

## **Examining the Relationship Between BMI, Sex, and Fundamental Movement Skill Performance in Low-Income Rural Children**

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### **Abstract**

This study examined the relationship between body mass index (BMI), Sex, and Fundamental Movement Skills (FMS) performance among low-income rural children aged 5 to 7 years. 39 children (20 boys and 19 girls) participated in the study. FMS proficiency was evaluated using the Furtado-Gallagher Child Observational Movement Pattern Assessment System (FG-COMPASS). The children's height and weight were measured to calculate BMI, which was then classified into 'normal weight' and 'overweight'. A two-way factorial ANOVA assessed the effects of sex and BMI group on manipulative fundamental motor skills (MFMS), locomotor fundamental motor skills (LFMS), and total fundamental motor skills (TFMS). We hypothesized that normal weight children would outperform their overweight counterparts in locomotor (LFMS), manipulative (MFMS), and total (TFMS) fundamental motor skills and that boys would outperform girls on MFMS and TFMS but not on LFMS. Our findings showed a significant main effect of sex on MFMS, with boys performing significantly better than girls. However, no significant main effects were found for LFMS or TFMS based on sex or BMI group. Furthermore, Pearson correlation analysis revealed weak, negative, non-significant correlations between BMI percentiles and all three motor skill scores. The study's results highlight the importance of considering sex differences when assessing FMS in children and indicate that overweight status may not necessarily relate to poorer motor skill performance in a rural, low-income context. Further research should ensure a balanced representation across BMI categories and explore the potential influence of demographic factors on motor skill development.

**Keywords:** body mass index, fundamental movement skills, sex differences, childhood obesity, rural children, physical activity, motor skill development

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## **1 Introduction**

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Childhood obesity is a prevalent issue with long-term health implications, as children who are overweight or obese are more likely to remain so into adulthood (Nader et al., 2006). Although obesity-related health conditions such as diabetes and hypertension may not manifest during childhood, they can emerge as individuals age (Daniels, 2006). The prevalence of obesity among children aged 2–19 increased from 13.9% in 1999–2000 to 19.3% in 2015–2016 (Pan et al., 2018). Obesity arises from several factors, including genetic predisposition (Gurnani et al., 2015), low energy supply (Bandini et al., 1990), and inactivity (Rodrigues &

Saraiva, 2011). In response to the growing problem of inactivity and obesity among children, professionals need to promote physical activity. A crucial component of this approach is the development of fundamental movement skills (FMS). Children proficient in FMS tend to engage in more physical activity and participate in sports more often than those with lower skill proficiency (Stodden et al., 2008; Wrotniak et al., 2006). FMS proficiency forms the basis for developing more complex motor skills in sport-like activities (Barnett et al., 2008). Therefore, examining the correlation between body weight and FMS levels in young children is critical to understanding the timing and nature of this association. Recent research indicates that obesity may influence the correlation between FMS and physical activity. Overweight children may be less

proficient in FMS than their normal weight counterparts (Okely et al., 2004), suggesting a cyclical relationship between FMS, physical activity, and obesity levels (2014). Therefore, strategies to prevent unhealthy weight gain in young people should include enhancing movement abilities as an integral facet of the intervention (Okely et al., 2004). Contrary to the widespread belief that maturation is the sole factor influencing FMS development, environmental factors, practice opportunities, reassurance, and teaching contribute significantly (Clark, 2007; Gallahue & Ozmun, 1998). Similarly, sex differences in FMS performance cannot be attributed solely to physiological factors appearing after puberty (Malina et al., 2004). Recent research reveals significant disparities between boys and girls in manipulative and locomotor abilities, with boys generally performing better in manipulative skills and girls showing a trend towards better locomotor skill proficiency (Barnett et al., 2008; Zheng et al., 2022). Boys' superiority in manipulative skills may be due to their preference for sports requiring these skills (Wrotniak et al., 2006). Given this context, our study aimed to investigate the relationship between body mass index (BMI), sex, and FMS performance among low-income rural children aged 5 to 7 years. We hypothesized that normal weight children would outperform their overweight counterparts in locomotor (LFMS), manipulative (MFMS), and total (TFMS) fundamental motor skills, and that there would be a significant negative correlation between BMI percentiles and LFMS, MFMS, and TFMS. Additionally, we anticipated that boys would outperform girls on MFMS and TFMS but not on LFMS.

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## 2 Methods

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### 2.1 Participants

We selected our participants using convenience sampling. The study involved 20 boys (mean age in months = 78.8,  $SD = 8.17$ ) and 19 girls (mean age in months = 79.0,  $SD = 9.76$ ) from a K–6 public school in Shelby County, IL. The predominantly Caucasian (99%) student population came from over 50% low-income families. Children with special needs were excluded due to the requirement to perform fundamental movement skills (FMS) as part of the research protocol. Parents received a letter explaining the study's purpose and providing informed consent. Two weeks later, reminders

were sent to parents who had not yet returned the signed consent forms. Only children with signed and returned consent forms were included in the study. This study was conducted following ethical standards and guidelines, and it received approval from the relevant Institutional Review Board (IRB). Participating students received a pedometer to encourage their involvement in the study.

### 2.2 Instrumentation and Procedures

#### 2.2.1 Anthropometry

Eligible students underwent height and weight measurements. A calibrated electronic scale (EatSmart Products Precision Digital) measured mass to the nearest 0.1 pounds, later converted to kilograms. Students were measured without shoes and heavy clothing. The scale was recalibrated after every 15 students to ensure accuracy. The height was measured to the nearest millimeter using wall-mounted tape. We calculated the BMI for each student using the height and weight measurements.

#### 2.2.2 Fundamental Movement Skill Proficiency

The Furtado-Gallagher Children Observational Movement Pattern Assessment System (FG-COMPASS)<sup>1</sup> assessed FMS proficiency during daily physical education classes. The FG-COMPASS<sup>2</sup> is a validated, reliable criterion-related, process-oriented assessment tool designed for school settings (Furtado & Gallagher, 2012). The assessment covered three locomotor skills (hop, horizontal jump, and skip) and five manipulative skills (throw, strike, kick, hand dribble, and catch). The gym was divided into two sections for concurrent assessment and physical education classes. Students were taken five at a time from their physical education classes and videotaped, performing the fundamental movement skills per the test protocol's instructions.

#### 2.2.3 Scoring

We calculated BMI percentile ranks for each participant according to the CDC guidelines (CDC, 2022a). Based on these results, we classified the participants into four categories: underweight,

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<sup>1</sup>Formerly titled Furtado-Gallagher **Computerized** Observational Movement Pattern Assessment System.

<sup>2</sup><https://fgcompass.com/>

healthy weight, overweight, and obesity. It is important to note that none of the students were deemed underweight. As per the test protocol, children received a score from 1 to 4 based on their performance for each fundamental movement skill. Each participant received a score for the locomotor subscale, the manipulative subscale, and the total test. Before data collection, videos of children performing locomotor and manipulative skills were used to train the principal investigator (PI) in the FG-COMPASS testing protocol. The PI and an experienced FG-COMPASS practitioner classified eight videos per skill. We decided that weighted kappa values below 0.8 required additional discussion between the PI and the expert to ensure the PI was familiar with the testing protocol. This joint classification improved the internal validity of the study.

### 2.3 Statistical Analyses

Preliminary analyses ensured no violation of the assumptions of normality, linearity, and homogeneity of variances. Descriptive statistics were calculated for all the main variables. Factorial ANOVAs tested the main effects of sex and BMI group (normal weight versus overweight) and the interaction between these two factors on manipulative fundamental motor skills (MFMS), locomotor fundamental motor skills (LFMS), and total fundamental motor skills (TFMS). A stricter significance level of  $\alpha = .01$  was adopted to control for Type I error due to multiple comparisons. Non-parametric Mann-Whitney *U* tests compared the individual motor skills of boys and girls, while Pearson’s correlation analysis examined the relationships between the BMI percentile and the three motor skills scores. Pearson’s criteria interpreted the strength of the correlations. All statistical analyses were conducted using the jamovi software package (The jamovi project, 2022).

## 3 Results

The results are presented in line with the study hypotheses. First, we will address the relationship between Fundamental Movement Skills (FMS) and Body Mass Index (BMI), followed by analyzing sex differences in FMS performance. Table 1 provides the descriptive statistics for FMS, categorized by sex and group. Participants were initially categorized into “normal weight,” “overweight,” and “obese” groups based on CDC guidelines (CDC,

2022b). However, due to the small sample sizes in the “overweight” and “obese” groups, these categories were merged and labeled “overweight”.

**Table 1:** Descriptive Statistics of Fundamental Movement Skills by Sex and BMI Group

	Sex	BMI	<i>N</i>	<i>M</i>	<i>SD</i>
LFMS	Boys	1	14	7.07	2.62
		2	6	6	1.67
	Girls	1	11	7.73	2.05
		2	8	7.25	2.38
MFMS	Boys	1	14	12.14	2.32
		2	6	12.5	2.95
	Girls	1	11	9.09	2.26
		2	8	9.13	2.36
TFMS	Boys	1	14	19.21	4.25
		2	6	18.5	4.23
	Girls	1	11	16.82	3.19
		2	8	16.38	3.81

*Note.* LFMS = Locomotor Fundamental Movement Skills; MFMS = Manipulative Fundamental Movement Skills; TFMS = Total Fundamental Movement Skills; BMI Group: 1 = Normal Weight, 2 = Overweight.

### 3.1 BMI Grouping

A two-way factorial ANOVA was conducted (see Table 2) 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,  $F(1, 35) = 15.6865, p < .001, \eta_p^2 = .309$ , with boys ( $M = 12.32, SD = 0.814$ ) scoring significantly higher than girls ( $M = 9.11, SD = 0.788$ ) - see Figure 1.

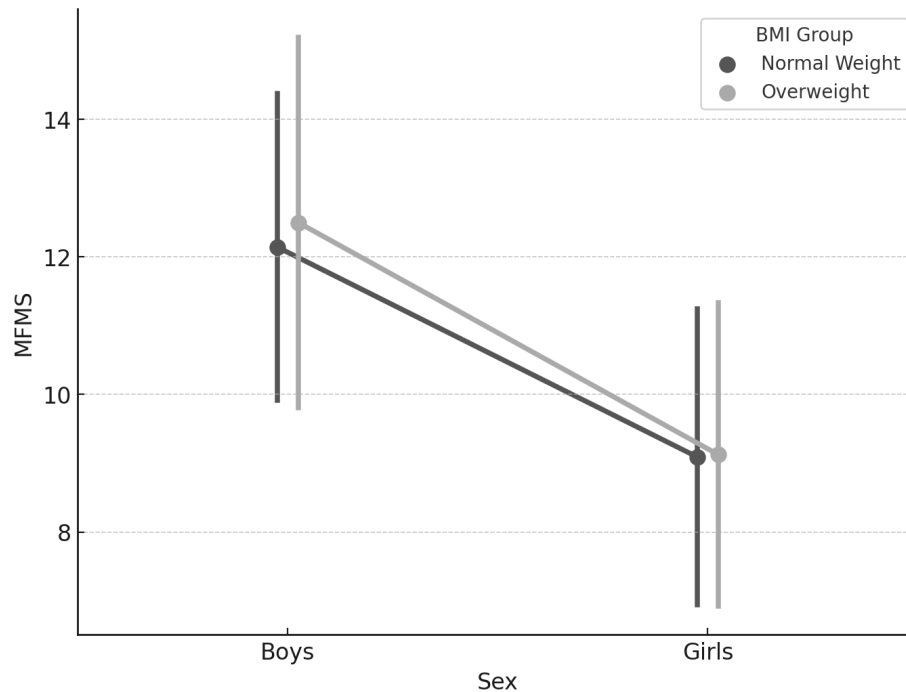
**Table 2:** Two-Way Factorial ANOVA Results for Manipulative Fundamental Movement Skills by Sex and BMI Group

Source	<i>df</i>	<i>F</i>	<i>p</i>	$\eta_p^2$
Sex	1	15.686	< .001	0.309
BMI	1	0.058	0.811	0.002
Sex × BMI	1	0.039	0.843	0.001
Residuals	35			

*Note.*  $\eta_p^2$  = Partial eta squared.

However, neither the BMI group nor the interaction between sex and the BMI group had a significant effect on MFMS. Another two-way factorial ANOVA examining the effects of Sex and BMI groups on Locomotor Fundamental Motor Skills (LFMS) revealed no significant main or interaction effects. Similarly, an ANOVA evaluating the effects of Sex

**Figure 1:** Means Plot Comparing Boys and Girls in the Manipulative Fundamental Movement Skill Subtest.



Note: This plot illustrates the average scores obtained by boys and girls in the MFMS. The error bars represent standard deviation scores.

and BMI group on Total Fundamental Motor Skills (TFMS) found no significant main or interaction effects. In summary, while boys significantly outperformed girls in MFMS, there were no significant differences for LFMS or TFMS based on sex or BMI group.

### 3.2 Sex Differences for Individual Skills

Significant sex differences were found in two motor skills: striking and kicking (see Table 3). The Mann-Whitney *U* test indicated significant differences in performance between boys and girls for these skills, with effect sizes suggesting large differences. Specifically, boys outperformed girls in both striking ( $U = 82.0, p = 0.001, r = 0.5684$ ) and kicking ( $U = 92.5, p = 0.003, r = 0.5132$ ). In contrast, no significant sex differences were found for the other individual motor skills, including dribbling, catching, hopping, jumping, skipping, and throwing. Although the Mann-Whitney *U* test results for these skills were not statistically significant, effect sizes varied, indicating varying degrees of difference in performance between boys and girls.

**Table 3:** Mann-Whitney *U* test Results for Individual Motor Skills

Skill	<i>U</i>	<i>p</i> -value	$r_{rb}$
Hop	142.0	0.164	0.2526
Jump	187.5	0.954	0.0132
Skip	167.5	0.508	0.1184
Throw	129.5	0.076	0.3184
Kick	92.5	0.003	0.5132
Dribble	141.5	0.131	0.2553
Catch	165.5	0.479	0.1289
Strike	82.0	0.001	0.5684

Note.  $r_{rb}$  = Rank biserial correlation.

### 3.3 Correlations

A Pearson correlation analysis (see Table 4) was conducted to examine the relationships between the BMI percent and Locomotor Fundamental Movement Skills (LFMS), Manipulative Fundamental Movement Skills (MFMS), and Total Fundamental Movement Skills (TFMS). The analysis revealed weak and non-significant correlations between BMI percent and all three motor skill scores: LFMS ( $r = -0.261, p = 0.108$ ), MFMS ( $r = -0.067, p$

= 0.687), and TFMS ( $r = -0.199$ ,  $p = 0.225$ ).

**Table 4:** Pearson Correlation Coefficients Between BMI and LFMS, MFMS, and TFMS

	BMI% ( $r$ , $p$ -value)
LFMS	-0.261, 0.108
MFMS	-0.067, 0.687
TFMS	-0.199, 0.225

Note.  $N = 39$ ;  $r$  = Pearson Correlation Coefficient.

## 4 Discussion

This study examined the relationship between body mass index (BMI) and FMS performance among low-income rural children aged 5 to 7. Additionally, we aimed to determine if there were sex differences in FMS performance. Despite our initial hypotheses, our research found no evidence to support the assertion that BMI is related to FMS locomotor, FMS manipulative, or total FMS performance. Regarding sex differences, we observed that boys and girls differed in the performance of manipulative FMS but not in locomotor FMS or total FMS. Specifically, boys performed significantly better than girls in striking and kicking. Our findings align with other studies (Graf et al., 2004; Logan et al., 2013; Wrotniak et al., 2006), which found weak negative associations between BMI and FMS performance. However, when grouping participants based on their BMI (normal weight and overweight), we could not confirm our hypothesis that FMS performance would differ based on BMI groupings. This contrasts with other studies that found significant differences between BMI groups when measuring FMS performance. For instance, Logan et al. (2013) found that children classified as “overweight/obese” by their BMI percentiles ranked significantly lower than their peers on the MABC-2 percentiles. Similarly, using the Kiphard-Schilling’s body coordination test - KTK, Lopes et al. (2012) and Graf et al. (2004) found that normal-weight children of both sexes had significantly higher FMS scores than children classified as “overweight”. Several factors could account for the non-significant findings among BMI groupings in relation to FMS performance. One primary consideration is the difference in participant demographics. Unlike previous studies, which predominantly involved urban populations, our research focused on participants from rural areas.

Tomaz et al. (2019) reported superior performance in striking and horizontal jumping amongst rural (low-income) children, irrespective of income status, compared to their urban counterparts. This suggests that rural environments offer more play opportunities, allowing children to become proficient in some fundamental movement skills regardless of their weight status. Moreover, the inability to find a significant main effect of BMI Group on LFMS, MFMS, and TFMS may be due to the disparity in sample sizes between groups. The ‘normal weight’ and ‘overweight’ groups were not equally represented in the sample, which may have affected the ANOVA result. When sample sizes are unequal, the statistical power to detect an effect can be reduced, especially if the smaller group exhibits greater variability in the dependent variable. This underrepresentation could increase the risk of Type I errors in the larger group and Type II errors in the smaller group. As a result, the disparity in our group samples may have obscured any potential effect of BMI group on the dependent variables. Future research would benefit from ensuring a more balanced representation across BMI categories, possibly via stratified sampling or oversampling of underrepresented groups. Our study supported the second hypothesis, consistent with previous research conducted by Barnett et al. (2008) and Wrotniak et al. (2006). We found that boys ( $M = 12.38$ ) outperformed girls ( $M = 9.11$ ) in manipulative but not locomotor skills. This is similar to the results of previous studies, where boys were more skilled in manipulative activities than girls. One possible explanation is that boys are more interested in activities that require manipulative skills, which could contribute to this gender difference (Wrotniak et al., 2006). Interestingly, Barnett et al. (2008) found that girls scored slightly higher than boys in locomotor activities, but the difference was not statistically significant. Boys and girls in early elementary school may be attracted to activities requiring fundamental movement skills.

### 4.1 Limitations

Several limitations should be considered when interpreting the findings of this study. First, our sample predominantly comprised low-income, rural children aged 5 to 7 years. Therefore, the results may not generalize to children from different socioeconomic backgrounds, urban areas, or other age groups. Second, our study relied on BMI as a proxy for children’s adiposity. While BMI is a

widely accepted measure, it does not directly assess body fat and its distribution, which may have different implications for motor performance. Future research could benefit from including more direct measures of adiposity, such as skinfold thickness or dual-energy X-ray absorptiometry (DXA). Third, the disparity in sample sizes across the 'normal weight' and 'overweight' groups may have influenced our ability to detect significant differences in FMS performance based on BMI groupings. Future studies should aim for a more balanced sample size across groups to increase statistical power and improve the robustness of findings. The results might have been influenced by the limited sample size, particularly concerning the comparison between BMI groups. Despite these limitations, our study provides valuable insights into the relationships between BMI, sex, and FMS performance among young children in low-income, rural settings. Our findings emphasize the need for additional study to fully comprehend these relationships and their implications for children's development and health.

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## 5 Conclusion

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This study explored the relationships between BMI, sex, and Fundamental Movement Skills (FMS) performance among low-income, rural children aged 5 to 7 years. Our findings revealed no significant effect of BMI on FMS performance, indicating that children's weight status did not significantly influence their motor skills in this sample. However, we identified a significant difference in manipulative FMS performance between boys and girls, suggesting that sex may play a role in developing certain motor skills. Our results contribute to the growing body of literature examining the complex relationships between physical characteristics and motor skill development in children. Importantly, these findings underscore the need for further research to elucidate these relationships, particularly in underrepresented populations such as low-income, rural children. Despite the lack of a significant association between BMI and FMS performance in our sample, it's important to recognize the broader health implications of obesity levels and poor fundamental motor skill development. Both factors have been independently linked to adverse health outcomes, such as cardiovascular disease and reduced physical activity levels. Therefore, comprehensive strategies that promote healthy weight and

motor skill development remain crucial for supporting children's health and well-being. In conclusion, our study highlights the nuances and complexities in the relationships between BMI, sex, and FMS performance. We hope our findings stimulate further research in this area, ultimately leading to more effective interventions supporting children's physical development and overall health.

## Acknowledgments

The authors extend their gratitude to the parents/guardians of all study participants.

## Conflict of Interest

We acknowledge that one of the authors of our manuscript is a member of the Editorial Board of this journal. We affirm that the submission has been handled according to the journal's established peer-review policy. As stipulated, alternate Board members have administered the peer review process for our manuscript, and the involved Editorial Board member has not participated in any part of the decision-making process. This ensures that the integrity of the review and publication process is upheld.

## Funding Sources

This research received no external funding.

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