

## Motor Skill Competency and Physical Activity in Elementary School Students

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### Abstract

**Background:** Childhood mastery of manipulative skills predicted their adolescent learning and mastering specialized skills needed for successful participation in sports and activity. This study investigated relationships between levels of manipulative skill competency and participation in physical activity in school-aged children.

**Methods:** 265 fifth-grade students voluntarily participated in this study. The students' skill performance in four basic specialized manipulative skills was assessed using reliable and valid assessment rubrics with process- and product-oriented criteria. The students' daily physical activity was assessed using a 7-day daily physical activity (PA) log. Data were analyzed with descriptive statistics and univariate analyses, Pearson bivariate correlation, and multiple R-squared liner regression methods.

**Results:** The results of regression models indicated that overall skill competency in four manipulative skills significantly contributed to weekly PA minutes for the total sample and girls, but not for boys. Specifically, girls' competency in soccer skills was a significant predictor of weekly PA minutes. Independent sample t-tests revealed that both boys and girls in the Skill-Competent group spent a significant amount of time in PA than their counterparts in the Skill-Incompetent group.

**Conclusions:** Manipulative skill competency plays a significant role in participation in PA inside and outside of school for school-aged children, especially for girls. Improving girls' manipulative skill competency is a key determinant of PA behavior for girls.

**Conflict of interest statement:** We do not have any financial interest of the subject matter discussed in the manuscript.

**Key words:** Manipulative Skills, Physical Activity, Physical Activity Measure, Skill Competency, Skill Assessments,

### BACKGROUND

Despite the critical role of regular physical activity in contributing to overall health and preventing childhood obesity [1-9], a substantial proportion of children are not engaging in the recommended amount of physical activity [1-3]. Due to physical inactivity, obesity prevalence in youth has almost tripled since 1980 [2, 3]. Currently, almost one-third of U.S. children are overweight or obese [2]. To effectively combat the obesity epidemic, U. S. Department of Health and Human Services (USDHHS) Physical Activity Guidelines [1] recommends that school-age children and adolescents participate in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) each day.

Fundamental motor skills are building blocks for children to successfully participate in a variety of organized and non-organized sports and physical activities [8-17]. They consist of locomotor skills, non-locomotor skills, and manipulative skills (object control). Cross sectional studies have found a positive relationship between fundamental motor skill competency and physical activity (PA) in children [9-17]. In particular, childhood mastery of manipulative skills predicted their adolescent learning and mastering specialized skills needed for successful participation in sports and activity [10, 11]. Supporting the empirical findings, Stodden et

al.[8] proposed a reciprocal and developmentally dynamic relationship between motor skill competence and physical activity. At the heart of the conceptual model, motor skill competence is an essential determinant of engagement in physical activity. Children with motor skill competence are willing to engage in higher levels of physical activity, while children with motor skill incompetence participate in lower levels of physical activity [8-17].

Previous studies have used various versions of an operational definition of motor skill competence without considering developmental nature and levels of motor skill competence[8]. In addition, previous studies [8-15] have used either product-oriented assessment or process-oriented assessment tools to assess children's motor skill competency with "yes" or "no" rating scale indicating "skilled" or "not skilled". Given the lack of using both process- and product-oriented assessments for assessing levels of motor skill competency, this study used PE Metrics assessment rubrics[18] to assess both process and product of skill performance.

To better understand how motor skill competency contributes to participation in physical activity, the purpose of this study was to examine relationships between manipulative skill competency and physical activity participation in school-aged children. This study hypothesized that (a) four manipulative skills were significant predictors of an overall weekly PA minutes, and (d) there were significant differences of weekly PA minutes between skill competent and skill incompetent groups by gender. The significance of this study was to provide insightful information about how to use tailored intervention strategies for promoting PA participation for boys and girls.

## METHODS

### Subjects

Participants were 265 fifth-grade students at elementary schools in a suburban area of the Mid-West in the United States. They were recruited from the second year of a 3-year Healthy Kids and Smart Kids project. The project was designed to help elementary school students become physically active, mentally healthy, and socially cooperative children through implementing the innovative physical education curriculums, Mileage Club (MC) Recess Program, and family and community events. The inclusion criteria for choosing the subjects of this study were that the fifth-grade students must complete all measures including four manipulative skill assessments and daily physical activity (PA) log. 265 fifth-grade students (133 boys, 132 girls) who met the inclusion criteria were comprised of the study subjects. The university institutional review board and the school district granted the permission for conducting this study. The parent/guardian signed the consent form to grant the permission of their child for participating in this study.

### Data Collection

**Motor skill assessments.** Students' motor skill competency in four manipulative skills was assessed using PE Metrics Assessment Rubrics<sup>18</sup> during a regular physical education lesson. With an extensive four-years field-testing skill performance of 4,000 students at 90 elementary schools across the nation, PE Metrics provide valid and reliable ready-to-use assessment rubrics to assess levels of students' motor skill competency with both process- and product-oriented criteria. Given the unique nature of a skill, The PE Metrics<sup>18</sup> provides grade-specific and skill-specific assessment rubrics. Each assessment rubric has its own unique essential dimensions and performance indicators on each of 4-point rating scales as well as the number of trial for testing. The skills selected from the PE Metrics [22] and assessed in this study were four manipulative skills, which are basic specialized skills used in playing a variety of team- and individual-sports by elementary school students.

For soccer dribbling, passing, and receiving assessment, students' performance levels were assessed on three essential dimensions: Dribbling, Passing, and Receiving with a 0-4 rating scale. Criteria for Competence (level 3) for Dribbling are: "dribble with control while moving at

a slow, consistent jog,” for Passing are: “sends a receiving lead pass to a partner so it can be caught outside the passing lane without a break in the receiver’s stride on at least 3 passes,” and for Receiving are: “moves forward and outside the passing lane to meet the ball and receiving at least 3 receivable passes” [18] (p. 120). Details of the assessment task were described on the PE Metrics [18] . One trial was allowed for the test. A total score of 9 indicated an overall competent level.

For the overhand throwing skill assessment, students were assessed on their performance levels of the two essential dimensions: Form and Accuracy to Target using a 0-4 rating scale. Criteria for Competence (Level 3) for Form are: “throws with selected essential elements: a) throwing elbow shoulder-high, hand back and side orientation in preparation for the throw. b) trunk rotation, with elbow lagging behind hip. c) weight transfer to non-throwing forward foot.” Criterion for Accuracy to Target is: “hits target area on wall” [18] (p. 117). Details of the assessment task were referred to the PE Metrics [18] . Each student was given 3 trials. A total score of 18 indicated an overall competent level.

For the basketball dribbling, passing, and receiving skills assessment, the students’ performance levels were assessed on three essential dimensions: Dribbling, Passing, and Receiving, with 0-4 rating scale. The assessment task involved a person in dribbling, passing, and receiving a ball with a partner while jogging within a lane marked with cones (15-foot wide and 150-foot long). The criteria for competency (level 3) for each skill echoed respective soccer dribbling, passing, and receiving. One trial was allowed for the test. A total score of 9 indicated an overall competent level [18] .

For the striking skill assessment, the students’ performance levels were assessed on the two essential dimensions: Form and Continuous Strikes, using a 0-4 rating scale. Criteria for Competence (Level 3) for Form are: “usually uses a side orientation” and for Continuous Strikes are: “strikes the ball continuously against the wall 5 times from 10 feet with added strokes that may be in front of the 10-foot striking line” [18] (p. 126). One trial was allowed for the test. A total score of 6 indicated a competent level [18] .

Physical activity measure. Students’ daily physical activity was assessed using a daily physical activity (PA) log. In review of a validated questionnaire [19] designed for measuring children a 7-day physical activity, the investigator designed a 7-day daily PA log for elementary school students in grade 5 to record their participation in physical activity each day. On the 7-day daily PA log, Monday through Sunday are listed under the left column labeled “days”. On each weekday, four items listed under the middle column labeled “where did you do PA” included in PE class, during recess, non-organized physical play, and organized sports/dances. On each weekend, only two items including non-organized play and organized sports/dances were listed. Under the right column labeled “how many minutes”, there are four blank rows on each weekday for participants to record the total minutes spent in PA in PE class, during recess, non-organized physical play, and organized games/dances. Besides that, there are two blank rows on each weekend for participants to record how many PA minutes they engaged in non-organized physical play and organized games/dances.

To help the students recall what they have participated in PA on the previous day and the previous weekend as objectively as possible, each physical education teacher worked with students’ home room teacher to monitor the students to record their participation in PA daily. The protocols were (a) at the beginning of each school day, the students recorded the total minutes of PA they participated in after school non-organized physical play and organized sports/dance on the previous day and/or the previous weekend, and (b) at the end of each school day, the students recorded the total minutes of PA they engaged in PE class and during recess on the daily PA log.

### Data Analysis

Descriptive statistics were computed for each manipulative skill assessment and weekly PA minutes. Independent sample *t*-test was utilized to examine the difference of the mean scores in

each skill assessment and weekly PA minutes between boys and girls. Pearson product-moment correlations were computed to examine relationships between each skill test and weekly PA minutes by the total sample and gender. Multiple R-squared linear regression analyses were performed to examine the association of manipulative skill competency with weekly PA minutes for the total sample and for boys and girls separately. Subsequently, standardized multiple regression coefficients were analyzed to assess a relative importance of each manipulative skill predicting weekly PA minutes for boys and girls separately. Further, a total score of the four manipulative skill assessments were computed to classify an overall skill competence into two groups (Skill-Competent Level = 42-56 scores, Skill-Incompetent Level = 14-41 scores) based on the PE Metrics criteria for defining the Competent Level. An independent sample *t*-test was conducted to examine a significant difference of the mean weekly PA minutes between two levels of overall skill competency by gender.

## RESULTS

### Descriptive Statistics and Univariate Analysis of Skills and Weekly PA Minutes

Table 1 presents the descriptive statistics of skill assessments by the total sample and gender. Regarding the skill assessments, the mean scores of the total sample showed moderately higher than the Competent Level on soccer skills, throwing skill, and basketball skills. The mean score of striking skill was at the Competent Level. Boys' mean scores of soccer skills, throw skill, and basketball skills were moderately higher than the Competent Level and their mean score of striking skill was slightly higher than the Competent Level. In contrast, girls' mean scores of three skill assessments were slightly higher than the Competent Level, but their mean score of striking skill was lower than the Competent Level.

**Table 1.** Descriptive Statistics of Skill Assessments by Gender and Total Sample

	N	Mean ± SD	SE	% of Competence
<b>Soccer skills (9 = Competent Level)</b>				
Boys	133	10.2 ± 1.70	.15	86%
Girls	132	9.1 ± 1.96	.17	67%
Total sample	265	9.7 ± 1.67	.12	77%
<b>Throwing skill (18 = Competent Level)</b>				
Boys	133	20.2 ± 3.21	.28	85%
Girls	132	18.4 ± 3.18	.28	65%
Total sample	265	19.3 ± 3.31	.20	77%
<b>Basketball skills (9 = Competent Level)</b>				
Boys	133	10.1 ± 1.59	.14	86%
Girls	132	9.2 ± 1.62	.14	74%
Total sample	265	9.67 ± 1.66	.10	80%
<b>Striking skill (6 = Competent Level)</b>				
Boys	133	6.4 ± 1.44	.13	76%
Girls	132	5.8 ± 1.40	.12	64%
Total sample	265	6.1 ± 1.45	.89	70%
<b>Total skill (42 = Competent Level)</b>				
Boys	133	46.9 ± 6.09	.53	77%
Girls	132	42.6 ± 5.70	.50	59%
Total sample	265	44.8 ± 6.28	.39	68%

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For boys, the greatest proportions of demonstrating the Competent Level or above were soccer skills (86%) and basketball skills (86%), followed by throwing skill (85%) and striking skill (76%). Although the proportions of girls demonstration of the Competent Level or above were different from those of boys, girls had a similar order as boys, ranging from highest to lowest (74% for basketball skills, 67% for soccer skills, 65% for throwing skill, and 64% for striking skill). The results of *t*-test indicated that boys scored significantly higher than girls on soccer skills ( $t = 4.92$ ), throwing skill ( $t = 4.57$ ), basketball skills ( $t = 4.30$ ), and striking skill ( $t = 3.54$ ) with  $df = 263$  at  $p < .01$  level.

**Table 2:** presents descriptive statistics of each weekly PA variable and a total weekly PA variable by gender.

	Mean ± SD (Boys)	SE	Mean ± SD (Girls)	SE
PE	57.54 ± 5.42	.47	57.77 ± 5.5	.49
Recess	96.03 ± 29.97	2.60	87.84 ± 32.74	2.85
Physical Play	207.73 ± 164.29	14.30	194.57 ± 136.49	11.80
Sports/dances	155.71 ± 191.58	17.13	162.05 ± 227.67	19.81
Total PA	514.73 ± 280.84	24.35	502.23 ± 269.82	23.48

Both boys and girls, on average, spent 58 minutes in PA during PE lessons. Boys spent 96 minutes and girls spent 88 minutes in PA during recesses. Boys' mean minutes spent in non-organized physical play were 207, while girls' were 195. Boys spent 156 minutes and girls spent 162 minutes playing organized sports/dances. Independent sample *t*-tests yielded a significant difference of mean weekly recess minutes between boys and girls ( $t = 2.12$ ,  $df = 263$ ,  $p < .05$ ), but not on the rest of PA variables. The results indicated that boys were more physically active than girls during recess.

### Bivariate Correlations between manipulative skills and Weekly PA Minutes

Table 3 shows Pearson bivariate correlations between each skill assessment and weekly PA minutes by the total sample and gender. For the total sample, soccer, throwing, basketball skills were moderately and significantly correlated with the weekly PA minutes at  $p < .01$ , except for striking skill. For boys, throwing, basketball, and striking skills were moderately and significantly correlated with the weekly PA minutes at  $p < .05$ , but soccer skills were not significantly correlated with the weekly PA minute. For girls, soccer, throwing, and basketball skills were moderately and significantly associated with the weekly PA minutes at  $p < .01$  level, but no significant correlation between striking skill and the weekly PA minutes was found.

**Table 3.** Bivariate Correlation Coefficients between Each skill and PA Total

		Soccer	Throwing	Basketball	Striking
Total Sample	PA total	.23**	.19**	.25**	.09*
Boys	PA total	.14	.18**	.17*	.15*
Girls	PA total	.32**	.19**	.33**	.02*

### Predictions of Manipulative Skills to Weekly PA minutes

Table 4 shows results of the multiple R-squared liner regression models predicting weekly PA minutes by the total sample and gender. Each regression model consisted of four manipulative skills as independent variables and the weekly PA minutes as a dependent variable. The results of the regression models indicated that the interaction of four manipulative skills significantly predicted the weekly PA minutes for the total sample and girls at  $p < .01$ , but not for boys. The manipulative skills explained 8% of the variance in the weekly PA minutes for the total sample, only 5% for boys, but 16% for girls. The standardized regression coefficients ( $\beta$ ) for the total

sample and for boys indicated that none of the manipulative skills was a significant contributor to the weekly PA minutes. In contrast, the standardized regression coefficients ( $\beta$ ) revealed that soccer skills were significant contributors to the weekly PA minutes for girls.

**Table 4.** Results of Regression Models by Total Sample and Gender

		R <sup>2</sup>	F	p	Beta	t	P
<b>Total Sample</b>							
	Model 1	.076	5.379	< .01			
	Soccer skills				.10	1.34	> .05
	Throwing skill				.09	1.25	> .05
	Basketball skills				.15	1.92	> .05
	Striking skill				-.01	-0.18	> .05
<b>Boys</b>							
	Model 2	.05	1.62	> .05			
	Soccer skills				-.01	-.07	> .05
	Throwing skill				.11	1.11	> .05
	Basketball skills				.10	0.81	> .05
	Striking skill				.08	0.88	> .05
<b>Girls</b>							
	Model 3	.16	5.94	< .01			
	Soccer skills				.23	2.26	< .05
	Throwing skill				.14	1.50	> .05
	Basketball skills				.18	1.79	> .05
	Striking skill				-.10	-1.12	> .05

### Levels of Manipulative Skill Competency and Weekly PA Minutes

Based on 42, the overall skill competent score, 102 boys were in the Skill Competence (SC) group ( $M = 49.52$ ,  $SD = 4.22$ ), while 31 boys were in the Skill Incompetence (SI) group ( $M = 38.42$ ,  $SD = 2.35$ ). An independent sample  $t$ -test revealed that boys in the SC group spent significant more minutes in weekly PA than their counterparts in the SI group ( $SC_{\text{mean}} = 539.87$ ,  $SI_{\text{mean}} = 432.06$ ,  $t = 2.08$ ,  $df = 58.51$ ,  $p < .05$ ). Similarly, based on 42, the overall skill competent score, 78 girls were classified into the SC group ( $M = 46.35$ ,  $SD = 3.46$ ), while 54 were in the SI group ( $M = 37.09$ ,  $SD = 3.38$ ). The results of  $t$ -test yielded a difference of the mean weekly PA minutes between the two groups ( $SC_{\text{mean}} = 538.36$ ,  $SI_{\text{mean}} = 450.04$ ,  $t = -1.91$ ,  $df = 121.97$ ) at  $p = .06$  level for girls.

### DISCUSSION

Consistent with the conceptual model [8], this study indicated that motor skill competency in the four manipulative skills played a significant role in contributing to weekly participation in PA among elementary school students. Specifically, both boys and girls who demonstrated the Competent Level in four manipulative skills spent a significant greater amount of time in PA than their counterparts who showed manipulative skill incompetency. Consistent with previous findings [10-15], this study indicated that children who demonstrated manipulative skill competency tended to be more physically active. The manipulative skills assessed in this study were basic specialized skills commonly used in a variety of sports. Demonstration of competency in the manipulative skills lays a solid foundation for children to successfully engage in a variety of popular forms of sports and games [8-11]. Also, previous studies showed that children with manipulative skill proficiency contributed to their continual engagement in physical activity during their adolescence [10,11]. This study suggests that helping children demonstrate competency

in manipulative skills is essential to facilitating children to participate in physical activity. One unique finding of this study was that the relative contribution of the manipulative skills to PA was gender-specific. Of the four manipulative skills, soccer skill competency significantly contributed to PA for girls. This might be related to an increasing popularity of soccer among girls. However, this study found that 67% of girls demonstrated the Competent Level in soccer skills, while 33% did not. In addition, about one-third of girls did not demonstrate the Competent Level in other skill assessments. On the contrary, boys significantly outperformed girls in all four manipulative skills. The proportion of boys who demonstrated the Competent Level in each skill assessment was greater than that of girls.

Another key finding of this study was that girls' motor skill competency in four manipulatives contributed to a relatively large portion of PA participation (16% of variance in weekly PA minutes), compared to boys' (5% of variance in weekly PA minutes). The results of this study confirm the critical role of manipulative skill competency in engaging PA among girls. Similarly, previous studies found that girls with manipulative skill proficiency maintained their interests and continued their participation in organized physical activity during adolescence [10,11]. In contrast, girls who were less competent in performing manipulative skills were more likely to discontinue their participation in sports-related physical activity during adolescence<sup>10,11</sup>. In addition, adolescents' participation in sports-related activities that require a repertoire of manipulative skills tends to carry over this habit into their adulthood [20].

Given the significant role of manipulative skill competency in contributing to PA for girls and a modest portion of girls who demonstrated manipulative skill incompetence, this study suggests that physical education teachers need to focus more efforts on improving girls' basic specialized manipulative skills used in playing team sports and individual sports. Physical education teachers need to design developmentally appropriate and instructionally progressive learning experiences for girls to learn and practice these skills. In the process of teaching, physical education teachers should provide girls with more specific and performance related feedback and also use appropriate teaching strategies to involve girls in playing an important role during game plays. Improving girls' competency in performing manipulative skills is an essential determinant that enables girls to participate in physical activity both in school and outside of school settings. This is because that the manipulative skills assessed in this study are basic specialized skills used in playing most popular team and individual sports among elementary school children.

### CONCLUSIONS

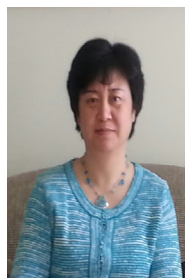
Boys and girls who demonstrated manipulative skill competency were more physically active than their counterparts with physically incompetent in the manipulative skills. The overall manipulative skill competency was more significant predictor of girls' physical activity, compared to boys. Improving manipulative skill competency is instrumental to increasing girls' physical activity participation.

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Dr. Chen is Associate Professor of School of Kinesiology at the University of Michigan. Her research primarily focuses on developing innovative and effective school-based physical activity intervention strategies for promoting daily moderate-to-vigorous physical activity, health-related physical fitness, motor skill competency, and intrinsic motivation for physical activity and identifying behavioral and psychosocial mechanisms of promoting and maintaining physically active habits and healthy weight in youth. She has been the principal investigator of two three-year U.S. Department of Education Carol White Physical Education Program (PEP) grant projects, which examined how school-based comprehensive physical activity programs facilitated elementary school students in developing healthy habits.

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