthood and the periods before and after puberty (up to 13 years and after 15 year in men and by the age of 11 and after the age of 13 in women) promote the improvement of motor learning and neurocognitive abilities(Hirtz & Starosta, 2002; Roalf et al., 2014). Moreover, it is necessary to examine whether the ability to fall is related to age (as taught in the "Safe Falls, Safe Schools" program).

Results of the examined researches showed that the Safe Schools Safe Falls physical educational programme is an effective way of reducing the risk of falls in school aged children, as well as high risk groups (i.e. elderly, people with eye diseases).

Gasiencia-Walczak B. et. al. 's (2018) study examined people with eye diseases as the clinical group (n=5) of the research, and they also had a prophylactic group (n=36) of physical therapy students. The intervention included consisted of 10 lessons (45 minutes once a week). Patients have done about 150 to 160 different falls back and on sides, which has been waved with fun forms of martial arts, avoiding collisions and motoric simulations mostly finalized by fall. PT students have done about 180-190 different falls and 40% exercises with avoiding a collusion, motoric simulations, and different forms of martial arts then patients. There was a significant difference before and after in dynamics of fault reduction of the body parts during a fall among PT students ($p<0.0001$). In case of patients with visual impairment, results were not significant, but there was a major difference as well (prior 9.0, and after 3.2 points)(Gasienica Walczak, Barczynski, & Kalina, 2018).
Invernizzi P. L. et al.'s (2019) sample performance was 32% better compared to Toronjo-Hornillo's (2018) sample (5.7%) on the backwards falling test before the intervention. Both studies demonstrated SFSSP's efficiency. The main difference between the two studies is that Toronjo-Hornillo's (2018) study concerned the time distribution related to SFSSP, which in both studies, was 100 h over five weeks. In Invernizzi P. L. et al.'s (2019) study, the intervention was monitored in one weekly session of 20 minutes, compared to Toronjo-Hornillo's (2018) two weekly sessions 10 min each (total of 20 min per week)(Gasienica Walczak et al., 2018).
According to Mroczkowski A. et. al.'s study (2015) a high susceptibility to injuries during a fall of children and lack of significant differences between studied groups proves small effectiveness of a traditional model of physical education in teaching the motor safety(Mroczkowski, 2015).

The Safe Fall program is aimed to protect children and adolescents when they fall by training motor responses in consideration of the protection of those areas of the body that are most at risk of injury: head, upper limbs, hip, or lower limbs.

DelCastillo-Anders Ó. et al.'s (2018) study's results show that through repeating exercisesin the Safe Fall program, students learn the correct motor response. The Safe Fall training program was successful in Physical Education classes in training appropriate motor responses to a fall in young children. The results suggest that the participants in the safe fall program, are at less risk of injury associated with a falls. This approach to prevent the harmful consequences of falls is a novel tool, which coincides with one of the needs raised by the WHO regarding the implementation of educational programmes based on falls research(DelCastillo-Andrés et al., 2018).

The proposal for implementation for the safe fall program constitutes a step forward for fall prevention programmes, as it responds in a preventive and proactive way to the problem for public health and safety posed by backward falls in the school population(Esparza, Mintegi, & Azkunaga, 2016; Guzmán, Manjón, Hernández, Esparza, & Martínez, 2014; Roman Maciej Kalina & Mosler, 2017; Morrongiello, Corbett, Cent West Injury Prevention, & Child Falls Prevention Working, 2016; Soriano Serrano et al., 2008; Toronjo-Hornillo et al., 2018).

Toronjo-Hornillo et al. did not study setbacks in terms of age(Toronjo-Hornillo et al., 2018). As it was previously shown, the sensitive phase of motor ability development varies with age(Padulo et al., 2019). Therefore, a comparison of each age groups is essential to present trends and clarify the effectiveness of the program / protocol.

Conclusion

The literature review was successful as we were able to identify relevant literature on children in the case of fall prevention, and how they are taught to avoid possible injuries.
From the selected literature, it is visible that by using the „Safe Fall Safe Schools" programme in P.Eclasses, it is possible to teach adolescent secondary school students techniques for falling backward in a safe and protected way in short time. The program is suitable to improve motor ability, it can achieve statistically significant development in motor responses of backward fall by adolescents. Therefore, this program could be included in the standard national program without significantly changing the common training lesson.It responds in this way to the overall objective of reducing the risk and severity of injuriesproduced by a sudden fall backward.

Our next goal is to prove that a short motor development program, which is already successful in Spain and Italy, can be adapted in Hungary as well. The Hungarian adaptation of the project is carried out by the Faculty of Health Sciences, University of Pécs (Hungary) in cooperation with the Hungarian Judo Association. Our first researches showed similar results to Toronjo_Hornillo et al. (2018) in Spanish sample, so the program works successfully also in Hungarian sample,regardless of cultural, social and nationaldifferences(Toronjo-Hornillo et al., 2018).

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