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FITNESS

Effect of a Skating Unit on Fitness in Fifth-Grade Students

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Abstract

This study investigated the effect of a skating unit on cardiovascular fitness, eyes-closed static balance, explosive power, and agility in fifth graders. During a 6-week skating unit (12 lessons), 71students (M_{age} = 10.34 years, range: 10–12 years) participated during regularly scheduled physical education classes. Three classes were involved, one serving as the control group and the other two as experimental groups (roller skating and in-line skating). The control group had no access to roller or in-line skates during class time, rather the curriculum consisted of soccer, dance, and softball. The experimental groups participated in a specifically designed skating curriculum adapted with permission from Skatetime and Skate in School. Results showed that the roller skating group had longer static balance times than the in-line skating group. Even though other factors reported nonsignificance, difference scores illustrated gains after intervention, suggesting that a skating unit could induce improvements. Further research examining significance between roller skating and in-line skating is warranted.

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Schwab and Dustin (2014) recommended that physical education teachers begin to look beyond the traditional classroom curriculum of activities such as football and soccer and consider implementing nontraditional activities into schools that have a positive impact on students' health and create lifelong behaviors into adulthood. Skating is one such nontraditional activity that physical education teachers can utilize to provide a fun means to achieve many health- and sport-related benefits.

Skating exists in several different forms, two of which are roller skating and in-line skating. Roller skating and in-line skating are stylish and fun forms of exercise suitable for all ages and experience levels (Gold, 2006). Roller skating and in-line skating are a means of transportation where participants use their physicality to propel themselves in a given direction on a platform of wheels. Throughout the years, skating has become more diverse by providing greater opportunities for individuals to participate in specialized activities such as hockey and aggressive, figure, and speed skating. Skating's diversity allows for the modification of traditional sports such as basketball and team handball, during which participants wear skates while participating, which adds another level of complexity and enjoyment (McManama, 2014; Skatetime, 2013a). The diversity of skating has led to many cities and municipalities investing in specially designed skate parks, boardwalks, paved trails, and skating rinks for skaters to skate in a safe environment free from the hazards of the road. However, most skaters enjoy the freedom of skating on neighborhood streets and sidewalks, which provide unique opportunities to perform tricks.

Skating is an aerobic activity and as such may lead to increased cardiovascular endurance along with the added benefits of enhanced balance, greater explosive power, and elevated motor ability demands. Prior research into the physiological changes in cardiovascular fitness found that in-line skating induced similar changes comparable to running in VO_2 max training volume and HR intensity (Melanson, Freedson, & Jungbluth, 1996; Melanson, Freedson, Webb, et al., 1996; Orepic et al., 2014; Wallick et al., 1995). Research has also suggested that skating (in-line and ice) can improve balance and explosive power in children (Keller et al., 2014; Muehlbauer et al., 2013) and postural control in older adults (Lamoth & Heuvelen,

2012). Finally, Rinne et al. (2007) found that the high level of motor ability demands from skating can improve a participants' "spatial orientation, kinesthetic differentiation, balance, reaction ability, and sense of rhythm" (p. 205).

The physiological benefits gained by those who participate in a skating unit illustrate the significance for schools and school districts to find the means to implement this type of activity into their curricula. In children, skating can reduce the onset of obesity and chronic diseases contributing to a healthier quality of life in adulthood. Regular participation in this activity can promote a healthy lifestyle to reduce the incidence of chronic debilitating illnesses such as heart disease, cancer, type 2 diabetes, and osteoporosis in adults (SHAPE America, 2016). Furthermore, such an activity meets the recommendations of the American Heart Association (AHA, 2015) that adults participate in 30 min of moderate aerobic activity 5 days weekly and children (AHA, 2016) receive a minimum of 60 min of moderate to vigorous aerobic activity daily. Menschik et al. (2008) found that adolescents who participated in "wheeled activities" such as in-line skating and roller skating were less likely to be overweight later in life, stressing the importance of skating's role on a person's health today and into the future.

Therefore, this study investigates the effect of a roller skating unit or an in-line skating unit on cardiovascular fitness, eyes-closed static balance, explosive power, and agility in fifth grade students. Specifically, do the PACER, static balance, vertical jump, and agility difference scores vary between students who participate in a unit in roller skating, those who participate in an in-line skating unit, and those who participate in a regular physical education class?

Method

Participants

Eighty-two fifth-grade students from an elementary school in the Southern United States participated in this study. Eleven students (13.4%) were removed from the analysis due to nonparticipation, incomplete data, or leaving the school. During their regularly scheduled physical education classes, three classes (n = 71) were divided into the control group (n = 19, 8 males, 11 females, M_{age} = 10.37 years) and two experimental groups of roller skating (n = 26,

11 males, 15 females, M_{age} = 10.31 years) and in-line skating (n = 26, 10 males, 16 females, M_{age} = 10.35 years). For the purposes of this study, students in the control group did not have access to the roller skates or in-line skates in physical education classes throughout the study.

Dependent Measures

Cardiovascular Fitness

The PACER (Léger & Lambert, 1982; Léger et al., 1988) was administered as a measure of cardiovascular fitness. Cone lines were set up 20 meters apart on the outdoor blacktop. The test began with participants lined up on one side of the course and when the audio track began, the subjects ran to the other side of the course. A beep indicated the pace at which the subject needed to reach the other end of course. As the music continued, the pace increased, and participants continued to run until they could no longer maintain the pace for two ends. The total number of ends was determined by subtracting the total number of ends run from the number of ends missed or not completed before the beep. The evaluator demonstrated the procedure but gave no other instruction to the participants.

Static Balance

The Modified Stork Standing Balance Test (Hammami et al., 2016) is a timed test measuring static balance. With shoes on, participants placed their hands on their hips and their nonsupporting foot against the inside of the supporting leg's knee. Holding that position, the participant closed their eyes and the evaluator started the time on a stopwatch. The test ended when any of the following occurred: the supporting foot's heel raised off the floor or the supporting foot moved/hopped in any direction, the participant's hand(s) came off the hips, eyes opened, or the nonsupporting foot moved from the supporting leg. The evaluator demonstrated the procedure but gave no other instructions to the participants. Participants had one practice attempt and two timed attempts with a short rest of approximately 2 min between each attempt. The longest attempt time was recorded to the nearest one hundredth of a second between the two attempts.

Explosive Power

Explosive power was measured with the vertical jump (Cheah et al., 2017; Leard et al., 2007). For this task, the evaluator first measured a standing reach. With shoes on, the participants stood in a natural position with their side against the wall and their dominant arm reaching overhead without overreaching. The highest reach point was recorded to the nearest half inch to establish the standing height (Chu, 1998). After the standing height was established, the jumping height was measured with a Vertec jumping apparatus. With their dominant side facing the apparatus, the participants stood under the apparatus with their feet shoulder width apart. The participants then performed a counter movement that allowed them to swing their arms down and back as they bent their knees. They then performed a jump and swung their arms up to touch the highest possible movable vane with their dominant hand (Wood, 2008). The evaluator demonstrated the procedure but gave no other instructions to the participants. The vertical jump was determined by the highest vane touched minus the standing reach and recorded to the nearest half inch. Participants were permitted one practice jump and two attempts with the best jump recorded to the nearest half inch.

Agility Run

The Illinois Agility Test (Dawes et al., 2012; Raya et al., 2013) measured participants' running agility. The length of the course was 10 m long with a width of 5 m. Four cones marked the perimeter of the box and designated the start, finish, and turning points of the test. In addition, four cones ran the length of the 10 m in the middle (5 m from the edge) of the box spaced 3.3 m apart. Taped arrows on the floor aided participants in performing the task. Participants assumed the start position by lying face down with head facing the start line and hands by their shoulders. The timer said "Go" and the stopwatch was started. They quickly rose from the floor and ran the course without knocking over any cones to the finish line, where time was stopped. The evaluator demonstrated the procedure but gave no other instructions to the participants. Participants performed two attempts with an approximate rest of 2 min between each attempt. The fastest time of the two attempts was recorded to the nearest one hundredth of a second.

Procedure

Before the start of the skating unit, students in the control and experimental groups performed a series of pretests measured over 2 days, which established a baseline. On Day 1, three tasks were measured: Standing Stork to measure balance, vertical jump to measure explosive power, and Illinois Agility Test to measure agility. On Day 2, the PACER test was administered as a measure of cardiovascular fitness. The class was divided into several groups that consisted of about five to seven participants to perform the task. Students had one attempt with the number of laps completed recorded for analysis.

During the 6-week (12-lesson) intervention, the control and experimental groups met twice weekly during their regularly scheduled 45-min physical education classes. This protocol required no change to their daily routine. During this time, the control group participated in their regularly scheduled curriculum that included the completion of a softball unit, dance unit, exercise stations, and the beginning of a soccer unit. The control group was not permitted to participate in any roller skating or in-line skating activities during class periods throughout the study. The experimental skating groups participated in a modified skating curriculum adapted and/or reprinted with permission from Skatetime (2013a, 2013b, 2017, 2018) and Skate in School (2016a, 2016b), which ensured commonality between the roller skating group and in-line skating group. Each daily lesson consisted of a warm-up, an activity of the day, and closure. All skating activities were held indoors throughout the study. During the intervention, the students in the in-line class had a scheduled school holiday that required the students to make up that day. The teacher and students agreed to make up the missed class time during the recess that followed the normally scheduled class time.

At the end of the intervention period, a series of posttests were performed to remeasure the students' fitness. The posttests were conducted by the assessment team and followed the 2-day protocol established during the pretesting. Students followed the same rotation of stations and evaluators managed the same stations established in the pretests, for consistency of data collection.

Treatment of Data

The Statistical Package for Social Sciences (SPSS) version 23 was utilized in the analysis of the descriptive statistics for this study. The dependent variable for this study was the difference in posttest minus pretest fitness testing scores. An ANOVA with three levels (control, roller skating, in-line skating) was conducted separately, evaluating difference scores for each of the factors: cardiovascular fitness, static balance, explosive power, and agility. Post hoc tests were conducted when appropriate. An alpha set at the .05 level defined the significance for all tests.

Prior to final analysis, three evaluations to determine the viability of the samples based on attendance, measurement error, and/or improper physical education attire during the pretest and posttest evaluations and to remove extreme outliers were performed on the samples. The teacher recorded daily attendance during the intervention period of this study. Participants who did not meet the 8 out of 11 lessons (72%) attendance had their data removed from final analysis. After a review of the attendance records, all ($n = 71$) students met the attendance requirement. The attendance rates by class were control 95.65%, roller skating experimental 96.5%, and in-line skating experimental 93%. Next, participants were removed from the analysis due to measurement error and/or improper physical education attire (i.e., boots) during testing periods. In total, nine Stork, five vertical jump, and three agility run data points were removed and treated as missing data. Finally, extreme outliers were identified and removed prior to final analysis. Jones (n.d.) defined an extreme outlier as a value that "lies more than 3.0 times the interquartile range [IQR] below the first quartile [Q1] or above the third quartile [Q3]" and is represented mathematically where the score (x) is "$x < Q1 - 3 * IQR$ or $x > Q3 + 3 * IQR$" (Extreme Outliers section, para. 1). In total, four participants (Illinois Agility, $n = 1$; Stork Standing, $n = 3$) were removed from the analyses.

Results

A one-way ANOVA, conducted on each dependent variable, resulted in significance for only the Stork balance, $F(2, 56) = 4.90$, $p = .011$. The difference scores between the posttest and pretest Standing Stork balance time, as assessed with eta-squared, showed strong association, accounting for 14.9% of the variance of the dependent variable.

Because Levene's test was nonsignificant, $F(2, 56) = 2.52$, $p = .090$, the variances were assumed to be homogeneous and post hoc comparisons were conducted with the Tukey-Kramer test. The group that participated in roller skating ($M = 3.57$) showed on average a greater increase in balance time compared to those participating in in-line skating ($M = -0.98$). No significant differences were found between the roller skating group ($M = 3.57$) and control group ($M = 0.29$), and the in-line skating group ($M = -0.98$) and control group ($M = 0.29$). Table 1 shows the 95% confidence intervals for the pairwise differences, as well as the difference scores and standard deviations for the three balance groups.

Table 1

95% Confidence Intervals of Pairwise Differences in Difference Scores and Standard Deviations for Modified Stork Standing Balance Test in seconds

Group	*n*	*M*	*SD*	Control	Roller skating
Control	17	0.29	3.38		
Roller skating	22	3.57	4.13	[-0.50, 7.05]	
In-line skating	20	-0.98	6.42	[-5.14, 2.59]	[-8.17, -0.93]*

Note. An asterisk indicates that the 95% confidence interval does not contain zero, and therefore, the difference in the means is significant at the .05 significance using Tukey-Kramer procedure.

Nonsignificance was reported at the .05 level for the PACER scores , $F(2, 67) = 1.49$, $p = .23$; vertical jump inches, $F(2, 63) = 1.34$, $p = .27$; and Illinois Agility time, $F(2, 63) = 1.60$, $p = .21$. Table 2 shows difference scores and standard deviations.

Table 2
Difference Scores and Standard Deviations

	PACER			Vertical jump			Illinoi agility		
Group	***n***	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***
Control	19	6.21	5.85	19	0.39	1.93	19	-1.28	1.60
Roller skating	25	4.60	4.26	24	1.27	1.84	25	-1.12	1.86
In-line skating	26	7.12	5.66	23	0.67	1.69	22	-0.40	1.62

Discussion

Those who participated in roller skating showed significance compared to those who participated in in-line skating. Because there is no research to compare these findings, these unique results suggest that roller skating is a better activity to improve eyes-closed static balance than is in-line skating. There are a few speculative theories for why this phenomenon may have occurred. First, the finding suggests that differences in the material used in the construction of the skate, leather for the roller skates and molded plastic for in-line skates, may have influenced the ankle strength the skater needed to maintain balance when using the leather boot roller skates. The leather boot is more pliable, which may require the ankle to "work harder" to maintain balance. Another possibility is that an increase in the frictional force may be required to roller skate than to in-line skating, where an increase in frictional forces requires participants to work "harder," thus increasing their lower body strength (McGinnis, 2013). The increase in friction could be attributed to two factors: the design of the skate and wheels in contact with the surface. The design of the roller skate places the wheels in a side-by-side (two in front and two in back) pattern, whereas the in-line skate places the wheels in a linear pattern. This design may require participants who roller skate to lift their legs higher so the wheels do not come into contact during the recovery phase in the gait while skating. This could place an increased workload on the weight-bearing leg, thus increasing proprioception and strength to maintain balance. Additionally, the differences in wheel size may be a factor related to friction. In-line skate wheels are taller and thinner compared to the smaller and wider roller skate wheels. These two design differences

could be an influencing factor on the potential for an increase in friction. However, to date, there is no research to back these theories and future research would need to investigate why roller skating was found to improve balance more than in-line skating was.

While no studies explaining these differences between roller and in-line skating were found in the literature, Muehlbauer et al. (2013) concluded that in-line skating induced a significance in a child's balance when measured with the Star Excursion Balance Test (measures both static balance and dynamic balance) in comparison to a nonskating control group. Even though, this study did not find significance in the control group compared to the in-line group in balance, the teacher stated that several participants at the beginning of the unit who needed assistance (carpet pads, use of the wall, partners, or ball cages with wheels) no longer needed assistance at the end of the intervention. Furthermore, students were required to push the limits of their comfort zone by participating in activities such as an obstacle course and slalom by weaving in and out of cones or other barriers. In addition, activities such as Limbo and Shoot the Duck required students to either shift their center of gravity and/or balance on one leg for a given length of time (Skatetime, 2013a, 2013b, 2017, 2018; Skate in School, 2016a, 2016b). Movement games (Noodle Tag, Side-by-Side Tag, and High-5 Tag) reinforced the development of balance in participants when having to duck, dodge, and jump to avoid being tagged or when trying to tag other participants (Skatetime, 2013a, 2013b, 2017, 2018; Skate in School, 2016a, 2016b). All these kinesthetic changes, such as turning, twisting, and spinning actions in skating, place a high demand on the vestibular organs and muscular systems in the improvement of balance.

Research involving ice skating, as opposed to in-line skating, revealed that children (Fragala-Pinkham et al., 2009; Keller et al., 2014; Walsh & Scharf , 2014) and older adults (Lamoth & Heuvelen, 2012) who participated in various ice-skating programs had a significant improvement in balance. Additionally, research has demonstrated that activities that improve balance can indirectly influence other factors such as explosive power and agility (Granacher et al., 2010; Hrysomallis, 2011; Yaggie & Campbell, 2006). While ice skating was not one of the treatment groups for this study, the similarities

it shares with roller skating and in-line skating suggest that it can induce improvements in balance.

Skating not only has several health benefits (Keller et al., 2014; Melanson, Freedson, & Jungbluth, 1996; Melanson, Freedson, Webb, et al., 1996; Muehlbauer et al., 2013; Orepic et al., 2014) but can also be fun. Fromel et al. (2017) and Wilson et al. (2005) found that girls rated skating as one of their top choices, boys to a lesser degree, of activities that not only promotes a healthy lifestyle but also allows them to engage socially with their peers. These findings reflected the teacher's observation during the skating intervention that skating reinforces the development of soft skills such as social development and personal behavior while meeting the recommended standards by SHAPE America (2013). Students were observed demonstrating personal responsibility by maintaining a clean and safe skating environment by making sure that skates, helmets, elbow pads, wrist guards, and other equipment were properly stored after each lesson. Additionally, remarks from the teacher indicated that the skating unit was a positive addition to the school day and a viable possibility in future physical education curriculum.

In conclusion, the purpose of this study was to determine the effects of a skating unit on the fitness level of fifth-grade students. Overall, the data suggest that roller skating, compared to in-line skating, is more beneficial for a participant's static balance. However, the pretest and posttest difference for cardiovascular fitness, explosive power, and agility clearly indicate improvements. While these factors were nonsignificant, the data suggest that these fitness factors can improve during a skating unit. This study illustrates that a nontraditional activity such as skating could be an effective teaching tools utilized by physical education teachers to improve fitness in children.

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