

Effects of a Physical Education Program on Children's Manipulative Skills

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We assessed effects of a physical education professional development program on 3 manipulative skills of 4th- and 5th-graders. Seven schools were randomly assigned to 3 treatment conditions: PES (Physical Education Specialists), TT (Trained Classroom Teachers), and CO (Controls). Students (358 boys, 351 girls) were randomly selected from 56 classes and tested on throwing, catching, and kicking. In the fall baseline, boys scored higher than girls; 5th-graders scored higher than 4th-graders. In the spring, children in PES schools had improvements of 21%; those in TT and CO schools gained 19% and 13%, respectively. Gain scores were significant for catching ($p = .005$) and throwing ($p = .008$). Intervention effects did not differ by gender or grade. Adjusting for condition, boys made significantly greater gains than girls. The results indicate that children's manipulative skills can be improved by quality physical education programs delivered by PE specialists and classroom teachers with substantial training.

Historically, the development of motor skills, including manipulative, locomotor, and nonlocomotor capabilities, has been a primary goal of physical education (Graham, 1987; Siedentop, 1990), and national standards for children's skill development have been generated through consensus and published (National Association for Sport and Physical Education, 1995). Most program models in physical education, including health-related physical education (Sallis & McKenzie, 1991) include motor skill development as a goal, although the emphasis it receives varies substantially from program to program (Buschner, 1994).

Skill performance is necessary for successful participation in game and sport play (Rink, 1993), as well as for negotiating environments that require highly refined movements (e.g., the military, theater acting, construction). Recent research is also

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documenting new connections between the use and development of movement abilities and the development of brain cells and academic capabilities (Caine & Caine, 1991). In addition, being motorically skilled has the potential for providing children with physical, social, and emotional benefits that may assist them in leading more active, healthy lifestyles. Children believe that being skilled is important (Lee, Carter, & Xiang, 1995), and educators have suggested that children who develop motor skills grow in confidence, which may lead to further participation in physical activity (Buschner, 1994).

The scientific bases of motor skill development have been well-documented from a number of perspectives (Haubenstricker & Seefeldt, 1986; Keogh & Sugden, 1985; Payne & Isaacs, 1991; Robb, 1972; Schmidt, 1991; Wickstrom, 1983). Skill acquisition is a gradual process and, in addition to diverse physiological readiness factors, becoming proficient requires opportunity, developmentally appropriate practice, and feedback. Older children are typically more skilled than those who are younger, and boys usually perform better on motor skill tests than girls (Haubenstricker & Seefeldt, 1986; Raudsepp & Paasuke, 1995; Reuschlein & Vogel, 1984). Gender differences in test performances by prepubescents, however, are generally not determined by physiological reasons (Thomas, Thomas, & Gallagher, 1993), raising the possibility that gender differences can be narrowed through increased practice and improved instruction.

Judging the effectiveness of programs based upon student learning is an important tenet of outcomes-based education (Vogel, 1986). Although a substantial number of studies on children's motor skill development have been reported (Haubenstricker & Seefeldt, 1986), few experiments assessed the generalizable effects of different programs over several months (Graham, 1991; Kelly, Dagger, & Walkley, 1989), and none could be located that were conducted in schools randomly assigned to treatment conditions.

Classroom teachers are responsible for substantial amounts of physical education (National Association for Sport and Physical Education, 1994). Less than 18% of the U.S. states offering a specialized physical education certificate require teachers of physical education (PE) at elementary schools to obtain it (Pate et al., 1995). Thus, classroom teachers are frequently untrained to conduct quality PE in which lessons are likely to produce optimal skill gains. Descriptive studies have shown that PE specialists usually provide better physical education than nonspecialists, particularly when judged on physical fitness outcomes (Faucette, McKenzie, & Patterson, 1990). No studies could be located in which professional development programs were examined for their ability to help in-service classroom teachers improve students' motor skills.

The current investigation focuses on manipulative skill development and is part of a larger study of the efficacy of an experimental health-related physical education curriculum and professional development program (SPARK—Sports, Play, and Active Recreation for Kids). The PE curriculum was designed to enhance both health-related fitness and sports/motor skills. Within a randomized field trial format, the SPARK program had previously been shown to produce increases in children's physical activity during PE classes (McKenzie, Sallis, Kolody, & Faucette, 1997) and to improve their health-related physical fitness (Sallis et al., 1997). Because of the importance that generalizable motor skills play in enabling children and, later, adults to participate successfully in health-enhancing physical activity, the study of skill acquisition during this program was a logical extension.

A secondary purpose of the study was to explore the development of children's motor skills by gender and grade level.

Children's ability to catch, kick, and throw a ball were assessed in the current study. Object control is a skill requirement in game and sport forms commonly available to children both at school and in the community (e.g., baseball, basketball, soccer, softball). It has been shown that children must master object control before they can use specific manipulative skills successfully in game strategies (Turner & Martinek, 1992). Mastery of basic manipulative skills enables children to attempt more specialized and complex movements that are part of more dynamic game and sport play, and mastery of advanced skills is typically required if adolescents are to be retained in youth sport. The three skills selected have been identified as appropriate grade-level outcomes (National Association for Sport and Physical Education, 1995), are generalizable to a number of games and sports, and have functional value for children's success in community physical activity programs.

Methods

Setting and Schools

The investigation was conducted in a suburb of San Diego, California. Prior to the larger study being initiated, physical education in the school district was the responsibility of classroom teachers. Principals agreed to participate in an experimental physical education program and have their school randomly assigned to one of three study conditions. Seven schools were then stratified by percent minority, and, within strata, two were randomly assigned to each of three experimental conditions. In the *Physical Education Specialist* (PES) condition, credentialed PE specialists were employed by SPARK, placed in the two schools, and given additional training by the investigators. In the *Trained Teacher* (TT) condition, the regular classroom teachers were trained in the intervention methods. The third condition was *Control* (CO), or usual PE, as typically implemented in the district by classroom teachers; no attempt was made to interfere with their ongoing PE programs. A third school was added to the CO condition to guard against loss of control schools. At the beginning of the study, all seven schools were provided the same pieces and amounts of equipment. Appropriate institutional, teacher, and parental consent were provided for various components of the study, including the measurement of children's motor skills.

Physical Education Program. The SPARK PE curriculum was implemented in the two PES and the two TT schools. SPARK was a comprehensive program, specifically designed so that goals, such as physical fitness and motor skills, would be developed by students as they participated in high levels of enjoyable physical activity. A written curriculum guide (McKenzie & Rosengard, 1994) identified the program philosophy and goals and included a yearly plan that was divided into units or themes of instruction. Units had established activity progressions and were usually 12 lessons in length. With few exceptions, teachers in the four intervention schools started units on the same schedule. The lessons were planned for 30-minute segments, which were to be conducted three times per week throughout the school year. Lessons had two parts: health-fitness activities (15 minutes) and skill-fitness activities (15 minutes). The health-fitness units conducted during the study included

aerobic games, fitness circuits, jump rope, and aerobic dance; the motor-fitness units included Frisbee, soccer, field games, basketball, volleyball, track and field, and softball.

Each teacher was provided with a three-ring binder containing lesson plans for each unit. The lesson plans were written in detail and identified the number and types of equipment needed, recommended class formations and transitions, and instructional cues for the specific skills being taught that day. The individual plans were designed to be attached to a clipboard for easy use during a lesson. While not the focus of this paper, an additional half-hour per week was allocated for classroom instruction and practice in behavioral self-management activities and skills.

Classroom Teacher Professional Development Program. Classroom teachers were trained to implement SPARK PE in the TT schools. This program, and teachers' satisfaction with it, have been described in detail elsewhere (Faucette, Nugent, Sallis, & McKenzie, 1997). Briefly, the program had three primary goals: (1) to generate classroom teachers' willingness to implement the PE and self-management curricula; (2) to enable them to understand and use specific physical education content; and (3) to enable them to develop the class management and instructional skills necessary to successfully implement the curricula. The in-service program was conducted by university faculty and by a public school PE specialist who simultaneously implemented the curricula in a PES school. During each training session, teachers experientially participated in curricular activities and practiced the skills they would later teach.

This study took place during the first 2 years of a 3-year intervention, and training was extensive during this time period (i.e., 32 hours over 11 sessions during the first year and 9 hours over 3 sessions during the second). About 70% of group training time was allocated to the PE curriculum and 30% to the self-management curriculum. Substitutes were provided to allow classroom teachers to attend training during the school day. Twenty-eight different classroom teachers participated in the professional development program, and their attendance at group sessions was 97%. Their mean satisfaction score of 4.83 on a 5 point scale indicated they evaluated training sessions very positively. TT students in this study came from the classes of 24 of the trained teachers.

On-site follow-up was provided to classroom teachers by a trained PE specialist. During the visits, that ranged in frequency from biweekly to bimonthly, the consultant /specialist assisted by leading grade-level planning meetings, modeling lesson segments, coordinating space and equipment use, and giving verbal and written feedback to teachers after observing their lessons.

PE Specialists. The SPARK PE curriculum was implemented in PES schools by 3 state-licensed (K-12) PE specialists. At the start of the program, 1 specialist had 11 years teaching experience and the 2 others were newly credentialed. The specialists received ongoing training in bimonthly meetings that were held off-campus at the Project office. During these meetings teachers frequently reviewed videotapes of their classes and received feedback on their instruction from an investigator.

Control Condition. Principals of control schools were asked to continue with their usual PE programs, which were commonly taught by classroom teachers who reportedly followed the state framework for PE. Also, principals were requested not to begin new PE initiatives with Grades 4 and 5 during the study.

Participants

One-third of the students in each fourth-grade class ($N = 403$) and, one year later, each fifth-grade class ($N = 413$) in the study schools were selected randomly by computer and participated in skills testing. They were tested in the fall, about 6 weeks after the school year began, and again in the spring, approximately 6 months later. Five students in the fourth-grade cohort and 7 students in the fifth-grade cohort (1.2% and 1.7%, respectively) were not available for the spring testing. Furthermore, 95 students belonged to both fourth- and fifth-grade cohorts; for analysis purposes, they were arbitrarily removed from the fifth-grade cohort. Complete data were thus available for 709 children (358 boys, 351 girls). Table 1 provides a breakdown of participants by gender, grade, and intervention condition.

Skill Testing

Three manipulative skill tests (throwing, catching, and kicking) were selected on the basis of expert opinion (Reuschlein & Haubenstricker, 1985), their use in previous studies (Graham, 1991), and our success in administering them in the field during a pilot study of 111 fourth- and fifth-grade students in another district. The following is a description of each.

Overhand Throw. From a distance of 40 feet, the child threw a regulation "rag" ball overhand to attempt to hit a circular target that was 6 feet in diameter and 1 foot off the ground.

Catch. The child attempted to catch a regulation softball-size "rag" ball that was tossed underhand from a distance of 45 feet with an arc, so that it would have landed within a target circle having a diameter of 20 feet.

Kick. The child attempted to kick a stationary, fully-inflated, 8-inch, play-ground ball 30 feet directly ("on the fly") into a 20-foot-by-10-foot rectangular wall target.

The order of testing in the seven schools was randomized. All tests were administered according to a written protocol by a team of eight trained, paid, adult assessors. Briefly, the three tests were conducted outdoors under favorable weather conditions in a random order and without the student's physical education instruc-

Table 1 Numbers of Students by Gender, Grade, and Study Condition

	Study condition		
	Controls	Classroom teachers	Physical education specialists
Boys			
4th grade	72	66	62
5th grade	60	56	42
Girls			
4th grade	67	76	55
5th grade	67	44	42

tor present. Just prior to a test, each participant was provided with scripted instructions and a demonstration by an assessor. The child took one practice trial and then made three successive scored attempts at the skill. An assessor scored the result of each trial immediately on a prepared form. A success was scored when the child caught the ball before it hit the ground, or hit the target directly on the throw or kick. Agreement between the participant and the assessor on the success of a trial was 100% for all three skills. A catching trial in which there was a bad toss by an assessor was retaken. The maximum range of scores was 0-3 for each skill, and 0-9 for "total skills," an aggregate variable created by summing the individual skills. Qualitative assessments about the participants' form were not made, and no verbal feedback was provided about their effort or skill topography. The assessors, who were trained by the measurement director, conducted practice tests on nonstudy children before data were collected. During data collection, the measurement director rotated from station to station to ensure that test protocols were being followed.

Data Analysis

Baseline Comparisons. To evaluate the need to adjust for baseline differences in the analysis of skills improvement, various preliminary analyses were performed on baseline data. For example, a $3 \times 2 \times 2$ analysis of variance of age (measured as of the fall of fourth grade for all students) with the factors *condition*, *gender*, and *grade* revealed slight but statistically significant differences by condition and gender. Age was also found to be significantly positively correlated with the three individual baseline skills and the baseline summary measure (all $p < .001$, correlations not reported).

Because of these findings, baseline skills were residualized to adjust for age before being analyzed for differences. That is, each of the four baseline measures was regressed on age, and residuals were calculated. The grand mean of the baseline measure was added to each residual, thus creating a residualized score that could be interpreted on the same scale as the raw score.

Each of the four residualized baseline skills was analyzed using a $3 \times 2 \times 2$ ANOVA with the factors *condition*, *gender*, and *grade*. Any nonsignificant interactions were dropped from the model. Significant differences in baseline skills were found across all three factors.

Analyses of Skills Improvement. Improvements in individual and summary skills were calculated by subtracting each student's fall measure from his or her corresponding spring measure. Each skill improvement was, as expected, significantly negatively correlated with the corresponding baseline (fall) measure (all $p < .001$), but was not correlated with age. The four improvement scores were residualized to adjust for age and baseline skill. For example, catch improvement was regressed on age and baseline catch, and the grand mean of catch improvement was added to each residual to create a residualized change score for catch.

Each of the four residualized change scores was analyzed using a $3 \times 2 \times 2$ ANOVA with the factors *condition*, *gender*, and *grade*. Nonsignificant interactions were dropped from the model. Post-hoc testing for specific differences among conditions was done by significance testing of the relevant parameters in the model.

Effect Size. For each skill change measure, an effect size was calculated to quantify the gains achieved by the intervention relative to the controls. It was calculated by dividing the difference between the adjusted mean PES and CO gains

(or between the adjusted mean TT and CO gains, whichever was larger) by an estimate of the underlying standard deviation of gain. For this estimate the square root of the within-cell mean square derived from the $3 \times 2 \times 2$ ANOVA was used. Effect sizes were similarly defined and calculated for the study of gender and grade. An effect size of 0.1 was considered small, 0.3 was moderate, and 0.4 was large (Cohen, 1977).

Results

For descriptive purposes, raw scores for total skills (sum of catch, kick, and throw scores) taken at pre- and post-measurement periods are displayed in Figure 1 by condition, gender, and grade. A $3 \times 2 \times 2$ ANOVA was performed on age with the factors condition, gender, and grade. No significant interactions existed among the three factors, but significant main effects were found for condition and gender. Students in the PES schools had a mean age of 9.56 years, whereas those in the CO and TT schools were on average 9.46 and 9.45 years old, respectively ($p = .013$). Boys were older than girls, their mean ages being 9.56 and 9.42 years, respectively ($p < .001$). There was no significant difference between grades: taken in the fall of fourth grade, the mean age of the fourth-grade cohort was 9.51 years, whereas that of the fifth-grade cohort was 9.47 years ($p = .198$). The group means reported above for each factor were adjusted for the other two factors in the ANOVA model.

The results of the $3 \times 2 \times 2$ ANOVAs of residualized baseline skills are summarized in Tables 2, 3, and 4. In only one model, catching, was there a significant interaction, between gender and grade ($p = .002$). Fifth-grade girls were significantly more skilled at catching than fourth-grade girls (2.20 vs. 1.58, $p < .001$). Fifth-grade boys were also more skilled at catching than fourth-grade boys, but the difference in skill levels (2.63 vs. 2.43, $p = .037$) was one-third smaller than that for girls. With respect to the main effect of condition, significant differences in catch were found (Table 2, $p = .036$), but Bonferroni-corrected tests of the model parameters did not reveal differences among any pairs of conditions.

Of kicking, throwing, and total skills at baseline, significant condition main effects for kicking and total skills were found (Table 2, $p = .015$ and $p = .013$, respectively). In both cases, the TT students were significantly more skilled than the PES students. The main effects of gender and grade were significant for all three of kicking, throwing, and total skills at baseline (Tables 3 and 4). Generally, boys were more skilled than girls, and fifth-grade children were more skilled than fourth-grade children.

The results of the $3 \times 2 \times 2$ ANOVAs of residualized change scores are also summarized in Tables 2, 3, and 4. In none of these models were significant interactions present. The main effect of condition was significant for catching and throwing (Table 2, $p = .005$ and $p = .008$, respectively). In both cases, the TT students improved significantly more than the CO students. For total skills, the condition main effect approached significance ($p = .059$).

The main effect of gender was highly significant for all skill changes (Table 3, all $p < .001$). Boys improved more than girls in all skills. Only for kicking was the main effect of grade significant (Table 4, $p = .001$), although for throwing and total skills it approached significance ($p = .087$ and $p = .080$, respectively). Generally, fifth-grade students improved more than fourth-grade students.

Effect sizes for these significant results can be interpreted as follows. The

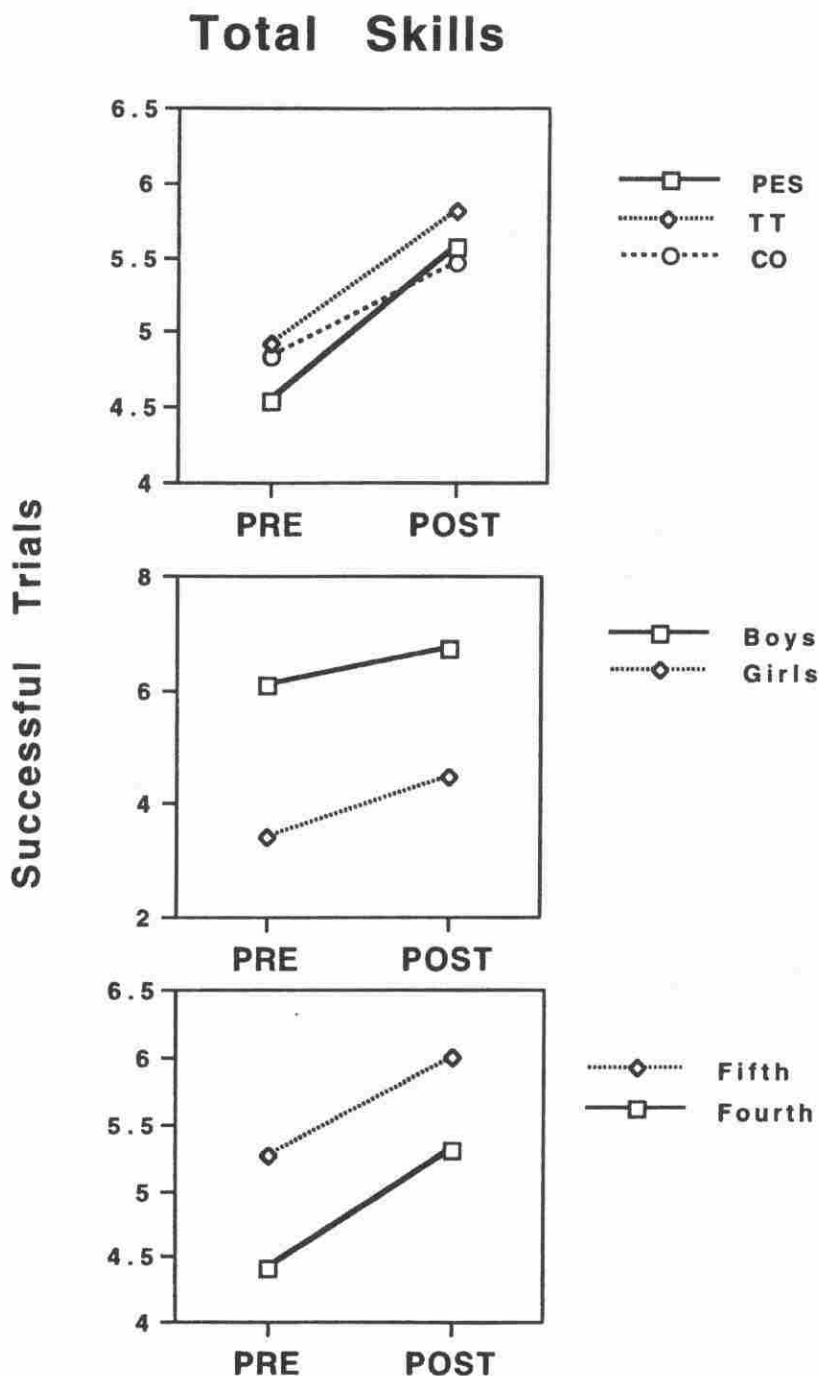


Figure 1 — Mean Pre- (fall) and Post- (spring) scores for total skills by Condition, Gender, and Grade.

Table 2 Mean Baseline Skill and Change Scores for Students ($n = 709$) in Control, Trained Classroom Teacher, and PE Specialist Schools, Adjusted for Gender and Grade

	(1) Controls ($n = 266$)	(2) Trained teachers ($n = 242$)	(3) PE specialists ($n = 201$)	Estimated SD^c	p value of main effect of condition	Significant contrasts ^d	Effect size
Baseline ^a							
Catch	2.27	2.29	2.08	0.92	.036	*	—
Kick	1.47	1.58	1.30	1.03	.015	$2 > 3$	—
Throw	1.16	1.16	1.10	0.92	.721		—
Total	4.90	5.02	4.48	1.98	.013	$2 > 3$	—
Change ^a							
Catch	0.29	0.47	0.41	0.63	.005	$2 > 1$	0.29
Kick	0.24	0.15	0.23	1.01	.577		0.09
Throw	0.15	0.39	0.22	0.91	.008	$2 > 1$	0.27
Total	0.65	0.97	0.92	1.63	.059		0.20

^aSquare root of within-cell mean square of $3 \times 2 \times 2$ ANOVA.^bPairwise comparisons with Bonferroni correction.^cBaseline skills were residualized for age at the beginning of fourth grade.^dChange scores were residualized for age and baseline skill.

*No significant pairwise comparisons.

Table 3 Mean Baseline Skill and Change Scores for Boys and Girls, Adjusted for Condition and Grade

	Boys (<i>n</i> = 358)	Girls (<i>n</i> = 351)	Estimated <i>SD</i> ^a	<i>p</i> value of main effect of gender	Effect size
Baseline ^b					
Catch	2.53	1.89	0.92	^d	—
Kick	1.90	1.00	1.03	.001	—
Throw	1.60	0.68	0.92	.001	—
Total	6.04	3.56	1.98	.001	—
Change ^c					
Catch	0.49	0.30	0.63	.001	0.30
Kick	0.38	0.03	1.01	.001	0.35
Throw	0.55	-0.04	0.91	.001	0.65
Total	1.16	0.54	1.63	.001	0.38

^aSquare root of within-cell mean square of $3 \times 2 \times 2$ ANOVA.^bBaseline skills were residualized for age at the beginning of fourth grade.^cChange scores were residualized for age and baseline skill.^dSignificant interaction between gender and grade, $p = .002$.**Table 4** Mean Baseline Skill and Change Scores for Fourth- and Fifth-Grade Students, Adjusted for Condition and Gender

	Fourth grade (<i>n</i> = 398)	Fifth grade (<i>n</i> = 311)	Estimated <i>SD</i> ^a	<i>p</i> value of main effect of grade	Effect size
Baseline ^b					
Catch	2.00	2.42	0.92	^d	—
Kick	1.32	1.58	1.03	.001	—
Throw	1.04	1.24	0.92	.003	—
Total	4.36	5.24	1.98	.001	—
Change ^c					
Catch	0.37	0.42	0.63	.275	0.08
Kick	0.08	0.33	1.01	.001	0.24
Throw	0.20	0.31	0.91	.087	0.13
Total	0.74	0.96	1.63	.080	0.13

^aSquare root of within-cell mean square of $3 \times 2 \times 2$ ANOVA.^bBaseline skills were residualized for age at the beginning of fourth grade.^cChange scores were residualized for age and baseline skill.^dSignificant interaction between gender and grade, $p = .002$.

effects of condition—specifically, TT relative to CO—on catch and throw improvement were small to medium. The effect of gender on throw improvement was between medium and large; for all other improvement measures, the effects of gender were between small and medium. For kicking improvement, the effect of grade was small.

Discussion

The primary purpose of this study was to investigate the effects of a physical education and professional development program on the manipulative skills of children. The finding of differential effects among the three study conditions on two of the three skills (catching and throwing) after only 6 months was surprising. Both the intervention and control curricula included activities that used these skills, and previous studies of skill acquisition in general physical education programs have not provided evidence of significant learning or change from baseline to posttests (Graham, 1991; Rink, French, & Tjeerdsma, 1996). Reasons for nonsignificant changes have included the limited length of the period of study; the limited opportunity students had to learn skills (e.g., small number of lessons, brief physical education classes, few actual skill trials); and the inclusion of multiple objectives in physical education programs (i.e., cognitive, fitness, social, and emotional objectives, in addition to motor skill learning).

Several factors associated with the intervention, which included a predesigned curriculum and professional development program, may have contributed to the stronger than expected skill gains. While heredity and growth are associated with skill learning, skill development can also be altered by changes in the learning environment, such as schedules of practice, feedback, and transfer (Robb, 1972). A main goal of the intervention under study was to engage children in ample amounts of moderate to vigorous physical activity. Systematic observations of lessons in the seven schools during the time of the study indicated that there were differences in the quantity and quality of the instruction provided in the CO, TT, and PES conditions (McKenzie et al., 1997). For example, students in PES and TT schools spent significantly more time actively engaged in fitness activities and skill drills (but not necessarily drills related to the three measured skills) than students in CO schools. At the same time, CO children spent significantly more minutes per week in free play than either PES or TT children. Graham (1987) has suggested that few motor skills are learned during game play; therefore, the differences in the amount of time PES and TT teachers allocated for skill drills may account for some of the changes in children's catching, kicking, and throwing. Another possible influence was the physical education and self-management curricula's promotion of activities that could be done outside of school, either through organized sport teams or with parent/guardians or friends. If intervention students joined more sports teams or practiced more times beyond physical education than controls, it may have influenced their learning of the measured skills.

Ashy, Lee, & Landin (1988) have suggested that practicing skills using correct technique is more important than the overall number of practice attempts. While the number of skill attempts during lessons was not measured, other data (McKenzie et al., in press) indicated that the specialists and trained classroom teachers provided more active instruction (i.e., prompts and feedback) during lessons than control teachers. The additional instructional prompts and feedback, which

were scripted within the curriculum, may also have had some influence on the development of skills. Meanwhile, children in PES and TT schools also became more physically fit than those in control schools (Sallis et al., 1997). Increases in fitness parameters, such as strength, may also have contributed to enhanced motor performances.

The effect sizes in Table 2 show that the curriculum had a small to moderate effect on skill improvement (Cohen, 1977) and that the impact on children was meaningful. The finding of no significant interactions for gender and grade on intervention condition suggests that the curriculum had similar effects on boys and girls and with fourth- and fifth-graders. From a curriculum development viewpoint, the finding that gains in skills were noted for boys and girls during both years is important.

With respect to absolute gains, TT students showed the most improvement in total skills, followed closely by PES students. In terms of percent gains, PES students improved the most at 21%, whereas TT and CO students improved 19% and 13%, respectively. (That TT students had higher baseline total skills explains the reversal in ranking of TT and PES.) These results suggest that children's manipulative skills can be improved by quality physical education programs delivered by both trained PE specialists and classroom teachers. This is an important finding, because elementary school physical education in North America is frequently taught by classroom teachers (National Association for Sport and Physical Education, 1994). It is important to emphasize, however, that the gains produced by the classroom teachers came as a result of implementing a carefully designed and tested PE curriculum and that this curriculum was accompanied by substantial training, monitoring, and follow-up support.

It is surprising that the PES condition did not lead to greater improvements than TT. Because of the extensive training of the PE specialists, the superior quantity and quality of their instruction (McKenzie et al., 1997), and the fitness outcomes their classes produced (Sallis et al., 1997), it was expected that PES students would improve their skills more than CO and TT students. Table 2 shows improvements in catching and total skills are similar for PES and TT. The lower baseline skill scores in the PES students may indicate that they had fewer opportunities for sports and game play outside of class.

A secondary purpose of this study was to explore the development of children's motor skills by gender and grade level. Previous studies of manipulative skills (Haubenstricker & Seefeldt, 1986) suggested that boys would be more skilled than girls. The girls' total skill scores at baseline were 41% lower than the boys' scores, and the girls had smaller absolute gains. At the end of the study, the girls' total skill scores were 43% lower than the boys' scores. This is a large difference, considering that the skills measured are those commonly used in coeducational activities offered in instructional and competitive programs at school and in the community.

Scores for all skills were higher at the fifth-grade baseline than at the fourth-grade baseline, and these differences were anticipated. Children are expected to increase their skills as they mature, as a result of natural growth and development and from the experiences they have in and out of school. Using adjusted scores, fifth-graders tended to make the greater improvements, particularly in kicking. It is unclear why kicking produced the only significant difference in increases by grade level.

The skill tests served as an authentic assessment of performances in a controlled context. The tests were outcome-based, with judgments being made on whether a ball was caught or thrown and kicked to target, not on how the performance looked topographically. A limitation of the study is that the tests did not measure the manipulative skills during game play, seen by some as the most authentic measure of a program's effectiveness (Rink et al., 1996). The measurement of the skills in controlled conditions, however, was a strength, in that the established performance setting was standardized across the seven schools during two different measurement periods.

Another strength of this study is that the skill tests provided a meaningful assessment of program outcomes. Throwing, catching, and kicking are fundamental and generalizable manipulative skills that are prerequisites to success in many school and community sports programs. Testing was done by an independent measurement staff, and the children's physical education teachers were generally unaware of test specifics, not informed of test results, and did not have drills prescribed in their programs that closely resembled the testing conditions. Multiple and diverse throwing and catching drills and games did, however, occur as part of Frisbee, field games, basketball, and softball units, and kicking balls occurred during soccer and field game units. The timing of the tests was not tied to preselected instructional units, so training in any particular skill usually did not immediately precede testing.

There were several limitations to this study. With only 6 months between baseline and post-measurement periods, an analysis of long-term effects was not possible. Additionally, the three measured skills represented only a subset of relevant manipulative skills for this age group, and other skills may have had smaller or larger intervention effects. As well, at each measurement period children, had only three attempts at each skill. This resulted in a range of scores from only 0 to 3 for each skill, and only 0 to 9 for total skills. This limited range constrained the ability to demonstrate significant change. The study of skill improvement from physical education curricula needs to be expanded to other age groups, other curricular approaches, and other skill outcomes.

The SPARK intervention was designed to be a comprehensive PE program, with an emphasis on promoting healthful patterns of physical activity. Several positive effects of the program on the quality and quantity of instruction (McKenzie et al., 1997) and children's physical fitness and increased physical activity during class time (Sallis et al., 1997) have been documented. Program components that may have contributed to beneficial effects on manipulative skills include: (a) a curriculum that built in multiple-skill practice trials in each lesson, (b) appropriate sequences for skill learning, (c) teacher feedback and praise for skill learning, and (d) encouragement to use movement skills in out-of-class activities.

It is important that children learn fundamental skills early in life, because they are prerequisites to successful participation in many sports and may be associated with increased health-related physical activity that continues into adulthood. From the analyses of residualized data, it appears that subgroups already more skilled at baseline (i.e., boys, fifth-graders, and those taught by trained teachers) tended to improve relatively more than those that were less skilled. The role quality school physical education programs play in developing skills cannot be over-emphasized. The present study indicated that modifications made within a physical education program in a school district can improve students' motor skills. The study also suggests that physical education programs may need to give additional

attention to the skill needs of girls, particularly if they are expected to participate on an equal basis with boys in activities involving manipulative skills.

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