

Article

Effect of the Safe Fall Programme on Children's Health and Safety: Dealing Proactively with Backward Falls in Physical Education Classes

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Received: 22 March 2018; Accepted: 10 April 2018; Published: 13 April 2018



Abstract: The aim of this study is to show that the implementation of the Safe Fall programme in physical education classes can help to reduce the negative effects of unintentional backward falls in the adolescent population, by teaching them how to protect themselves when falling. A quasi-experimental research design was applied in a sample of 120 children ($M = 15.1$ years, $SD = 2.45$), attending a secondary school in Seville (Spain). Data was collected on an ad hoc observation scale INFOSECA (which records five basic elements during a backward fall: position of the neck, the hands, the trunk, the hips, and the knees), applying descriptive, correlational, and contrast statistics. The criteria for considering statistical significance was $p < 0.05$ in McNemar's test. The data indicates that learning safe and protected ways of falling backward is possible through the implementation of the Safe Fall programme, and no differences were found in terms of gender.

Keywords: falls; childhood; prevention; education; school health

1. Introduction

The study of falls among the school population has attracted a great deal of social interest in terms of public health, safety, and the protection of minors, becoming an important component of intervention in developed societies throughout the world. This interest in the study of fall-induced injuries and their consequences has been reflected in studies published in high-impact Spanish and international journals in the area of psychology and public health [1–6].

The World Health Organisation [7], drew attention to the fact that falls represent the second-leading cause of death from unintentional injuries among minors throughout the world. In Spain, different studies [3,8–10] have presented falls as the third most common cause of death from unintentional injuries among this population (approximately 13% of child mortality). In first place are traffic accidents (23.7%), followed closely by drownings (20%). In the context of Andalusia, a previous study [11] pointed out that falls represent 4.3% of accidental deaths at that age, and of these falls 26% take place at school. Likewise, a study supported by the Spanish Association of Pediatrics and Primary Health Care [12] pointed out that falls are the main cause of unintentional injury in children under 14. The figures from Spain tie in with those of the European Child Safety Alliance [13] at an international level. To give an idea of what this costs in terms of health care, the USA reports an annual health expenditure of 50 billion dollars associated with fall-related injuries in children from 0 to 14 years [8].

The scientific community has reacted in Spain [8,10–12] and internationally [2,4,14] with preventive programmes that, from a multisector approach [6], partially solve the problem of falls, as children will continue to have falls since it is in their nature to do so [15].

To provide a response to fall-related issues in children beyond mere prevention programmes, something not found in the specialized literature on falls, this study presents a proactive educational programme, Safe Fall [16], which introduces the teaching of safe and protected ways of falling to schoolchildren as an adapted physical activity to be included in physical education (PE) classes. The programme is in line with proposals of the WHO internationally, and the Ministry of Health in Spain [17] encouraging multisector programmes designed to minimize fall-related injuries. Interest in the Safe Fall programme amongst future health and education professionals was underlined by a recent study amongst this group showing great demand for training in this area [18].

Safe Fall has been designed to minimize the consequences of injuries from unintentional falls in schoolchildren through group work on movements, balance, and basic and specific motor abilities. Above all, it focuses on automating movements to ensure children protect themselves in the event of an unintentional fall. The programme also aims to bolster the competencies of specialists in PE, sports, and health in more protected and safer ways of falling. This is an addition to current programmes focusing on fall-prevention; it gives teachers an important and innovative, proactive tool with which they can teach children in PE classes how to fall more safely.

The aim of this study is to show that the implementation of the Safe Fall programme can help reduce the consequences of unintentional backward falls in schoolchildren by teaching them motor responses that are associated with less harmful ways of falling.

2. Materials and Methods

With an explanatory objective, and from a positivist paradigmatic approach, a quantitative methodology based on the experimental method was adopted to apply a pretest–posttest quasi-experimental research design.

2.1. Sample

Sample selection was performed using incidental sampling [19], with the final sample consisting of 120 schoolchildren whose ages ranged from 12 to 17 years ($M = 15.1$ years, $SD = 2.45$), all attending a private, but partially publicly-funded, secondary school in Seville (Spain). Information was collected from 1st, 2nd, and 3rd year students (26.8%, 23.3%, and 23.3%, respectively) in compulsory secondary education, and the rest (26.6%) were in their first year of baccalaureate studies during the 2016/17 school year. By gender, 54.2% were male and 45.8% female.

2.2. Process

The study intervention period lasted 5 weeks, from 17 April to 19 May 2017. Empirical data were collected using the INFOSECA ad hoc observation scale (Information Scale on Safe Ways of Falling) (Appendix A). A video-graphic record was made of each student for of the pretest and posttest for subsequent analysis by 5 independent experts, plus the principal investigator. The experts were previously trained to collect data as follows: each of them viewed 10 execution models at different time points (twice in a row, every two days, for a total of 5 training sessions). On the collected data, the level of reliability intra-evaluators for this scale presents a value for the Kappa index of 0.95 for the neck variable, 0.99 for the hands, 0.93 for the trunk variable, 0.87 for the hip, and 0.88 for the knees. Later, it was established that the level of reliability between evaluators for this scale presents a value for the Kappa index of 0.93 for the neck variable, 0.98 for the hands, 0.75 for the trunk variable, and 0.82 and 0.84 for the hip and knees, respectively. Pupils' parents or tutors were informed about the implementation characteristics of the programme and gave their informed consent for the study.

The design of the resulting instrument meant that 5 fundamental elements to be taken into account during the process of a safe and protected backward fall would be recorded dichotomously (on a

nominal scale, either well executed or badly executed): first, protect the head (reduces the frequency and/or intensity of the blow to the neck on the ground); second, avoid using hands to break the fall (reduces the frequency and/or intensity of the support of the upper limbs on the ground); third, roll up into a ball (progressively increases the surface of the impact on the ground); fourth and fifth, bend the hips and the knees (reduces the height of the fall and helps in rolling up into a ball). Content validity was demonstrated via the conjugation of two fundamental perspectives: the theoretical review about the state of the question and the assessment of two judo specialists who were experts in falls.

The pretest was done only once by each student and it recorded pupils' spontaneous motor response to a sudden backward fall. The programme was then implemented in three phases as part of P.E. classes. First was a theoretical presentation about falls and their consequences at school age (1 h), which consisted of a practice session, Level I in the gym, on the specific techniques of Safe Fall (the content of the 50 min practical lesson consisted of a presentation of the positions to be avoided in the event of a fall, presenting to the students which positions are protected and safe in the event of a fall, and a battery of exercises and games to allow them to practice but also to encourage them to think about the information and the aforementioned items). In the 10 successive sessions (within the warm-up of the physical education class) two 5 min exercises or one 10 min exercise were performed, so the total time spent was 10 min per 10 sessions. These last exercises are chosen in a sequence and, depending on their level of difficulty at the teacher's discretion, adjusting to the learning progressions established in the program, reviewing some known exercises and introducing new ones depending on the level of student achievement. After the implementation of the Safe Fall programme, a posttest was conducted to collect the assimilated motor response to a sudden backward fall (Appendix A). Again, to collect this data, each student performed the test once (posttest).

Data was analyzed with the statistical package IBM SPSS v24 (IBM, New York, NY, USA) in a Mac environment. Descriptive, correlational, and contrast statistics were applied. The criteria for considering statistical significance was $p < 0.05$ in McNemar's test. The gender contrast was determined via a Student's t-test.

3. Results

The following section presents the main results of the study, in relation to learning protected and safe ways of falling backward. First, general descriptive information was provided. The application of contrast statistics confirmed the impact of the programme: the assimilation of the protected fall procedure was positive.

3.1. Backward-Fall Mechanization Routines for Secondary and Baccalaureate Students

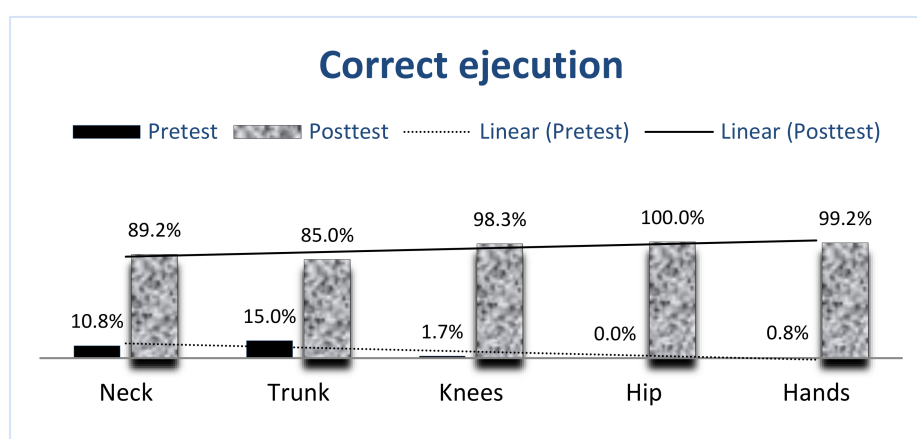
Table 1 illustrates performance results before and after the application of the programme. The data reflect that, before the application of the programme, less than a third of the sample bent their neck for protection in the fall (10.8%) and there were even lower values (less than 1%) for subjects who did not use hands to minimize the impact for upper limbs on the ground.

As for rolling up, the safety position, which increases the surface area hitting the ground, the data show that only 15% of the students did this correctly before the implementation of the programme. To this last figure, another notable figure can be added: not one student bent their upper limbs during the fall. The descriptive analysis concluded that 1.6% of the students correctly bent their knees during the unintended backward fall as a measure of safety and protection.

As Figure 1 shows, after the application of the Safe Fall programme, the posttest shows results that are clearly different from those obtained in the pretest (the students had correctly learnt each of the five technical movements involved in a safe and protected backward fall, with this being particularly notable in the variables of bending the neck and using hands).

Table 1. Statistics on assimilation of variables for safe and protected backward falls (* $p < 0.05$ in McNemar test; N = number of subjects; χ^2 = chi square).

	Pretest N		Posttest N		χ^2	p
	Yes	No	Yes	No		
Bending the neck	13	107	107 *	13	105.009	0.000
Using hands	1	119	106 *	14	104.009	0.000
Rolling up	18	102	85 *	35	65.015	0.000
Bending hip	0	120	86 *	34	84.012	0.000
Bending knees	2	118	109 *	11	105.009	0.013

**Figure 1.** Effects of the program on the competence of pupils to assimilate a safe and protected backward fall.

3.2. Effects of the Programme on the Competence of Secondary and Baccalaureate Pupils to Assimilate a Safe and Protected Backward Fall

Contrast statistics (chi-square and bilateral exact significance) were applied to determine whether there were significant differences because of the application of the Safe Fall programme and not due to chance (Table 1). The pairs of data were analyzed from the pretest and posttest for each of the recorded direct variables by applying McNemar's exact test ($p < 0.05$).

Regarding the five direct variables of protection and safety proposed in the study for a sudden backward fall, Figure 1 shows an increase in the correct protection position for students in all the variables after the application of the programme. The proportion of students who bent their neck in a sudden fall was 10.8% before the application of the programme and 89.2% afterwards. In this case, McNemar's test presented a (bilateral) exact significance below 0.05 (Table 1). This figure indicates that pupils improved their ability to bend their necks in the fall from what they had learnt in the Safe Fall programme.

On the action of not putting their hands on the ground during the fall, the percentage of students who did this correctly before the programme was 0.8%, compared to the 99.2% who did perform it correctly after implementation [(bilateral) exact significance = 0.00]. For the rolling up variable, the proportion of students who did perform this correctly before the programme was 15.0%, compared to the 85.0% afterwards [(bilateral) exact significance = 0.00]. The bending of the hip was done incorrectly by all students before the programme, compared to the 100.0% afterwards [(bilateral) exact significance = 0.00]. Finally, the bending of knees variable was done correctly by 1.7% of the sample before the Safe Fall programme, with this figure dropping to 98.3% after implementation [(bilateral) exact significance = 0.013]. As the McNemar test presented a (bilateral) exact significance below or

equal to 0.01 in all the direct variables, there is a 99% probability of not being mistaken when affirming that this improvement is due to the Safe Fall programme and not to chance.

Differences of the effect of the programme in terms of the pupils' gender were examined using a Student's *t*-test for contrast. No significant statistical differences were found for this variable, showing that the programme was equally effective for boys and girls.

4. Discussion

The proposal for implementation of the Safe Fall programme constitutes a step forward for fall prevention programmes [4,8,10,12,14] 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. It responds to calls from the WHO [7], at an international level and the Ministry of Health [17] in Spain, for the design of effective prevention programmes, which are extensive and versatile, in order to eliminate the factors that lead to falls and reduce the severity of the injuries that do occur, with the latter being possible by teaching children how to protect themselves and minimize their injuries when they do fall [16].

The Safe Fall programme is coherent with child safety in the event of falls as it teaches the process of falling backward by automating protective motor actions for specific parts of the body that are more often injured in falls [3,8–10]: the head, the upper limbs, and the hip or lower limbs, amongst others.

Child development between 12 and 17 years brings with it more dynamic and complex physical-sport activities from a motor point of view (e.g., Parkour, mountain biking, and climbing), and this leads to an increase in the number and type of falls endured [15,20]. Together with this, in developed countries, children at this age become involved in more sporting activities, and many of them have an inherently high risk of injury [3,10]. The development of basic motor skills, work on turning, learning how to balance, and general dynamic coordination worked on through the theoretical basics of motor tasks proposed in the Safe Fall programme [16] prepare children to react in the event of a sudden backward fall and to impact in a safer and more protected way, as has been demonstrated in the study.

It is vital to establish the factors and circumstances that come into play in a fall [13,15], to lay out the appropriate methodological development to enable the automation of protected ways of falling backward. The results of this study are coherent with the more frequent types of injuries [3,21] and show that it is possible to avoid or reduce, for example, the intensity of the impact of the head against the ground, thereby preventing the most serious type of injury produced by a fall [8].

No significant differences were found in terms of gender after the implementation of the programme, which proves the programme is suitable for both boys and girls, despite the formers' greater tendency to experience falls [12].

Learning a safe and protected way of falling backward using the Safe Fall programme has a direct influence on the main cause of injuries among children [11–13]. It should be noted that there is no proactive and specific programme in the world that teaches school-age children to fall in a safe and protected way.

The Regional Government of Andalusia [11] found that 26% of children's falls occur at school. As a result, given the need to train secondary school teachers [18] in the specific area of falls, this programme has been designed as a useful and practical tool for future education and health professionals working with adolescents.

The implementation time of this research made it possible to verify that an assimilation of motor gestures that allows students to fall safely. Regarding the length of the programme, one of the premises of its success is the individuals' long-term continuity of physical activity. It is necessary to continue with new longitudinal studies that center their objective in assessing the minimum time of implementation of the programme needed to guarantee the automation of the protective motor gestures or the persistence of the gestures learned through the programme. Likewise, new lines of research that look at, for example, the number and severity of injuries caused in a school population as a consequence of an unintentional fall, before and after the implementation of the Safe Fall programme,

are proposed. This would allow for a prediction of the transfer of the learned motor gestures to other contexts.

It must be mentioned as one of the limitations of the study that not many references were found in the literature [22] that would allow us to contrast the results obtained with the Safe Fall programme with another on a regional, state, or international level and to enable a meta-analysis of data.

In light of these results, the programme could be extended to include specific exercises to learn to fall sideways and forward. Likewise, ad-hoc observation scales will have to be developed and validated to record the learning of safe and protected ways of falling in these directions. In turn, the results of the study open new study perspectives whose hypotheses have not been considered here. Thus, a correlation between learning a safe and protected way of falling and raising the self-confidence of students when performing motor activities in PE classes needs to be established.

5. Conclusions

The conclusions stemming from this study show that, by using the Safe Fall programme in P.E classes, it is possible to teach adolescent secondary school students techniques for falling backward in a safe and protected way. In turn, the Safe Fall programme responds proactively to the call from the WHO for the implementation of education programs based on fall-related research.

It responds in this way to the overall objective of reducing the risk and severity of injuries produced by a sudden fall backward.

Author Contributions: Luis Toronjo-Hornillo conceived and designed the experiments; Óscar DelCastillo-Andrés performed the experiments, analyzed the data, and wrote the paper; María del Carmen Campos-Mesa reagents/materials/analysis tools; Víctor Manuel Díaz Bernier reagents/materials/analysis tools; María Luisa Zagalaz Sánchez performed the experiments and contributed reagents/materials/analysis tools.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix

STUDENT ASSESSMENT

School:			
Number of subject on list:		Sex: Male/Female	
Age:	Year:	Group:	Date:
Name of observer:			

Description of the Starting Position for Activity Assessment:



- crouching position (buttocks slightly clear of the floor)
- wrists held by a classmate

- position of imbalance with the trunk angled forward while the classmate holds on to the wrists (they will later let go without warning to provoke the backward fall)

When the classmate lets go of the wrists, the observer records on the following table whether the subject performed the actions in the different areas.

INFOSECA Scale for the Systematic Observation of BACKWARD FALL

Criterion	Description	YES	NO
neck	bends the neck (chin down towards chest)		
hands	put hands on floor (protects the head)		
trunk	rolls into a ball and rolls over		
hips	keeps the hips bent		
knees	keeps the knees bent		

Minimum Total Assessment:

Three affirmative out of five. Essential to have an affirmative response in the “neck” criterion.

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