# The Relationship Between Fundamental Movement Skills and Body Mass Index in Elementary-Age Children

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# Abstract

Mastery of fundamental movement skills (FMS) is considered a crucial component in securing physical activity participation and, in turn, decreasing the likelihood of obesity. This study aimed to investigate the relationship between body mass index (BMI) and FMS performance among children ages 5 to 7 years in a rural school system. Secondly, we intended to investigate BMI grouping and gender differences in FMS performance. Participants were 39 kindergarteners and 1st graders (20 boys and 19 girls) in an Eastern Illinois K–8 public school. BMI was calculated for each participant using CDC guidelines (CDC, 2008). FMS performance was assessed using the Furtado-Gallagher Computerized Observational Movement Pattern Assessment System (FG-COMPASS). Pearson correlation coefficients were calculated to examine the relationship between BMI percentile and FMS performance. A small but negative correlation that was not significant was found for FMS Locomotor, r(2) = – .26, p > 05, and FMS Total r(2) = - .20, p > 05. In addition, a Two-way Factorial MANOVA was conducted to determine the effect of BMI levels and gender on the performance of FMS. MANOVA results indicated that gender, Wilks’ Lamda = .637, F(2,32) = 11.23, p < .001, significantly affected the combined dependent variables. No significant main effect was detected for BMI levels. Univariate analysis of variance post-hoc tests revealed that the performance of manipulative FMS significantly differs for gender, F(1,33) = 16.08, p < .001, with males (M = 12.38, SD = 2.8) overperforming females (M = 9.11, SD = 2.21). Performance of locomotor fundamental movement skills does not significantly differ for gender. These findings have implications for educators and health professionals working with rural children. Programs must ensure that boys and girls have equal opportunities to practice and master manipulative FMS.

*Keywords*: body mass index, fundamental movement skills, obesity, physical activity

# The Relationship Between Fundamental Movement Skills and Body Mass Index in Elementary-Age Children

According to the National Centers for Disease Control and Prevention (2022), childhood obesity has almost tripled since 1980. The occurrence of obesity in 1st-grade to 5th-grade students has increased from 6.5% in 1980 to 19.6% in 2008. In grades 6th through 12th, the percentage has risen from 5.0% to 18.1%. Obesity can be caused by several factors, including but not limited to low-energy supply, inactivity, and possible genetic predisposition. Children who are overweight/obese have a greater chance of remaining overweight/obese throughout adolescence and into adulthood (Nader et al., 2006). In addition, health conditions such as diabetes, hypertension, and cardiovascular disease may be absent during childhood but may appear as the individual ages (Daniels, 2006). Thus, it is important for children to stay active and one way to achieve this is by making sure they reach proficient levels on most fundamental motor skills (e.g., skipping, galloping, hopping, overhand throwing, kicking, dribbling, etc.).

ha1:fms-obe

Typically, FMS are divided into locomotor (LFMS) and manipulative (MFMS) skills. Researchers often consider total FMS (TFMS) by combining scores from LFMS and MFMS. Evidence shows that overweight children may be less proficient in fundamental movement skills than non-overweight children. This relationship may be an extension of infant weight and motor activity relationships (Wrotniak et al., 2006). In addition, overweight children tend to engage less often in physical activities, preventing them from acquiring fundamental movement skills (Stodden et al., 2014). Moreover, past research (Wrotniak et al., 2006) has indicated that children who acquire mastery in FMS tend to engage in more physical activity and participate in sports more often in comparison to those with lower levels of motor skill proficiency. This is important considering that FMS proficiency is the basis for developing more complex (specialized) motor skills used in sport-like activities (Barnett et al., 2008). According to Stodden et al. (2008), the association between motor skill proficiency and regular participation in physical activity begins in early childhood, fully matures in the teenage years, and continues into adulthood. Thus, children lacking fundamental movement skill development will likely have decreased participation in activities involving skills such as running, jumping, skipping, or specialized sport-related skills during the middle to late childhood, which could impact an active lifestyle as they age (Lopes et al., 2012). Hence, it is crucial to examine the correlation between body weight and FMS levels in young children to understand the timing and nature of this association. Armed with this understanding, professionals can improve their approach towards intervening in school environments.

ha2: fms-sex

Additionally, it is important to take into account sex differences in FMS performance. There is a prevailing belief that fundamental movement skills are primarily influenced by maturation and not greatly affected by external factors. However, while maturation does play a role in the development of these skills, it is not the only factor at play (Clark, 2007). The environment, chances for practice, reassurance, and teaching all contribute to developing fundamental movement skills (Gallahue & Ozmun, 1998). Research has indicated that there are significant disparities in manipulative and locomotor abilities between boys and girls. A recent meta-analysis (Zheng et al., 2022) examined sex differences in the proficiency of fundamental movement skills among children aged 3 to 6 years, a crucial period for motor skill development. The study found that boys were more proficient in total FMS and maniputive skills compared to girls. Meanwhile, girls showed a trend toward better locomotor skill proficiency, though this was not statistically significant. In addition, the study revealed that age was associated with gender differences in object control skills, with boys’ advantage in these skills increasing as they aged. In a study involving 1045 elementary-age children (7-11) (Barnett et al., 2008) found that boys performed better in executing manipulative skills such as catching, overhand throwing, and kicking in comparison to girls. On the other hand, girls performed slightly higher on locomotor skills, but again the difference was not statistically significant.

In another study, Wrotniak et al. (2006) found that boys displayed superior performance in terms of running speed and agility, and also excelled in the skill of overhand throw, as compared to girls. The authors argue that this could be due to the type of sports and games they are drawn to participate in, which may give males more opportunities to practice and refine motor skills. Males are drawn to more sports involving manipulative skills than locomotor skills. One potential reason for the differences in motor skills between males and females could be connected to their surroundings and social interactions with peers. Wrotniak et al. (2006) suggests that the reason why males tend to have better motor skills than females could be because of the types of sports and games they participate in. Specifically, males seem to be more interested in sports that require manipulative skills rather than locomotor skills.

Therefore, this study aimed to investigate the relationship between body mass index (BMI), sex, and FMS performance among low-income rural children ages 5 to 7 years.

ha1: fms-obe

Our first hypothesis relate to fundamental motor skill and obesity levels. We proposed that disparities would exist in the performance of fundamental movement skills between overweight and non-overweight children, with an anticipation of superior performance exhibited by non-overweight children compared to their overweight counterparts on locomotor (LFMS), manipulative (MFMS), and total (TFMS) - locomotor and manipulative combined - fundamental motor skills. In addition to grouping comparisons, we correlated BMI percentiles and FMS performance and anticipated negative significant correlation between BMI percentiles and LFMS, MFMS, and TFMS.

ha2: fms-sex

For our second hypothesis, we anticipated that boys would outperform girls on MFMS and TFMS but not on LFMS.

# Method

## Participants

Twenty boys (mean age in months = 78.8, SD=8.17) and 19 girls (mean age in months = 79.0, SD=9.76) participated in this study. The sample came from a K-6 public school in Shelby County, Illinois. Most students were Caucasian (99%), and over 50% of the parents whose children attended the school were considered low-income families. Because prospective participants were required to perform various fundamental movement skills (e.g., skipping, running, throwing) as part of the research protocol, children with special needs were excluded from this study. A letter briefly explaining the study’s purpose, along with the informed consent, was sent to parents. Two weeks after the initial contact, we emailed only those parents who still need to return the signed informed consent. Only those children whose parents signed and returned the informed consent were selected to be part of the study. Research procedures were approved through the Eastern Illinois University Institutional Review Board. To encourage student participation in the study, those who submitted their informed consent form on time were given a pedometer as a reward.

## Instrumentation and Procedures

### Anthropometry

Eligible students had their height and weight measured. Mass was measured on a calibrated electronic scale (EatSmart Products Precision Digital) to the nearest 0.1 pounds before being later converted to kilograms. We measured students with shoes and heavy clothing removed. The scale was calibrated using a 10-pound weight after every 15 students were measured to ensure scale accuracy. Height was measured to the nearest millimeter using a tape taped to the wall. Students were barefoot and stood with their backs to the wall while their height was being taken. Participants’ height and weight measurements were used to calculate the BMI of each student.

### Fundamental Movement Skill Proficiency

Like the anthropometric data, we assessed FMS proficiency during the daily physical education classes. The gym was split in two so that assessment and the physical education class could be carried out concurrently. Students were taken five at a time from their physical education classes and videotaped while performing the fundamental movement skills per the test protocol’s instructions. A trained person administered the Furtado-Gallagher Computerized Observational Movement Pattern Assessment System (FG-COMPASS).

The FG-COMPASS is a criterion-related and process-oriented assessment tool developed for school settings. Content-related validity evidence and reliability of classification decisions (Furtado & Gallagher, 2012) have been reported for the FG-COMPASS. We collected data on three locomotor (hop, horizontal jump, and skip) and five manipulative (throw, strike, kick, hand dribble, and catch) skills.

### Scoring

BMI was calculated for each participant, and scores were converted to percentile ranks following the CDC guidelines (CDC, 2022b). In addition, participants were classified based on the following criteria: underweight - less than the 5th%; health weight - 5th% to less than the 85th%; overweight - 85th% to less than the 95th%; and obesity - equal or greater than the 95th%.

Before FMS data collection, the principal investigator (PI) coding the videos was trained to become familiar with the test protocol. Videos of children performing locomotor and manipulative skills were used for training purposes. The PI and someone highly experienced with the FG-COMPASS testing protocol classified eight videos per skill. Classification scores between the PI and the expert were compared, and disagreements were discussed between the two raters. This served to improve the internal validity of this study. Per the test’s protocol, children are coded as 1, 2, 3, or 4 based on their performance on each fundamental movement skill. We added the scores for each skill within their respective subscale. Each participant was assigned a score for the locomotor subscale, the manipulative subscale, and the total test (i.e., subscales combined).

## Statistical Analyses

Preliminary analyses were first conducted to ensure no violation of the assumptions of normality, linearity, and homogeneity of variances. Descriptive statistics were calculated for all the main variables in the study.

Next, a series of factorial ANOVAs were conducted to examine the effects of sex and BMI group (normal weight versus overweight) on three separate dependent variables: Manipulative Fundamental Motor Skills (MFMS), Locomotor Fundamental Motor Skills (LFMS), and Total Fundamental Motor Skills (TFMS). The ANOVAs were designed to test the main effects of sex and BMI group, as well as the interaction between these two factors on each of the motor skill types. A stricter significance level of p < .01 was adopted to control for Type I error due to multiple comparisons.

Furthermore, non-parametric Mann-Whitney U tests were used to compare boys and girls on individual motor skills, namely, hop, jump, skip, throw, kick, dribble, catch, and batting. Mann-Whitney U tests were used in this case because these measures were ordinal, and it was unclear whether the data followed a normal distribution.

Additionally, Pearson’s correlation analysis was implemented to examine the relationships between BMI% and the three motor skills scores (LFMS, MFMS, TFMS). Pearson’s criteria were employed to interpret the strength of the correlations, with r values below 0.3 regarded as weak, 0.3 to 0.5 as moderate, and above 0.5 as strong.

All statistical analyses were conducted using jamovi software package (ref).

# Results

We start by presenting the descriptive data in Table 1. Then, we separate the results based on our stated hypotheses. We first address the grouping and correlation analysis for our first hypothesis - differences between FMS and BMI. Then, we present the results concerning our second hypothesis - sex difference in FMS performance.

You can find the descriptive statistics for FMS splitted by sex and group in Table 1. We originally placed participants into three groups based on CDC guidelines (ref): Normal weight, Overweight, and Obese. Because of a small sample sizes in the Overweight and Obese groups, we decided to combine these categories and call it Overweight.

<insert table 1 near here>

## BMI grouping

A two-way factorial ANOVA was conducted to examine the effects of sex and BMI group on manipulative fundamental motor skills (MFMS). There was a significant main effect of sex on MFMS, F(1, 35) = 15.6865, p < .001, partial η² = .309. Boys (M = 12.32, SE = 0.814) scored significantly higher on MFMS than girls (M = 9.11, SE = 0.788). However, there was no significant effect of BMI group, F(1, 35) = 0.0581, p = .811, partial η² = .002, and no significant interaction between sex and BMI group, F(1, 35) = 0.0396, p = .843, partial η² = .001.

An additional two-way factorial ANOVA was conducted to assess the impact of Sex and BMI group on locomotor fundamental motor skills (LFMS). No significant main effect was found for either Sex, F(1, 35) = 1.517, p = .226, partial η² = .042, or BMI group, F(1, 35) = 1.002, p = .324, partial η² = .028. There was also no significant interaction between Sex and BMI group, F(1, 35) = 0.147, p = .703, partial η² = .004.

Lastly, a two-way factorial ANOVA was conducted to examine the effects of sex and BMI group on total fundamental motor skills (TFMS). There were no significant main effects for sex, F(1, 35) = 2.988, p = .093, partial η² = .079, or BMI group, F(1, 35) = 0.1958, p = .661, partial η² = .006. Additionally, the interaction between sex and BMI group was not significant, F(1, 35) = 0.0107, p = .918, partial η² = .000.

In summary, while there was a significant effect of sex on MFMS, with boys performing significantly better than girls, no significant effects were observed on LFMS or TFMS. Additionally, no significant differences were found between BMI groups across all motor skill categories. The interaction effects between sex and BMI group were not significant in any of the analyses.

## Correlations

Certainly, if we’re interpreting these results using Pearson’s criteria, which often consider correlations below 0.3 as weak, 0.3 to 0.5 as moderate, and above 0.5 as strong, the revised interpretation would be as follows:

A Pearson’s correlation analysis was conducted to investigate the associations between BMI% and different motor skills scores (LFMS, MFMS, TFMS).

The correlation between BMI% and LFMS was found to be weak and negative, but not statistically significant (r(37) = -0.261, p = .108). This suggests that while there is a small downward trend indicating that higher BMI% may be associated with lower LFMS, this correlation is not strong enough to be statistically significant within this sample.

Similarly, the correlation between BMI% and MFMS was found to be very weak and negative, but also not statistically significant (r(37) = -0.067, p = .687). This indicates that higher BMI% does not significantly impact MFMS within this sample.

The correlation between BMI% and TFMS was found to be weak and negative, but not statistically significant (r(37) = -0.199, p = .225). This suggests a slight downward trend where higher BMI% might be associated with lower TFMS, but this correlation is also not statistically significant within this sample.

In summary, while there are weak negative trends between BMI% and the different motor skills scores, none of these correlations reached statistical significance in this sample. According to Pearson’s criteria, the strength of these correlations is considered weak. This suggests that in this sample, BMI% may not significantly impact these motor skills.

table 2 here

table 3 here

table 4 here

# Discussion

The purpose of this study was to explore the connection between body mass index (BMI) and FMS performance in children aged 5 to 7 years. Additionally, the study aimed to examine any differences in FMS performance based on BMI grouping and gender.

Our study did not find any evidence to support the idea that BMI is associated with FMS locomotor, FMS manipulative, and FMS total. Our results align with Logan et al.’s study in 20, which also found no significant connections between BMI and FMS.

We discovered that BMI had only small and insignificant correlations with FMS Locomotor (r = - 0.26) and FMS Total (r = - 0.20). Unlike previous investigations by Field, Graf et al., Logan et al., and Lopes et al., we were unable to confirm the hypothesis that manipulative and locomotor skills performance varied based on BMI levels. Children classified as “normal weight” had no significant differences in their skills compared to those classified as “overweight” or “obese.”

# Method

General remarks on method. This paragraph is optional.

Not all papers require each of these sections. Edit them as needed. Consult the [Journal Article Reporting Standards](https://apastyle.apa.org/jars) for what is needed for your type of article.

## Participants

Who are they? How were they recruited? Report criteria for participant inclusion and exclusion. Perhaps some basic demographic stats are in order. A table is a great way to avoid repetition in statistical reporting.

## Measures

This section can also be titled **Materials** or **Apparatus**. Whatever tools, equipment, or measurement devices used in the study should be described.

### Measure A

Describe Measure A.

### Measure B

Describe Measure B.

## Procedure

What did participants do?

How are the data going to be analyzed?

# Results

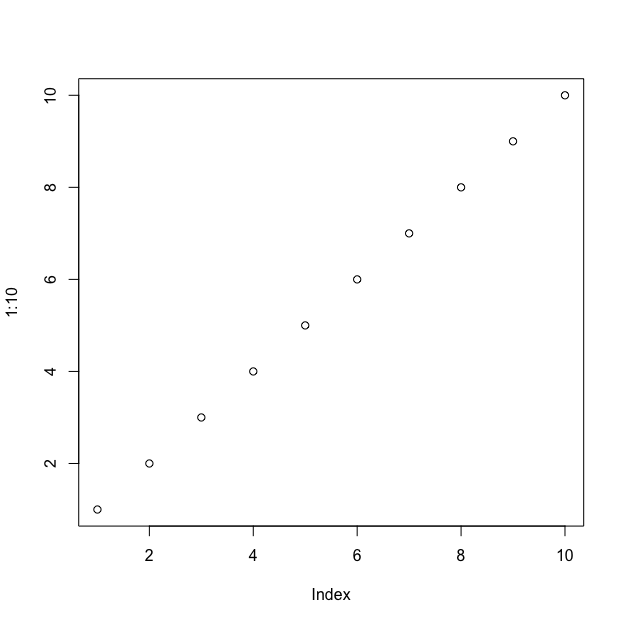
## Descriptive Statistics

Here we describe the basic characteristics of our primary variables.

Let’s make a figure. A reference label for a figure in APA format must have the prefix apafg-. This is different from the usual Quarto prefix fig-.

Figure 1

This is the figure caption.



*Note*. This is a note below the figure.

To refer to any figure or table, put the chunk label in curly braces. For example, see Figure 1. In Figure 2, we import an image.

Figure 2

This is an imported graphic.



*Note*. My note.

We can make a table the same way as a figure except that the label prefix is apatb-. Again, this is different from the usual quarto prefix tbl-, which will put the table table caption in the wrong place and with non-APA formatting.

Table 1

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| Numbers | Letters |
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| 1 | A |
| 2 | B |
| 3 | C |
| 4 | D |

*Note*. Here is the note below the table.

To refer to this table in text, put the table’s reference label in curly braces like so: As seen in Table 1, there is not much information.

What if you want the tables and figures to be at the end of the document? In the .pdf format, you can set the floatsintext option to false. For .html and .docx documents, there is not yet an automatic way to put tables and figures at the end. You can, of course, just put them all at the end, in order. The reference labels will work no matter where they are in the text.

# Discussion

Describe results in non-statistical terms.

## Limitations and Future Directions

Every study has limitations. Based on this study, some additional steps might include…

## Conclusion

Let’s sum this up.

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# Appendix

If there are multiple appendices, label them with level 1 headings as Appendix A, Appendix B, and so forth.