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Original Article

The "Safe Falls, Safe Schools" multicentre international project: evaluation and analysis of backwards falling ability in Italian secondary schools

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Abstract:
Problem statement: Different studies have reported on the epidemiology related to injuries resulting from falls, which are the most common causes of injury in Italy. The World Health Organization considers falls as the second leading cause of accidental or unintentional deaths worldwide. However, it has been demonstrated that the Safe Fall, Safe Schools Programme (SFSSP) based on 10-min warm-up sessions is able to teach techniques for falling backwards in safe way during physical education (PE) classes. Unfortunately, there are no studies that have analysed extensive warm-up and detraining effects related to the age. Aim: The aim of this study was to assess extensive specific warm-up (20 min) and detraining effects after five weeks on the SFSSP on Italian secondary school students according to age. Methods: Eighty-seven secondary school students took part in this investigation. Students were divided into two groups, equally distributed by age. The trial-control group (TC=39) and the control-trial group (CT=48) performed the same PE lesson for 10 weeks. In the first five weeks, two different 20-min warm-up exercises were performed (TC=SFSSP; CT=conventional warm-up); after five weeks, the warm-ups were inverted (TC=conventional warm-up; CT=SFSSP). The backwards falling ability test carried out among both groups was evaluated in relation to the position of the neck, trunk, knees, hips and hands, before and after five and 10 weeks. Results: McNemar's test showed significant differences (between pre- and mid-time points, $P<0.05$) for the neck, trunk, hip and hands, while no significant differences were found in the knee value ($P=0.581$ in TC). No differences were found between the mid- and post-time points for TC. In CT, no differences were found in-between (pre- and mid-time points, $P>0.05$) for all variables studied. Significant differences ($P<0.05$) were found in-between the mid- and post-time points for CT in all variables studied. Analysis of the total scores for SFSSP showed significantly differences in TC and CT ($P<0.0001$). The Wilcoxon signed-rank test showed no significant differences (total scores: first year=1.68±1.05 AU; fifth year=1.47±0.86 AU; $P=0.34$) before the SFSSP intervention, while the SFSSP was able to improve the ability after intervention (total scores: first year=4.47±0.84 AU; fifth year=3.91±1.40 AU; $P<0.01$). Conclusions: The SFSSP was able to improve motor ability for both groups and the detraining effect was found to maintain the same ability level compared to that after the SFSSP intervention. Participants started with the same level of backwards falling ability and each group, after the intervention, significantly raised its score, confirming the efficacy of the intervention. Therefore, the SFSSP could be included in the standard national programme without changing the standard training lesson.
Key words: INFOSECA, injury prevention, motor learning, motor skills, physical literacy, students.

Introduction

Motor ability learning and regular physical activity are crucial aspects in maintaining good health (Padulo et al., 2019) throughout the lifespan (Tang et al., 2008; Liong et al., 2015). Indeed, movement skills learning allows the population to master the numerous good practice examples that can help to prevent health risks (Giblin et al., 2014). Falls are recognized as the most frequent cause of accidental injury in Italy (ISTAT, 2014). Different studies have reported on the epidemiology of fall-related injuries in Italy, where 54.8% of people have experienced an accidental injury caused by falling (ISTAT, 2014). The World Health Organization (WHO) considers falls to be the second leading cause of accidental or unintentional injury deaths worldwide (WHO, 2018). Meanwhile, the Safe Fall, Safe Schools Programme (SFSSP) aspires to become one of the "good practice" examples that can help in preventing injuries and so maintaining good health if repeated throughout an individual's life. The SFSSP could come under the range of physical literacy topics, defined by Whitehead (2010, 2013) as "a disposition to capitalize on our human embodied capability, wherein the individual has: the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the life-course". The main aim of the SFSSP is to prevent falls in the lifespan (Toronjo-Hornillo et al., 2018). Falls are frequent among the elderly (ISTAT, 2014); therefore, the SFSSP should be proposed to prevent fall risks and injuries related to this population. Since 2017,

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the SFSSP has been part of a multicentre proactive international project to teach people how to fall safely (Del Castillo-Andrés et al., 2019). Therefore, knowledge of specific skills and motor behaviours as well as falls could help to prevent fall risk and related injuries. It was demonstrated that the SFSSP in secondary school physical education (PE) classes allows adolescent students to learn backwards falling techniques in a safe and protected way (Toronjo-Hornillo et al., 2018).

Indeed, it is widely known that adolescence (14-18 and 12-17 years in males and females, respectively) is characterized by a decrease in the time spent on physical activity (Sherar et al., 2007) as well as coordinative ability impairment (Hirtz & Starosta, 2002). In the same way, abilities such as abstraction, mental flexibility, working memory (Alesi et al., 2015) and attention (De Giorgio et al., 2018) seem to experience a decrease during adolescence as well, reaching their lowest level (Roalf, 2014).

Conversely, early adulthood and periods before and after puberty (until the 13th year and after the 15th year of age in males; until the 11^{th} year and after the 13^{th} year in females) are conducive to improvements in motor learning and neurocognitive abilities (Hirtz & Starosta, 2002; Roalf, 2014). Moreover, it is necessary to investigate whether backwards falling ability, as taught by the "Safe Falls, Safe Schools" programme, is related to age. However, as previously mentioned by Toronjo-Hornillo et al. (2018), learning how to fall backwards has not been investigated in relation to age. As previously demonstrated (Padulo et al., 2014), motor ability sensitivity differs according to age. For this reason, age comparisons can be useful to identify the trends and benefits needed to clarify this paradigm. Therefore, the first aim of this study was to analyse the effects of the SFSSP warm-up on Italian secondary school students in the first five weeks, while the second aim was to investigate the detraining effects after the SFSSP intervention.

Material and methods

Participants

Eighty-seven secondary school students took part in this investigation. The sample, comprising 53 students in the first year of high school (13 years) and 34 students in the fifth year of high school (17 years), was randomly selected and balanced according to age (one-to-one ratio), with each participant assigned to one of two groups. The trial-control group (TC=39) and the control-trial group (CT=48) took part in the same PE lesson for 10 weeks: in the first five weeks with two different 20-min extensive warm-up sessions (TC=SFSSP; CT=conventional warm-up); after five weeks, the warm-ups were inverted (TC=conventional warm-up; CT=SFSSP). Before and after five - 10 weeks, the backwards falling ability test on both groups was evaluated in relation to the position of the neck, trunk, knees, hips and hands. The study protocol was approved by the Ethics Committee (University of Milan) according to the Declaration of Helsinki for Human Rights.

Experimental protocol

Both of the groups (TC and CT) undertook the backwards falling test at the pre-, mid- and post-10-week stages during regular PE lessons. All investigations were performed in a large classroom with the temperature and relative humidity for each session ranging between 22°C and 24°C and 25% and 27%, respectively.

The technical characteristics of the observation area (OA), the test protocol and the video analysis were standardized following the protocol described by Toronjo-Hornillo et al. (2018).

Test protocol

Participants were asked to enter the OA and stand with their feet on the side line of the square nearest to the height indicator, with their back facing the square centre. One researcher held each participant by his or her wrists, while he or she bent his legs and unbalanced himself or herself backwards until he or she touched the height indicator with his or her gluteus maximus. In a random moment, after the starting signal, the researcher released the participant's wrists in order to initiate a backwards fall.

Observation team

The entire observation process was executed by a familiarized team with the following roles: a controller and an observer. The controller was responsible for each participant's starting position, the sponge setting and making sure the students had the necessary clothing for carrying out the backwards falling test. The observer was responsible for video recordings and directing the execution of the test, starting with giving the start signal. In order to guarantee a homogeneous observation, the students were standardized in terms of the clothes they wore in order to avoid any interference with executing motor skills (e.g., hood, scarf, large clothes) as well as required to wear shoes.

Observation area

Tests were performed in the OA, which was an isolated section of the school gym where observations were executed to avoid any learning effect. The backwards falls were executed on a polyurethane foam mattress, covered in plastic (1m × 2m × 0.05m; 20 kg/m³ density). Upon the mattress, a square of 1m × 1m was delimited

with contrasting colour adhesive tape. In the centre, the height indicator was set at a distance of 0.01m inside the square from the observer's nearest side. The height indicator, made out of soft material (like a sponge), was 0.05m high and big enough to be seen by the observer during video recording. The camera was set on a tripod, at a height of 1 m and perpendicularly distanced at 3m from the external side of the mattress. The position of each tripod was marked to standardize the calibration area. The sample rate for each video camera was fixed at 30 Hz.

Video analysis

Video analysis was executed subsequent to the recording of the backwards falls. Data were collected using the INFOSECA observation scale (Toronjo-Hornillo et al., 2018), which records five basic elements during a backwards fall, i.e., in relation to the positions of the neck, trunk, hips, knees and hands. Each basic element was defined by a detailed description. One point was given for each element when the participants positively performed the backwards fall as described and zero points when not. 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 (back); kept the hips bent (hip); kept the knees bent (knees); and protected the head (head) (Toronjo-Hornillo et al., 2018).

Safe Fall, Safe School Programme

The SFSSP, based on 20 min of warm-up exercises, comprised the following exercises: balance exercises in both static and dynamic positions; explanations and applications of basic elements for learning about safe falls; positions to avoid during falls. During the explanations and applications, the teacher placed all the participants in a straight line and every exercise was clearly demonstrated. Subsequently, the pupils performed the exercises.

Physical education programme

Each lesson consisted of an introductory, a preparatory, a main and a final part, comprising the following exercises (Hraste et al., 2018): team sport activity, pre-athletics and athletics disciplines (high jump, long jump, sprint). The introductory parts of the lessons were carried out in the form of running, walking and/or other games assignments.

Statistical analysis

Data analysis was performed using the IBM SPSS v20 software (IBM, New York, NY, USA). All data were described as means and standard deviations. Descriptive, contrast and age-contrast statistics were applied. The INFOSECA schedule was compared with McNemar's test and the significance level was fixed at $P<0.05$. For total scores, the Kolmogorov-Smirnov test was performed in order to assess the normal distribution of data. A coefficient of variation (CV) was calculated in the pre- and post-SFSSP interventions as SD/mean × 100. The contrast between total scores (as the sum of individual variables) was determined via the Mann-Whitney U test. The total scores for the contrast between the pre-, mid- and post-time points were obtained via the Friedman test. The post-hoc test was performed using the Wilcoxon signed-rank method. All participants were divided into two age groups (first-year group=13-14 years; fifth-year group=17-18 years) based on the SFSSP, independent of the training period. The Mann-Whitney U-test was performed to compare the age groups in the pre- and post-SFSSP interventions.

Results

Descriptive statistics

In the TC and the CT groups, significantly different measures of weight (TC=58.50±11.00 kg; CT=65.42±11.91 kg; $P<0.05$) and height (TC=1.71±0.10m; CT=1.82±0.11m; $P<0.01$) were obtained. No significant differences were found in BMI (TC=20.62±3.31 kg/m²; CT=21.19±2.90 kg/m²; $P=0.34$). When comparing the first- and fifth-year groups, a significance was found for measures of weight and BMI (first year=60.18±11.22 kg; fifth year=65.66±12.42 kg; $P<0.05$), but no significant differences were found for height (first year=1.71±0.06m; fifth year=1.73±0.09; $P=0.266$).

Contrast statistics

TC. McNemar's test showed statistical differences in all variables of the backwards falling test between the pre- and the mid-time points about the SFSSP intervention, excepted for the knees' values (percentage of success: pre- to mid-neck=61.54-94.87%, $P=0.01$; pre- to mid-back=0.00-89.74%, $P<0.01$; pre- to mid-knee=66.67-74.36%, $P=0.58$; pre- to mid-hip=23.08-94.87%, $P<0.01$; pre- to mid-hands=0.00-71.79%, $P<0.01$; Figure 1a).

No differences were found between the mid- and the post-time points, which showed higher scores in all variables compared to the pre-time points (percentage of success: mid- to post-neck=94.87-100.00%, $P=1.00$; mid- to post-back=89.74-76.92%, $P=1.00$; mid- to post-knee=74.36-84.21%, $P=1.00$; mid- to post-hip=94.87-100.00%, $P=0.50$; mid- to post-hands=71.79-73.70%, $P=0.77$; **Figure 1a**).

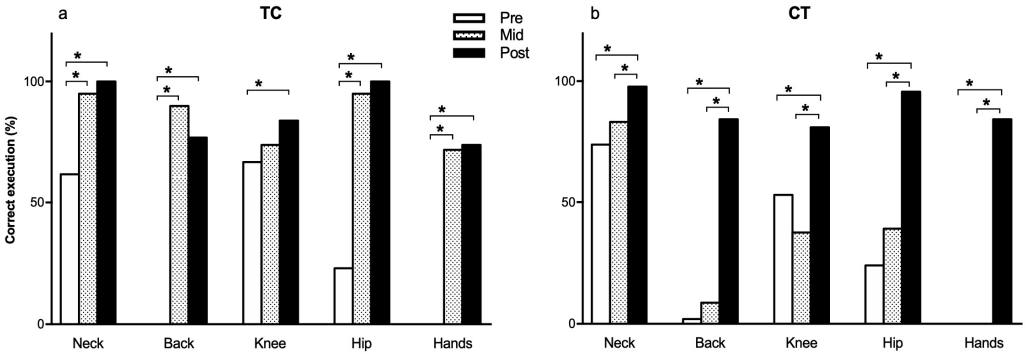

Fig. 1. SFSSP effects on backward fall test. *P<0.05

CT. McNemar's test showed no statistical differences between the pre- and the mid-time points (percentage of success: pre- to mid-neck=72.92-83.33%, P=0.27; pre- to mid-back=2.08-8.33%, P=0.37; pre- to mid-knee=52.08-37.50%, P=0.19; pre- to mid-hip=22.92-37.50%, P=0.19; pre- to mid-hands=0.00-0.00%, P=1.00; **Figure 1b**). Differences in all variables were found between the mid- and the post-time points (percentage of success: mid- to post-neck=83.33-97.83%, P=0.04; mid- to post-back=8.33-82.61%, P<0.01; mid- to post-knee=37.5-81.08%, P<0.01; mid- to post-hip=37.50-95.65%, P<0.01; mid- to post-hands=0.00-82.61%, P<0.01; **Figure 1b**). The post-time points had a significantly higher score compared with the pre- and mid-time points in all considered variables (**Figure 1b**).

Total score analysis

In the TC group, differences were evidenced by the Friedman test (P<0.01), while the Wilcoxon post-hoc test showed a significant difference in the pre-time points compared to all the others (pre-score=1.51±0.91 AU; mid-score=4.25±1.04 AU; post-score=4.25±1.09 AU). No differences between the mid- and post-time points were found (pre vs. mid: P<0.01; mid vs. post: P=0.77; pre vs. post: P<0.01; **Figure 2**). Concerning the CT group, similar to the TC group, the Friedman test was significant (P<0.01).

Meanwhile, the post-hoc test revealed a difference between the post-time point and all others (pre-score=1.50±0.92 AU; CT mid-score=1.66±1.06 AU; post-score=4.25±1.19 AU), but the pre- and mid-time points were found to be equal (pre vs. mid: P=0.30; CT mid vs. post: P<0.01; CT post vs. pre: P<0.01; **Figure 2**). The Mann-Whitney U test compared both groups for each time point. Regarding the pre- and post-time points, there were no significant differences between either group (pre and post with P=0.78 and P=0.86, respectively; **Figure 2**), while a significant difference was found in the mid-time point in-between groups (P<0.01), with the TC group recording a higher score in-between groups.

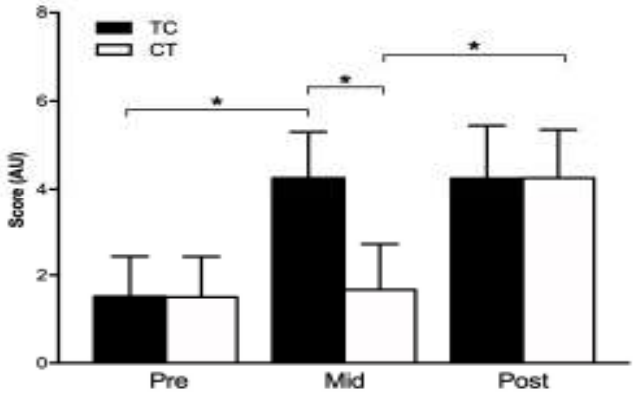

Fig.2. Mean scores of TC and CT at Pre, Mid and Post time points."*" P<0.05.

Age contrast

Before the intervention, no significant differences were found (scores: first year=1.68±1.05 AU; fifth year=1.47±0.86 AU; P=0.34; **Figure 3**) in-between age groups. The first-year age group revealed a significant difference (14.31%) after the SFSSP intervention compared to the fifth-year age group with P<0.05 (scores: first year=4.47±0.84 AU; fifth year=3.91±1.40 AU, P<0.01; **Figure 3**).

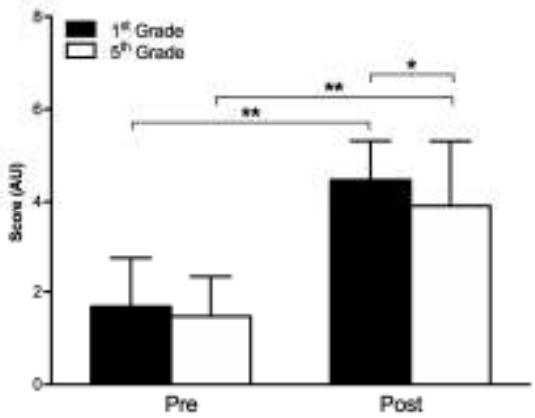

Fig.3. Mean scores by the participant's age, at Pre and Post time points. "*" P<0.05; "**" P<0.01

Discussion

This investigation showed, for the first time, the effects of an extensive warm-up lasting 20 min (based on the SFSSP) and the detraining effects on the ability to fall backwards. Our results confirmed that the participants started with the same level of ability at falling backwards (32% with a CV of 97%) and that, after the intervention, each group significantly raised its score. The TC group improved between the pre- and the mid-time points and the CT group between the mid- and the post-time points; these findings represents the SFSSP's main effect. It is possible to compare ours results with those in Toronjo-Hornillo's (2018) study, where participants were in the same age range, i.e., between 13 and 17 years of age. Our sample's performance was 32% better compared to that of Toronjo-Hornillo's sample (5.7%) on the backwards falling test in the pre-intervention stage (**Table 1**). The aforementioned difference levelled out in the post-intervention data (**Table 1**). Both studies demonstrate the SFSSP's efficacy (54% and 89% in our study and Toronjo-Hornillo's (2018) study, respectively). Furthermore, if the data from the pre-treatment stage in both studies showed a higher CV (97% and 120% in our study and Toronjo-Hornillo's (2018) study, respectively), the SFSSP was able to decrease the data's heterogeneity as revealed, post-treatment, for both studies (10% and 7% in our study and Toronjo-Hornillo's (2018) study, respectively). The main differences between our study and that of Toronjo-Hornillo et al.'s (2018) investigation concerned the time distribution related to the SFSSP, which, in both studies, was 100 h over five weeks: in our study, the intervention was administrated in one weekly session (20 min for each one session) compared to two weekly sessions of 10 min each (10 + 10 min, i.e., a total of 20 min per week) in Toronjo-Hornillo et al.'s (2018) investigation.

Table 1. Percentages of success in individual values Pre and Post SFSSP, in the Present and Toronjo-Hornillo (2018) studies

Element	Present research		Toronjo-Hornillo et al, 2018	
	Pre (%)	Post (%)	Pre (%)	Post (%)
Bending Neck (Neck)	73.6	95.3	10.8	89.2
Rolling Up (Back)	4.6	84.9	15.0	85.0
Bending Hip (Hip)	50.6	79.0	1.7	98.3
Bending Knees (Knees)	31.0	94.2	0.0	100.0
Using Hands (Hands)	0.0	76.7	0.8	99.2
Mean	*32.0*	*86.0*	*5.7*	*94.3*
SD	*31.0*	*8.5*	*6.8*	*6.8*
CV	*97.1*	*9.9*	*120.2*	*7.2*

Other studies have revealed a retention ability in the case of motor tasks (Savion-Lemieux & Penhune, 2005), where they compared two balanced groups during learning sessions (five days) with different workloads.

Savion-Lemieux et al (2005) showed that, despite a different workload, both groups reached the same motor task competence level. Regarding detraining effects, Savion-Lemieux et al. (2005) reported the benefits after four detraining weeks without any changes to the motor task in both groups. The same detraining effects were found in our study where the students were able to maintain the same level of motor ability performance as demonstrated for each element related to the backwards falling ability.

This detraining led to the conclusion that, similar to this study, the learning and retention of motor skills do not depend on the quantitative amount of practice performed, but rather on the learned quality of the movement (Savion-Lemieux et al., 2005). When comparing the SFSSP effects on the fifth-year students with those on the first-year students (**Figure 3**), a small difference in-between group was observed (49% and 56%, respectively). This small difference (-7%) could be explained by the higher school workload on the fifth-year students compared to the first-year students. From our point of view, these results are consistent with those of Szturm et al. (2013), who found that executive functions and motor control might be influenced by school workload.

Conclusions

The SFSSP was able to improve motor ability for both groups and the detraining effect was found to maintain the same ability level compared to after SFSSP intervention. Participants started with same level of backwards falling ability and each group, after the intervention, significantly raised its score, confirming the efficacy of the intervention. Therefore, this SFSSP could be included in the standard national program without changing the standard training lesson.

Conflicts of interest: The authors declare that they have no conflict of interest.

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