**Original Research Article**

**Comparative Analysis of Aerobic Capacity Among Preadolescent: A Cross-sectional Study in Rivers State, Nigeria**

**Abstract**

**Background:** Aerobic capacity, commonly evaluated through a person's maximum oxygen uptake (VO₂max), serves as a vital measure of cardiovascular and respiratory efficiency.The study aims to compare the aerobic capacity of preadolescent indigenous population of Rivers State, Nigeria

**Methods:** This cross-sectional descriptive study examined the aerobic capacity of preadolescents aged 8–12 years in Rivers State, Nigeria. A multi-stage proportionate random sampling method was used to recruit 400 healthy participants of Rivers State origin. The PACER test, a standardized tool from the FITNESSGRAM program, was employed to assess aerobic capacity, while BMI was measured using digital scales and stadiometers to support broader health profiling. Eligibility required parental or self-consent. Data were analyzed using SPSS software; the Mann-Whitney U and Kruskal-Wallis test was used. A significance level of p<0.05 was applied to determine statistical relevance.

**Results:** 400 preadolescents aged 8 to 12 years participated in the study, with females comprising 59.8% of the sample. The Mann-Whitney U test revealed no significant difference in aerobic capacity between males and females (p = 0.263), and the Kruskal-Wallis H test identified significant differences in aerobic capacity across age groups (p < .001). Post hoc analysis showed that 9-year-olds significantly differed from 11- and 12-year-olds and 8-year-olds differed from 11-year-olds.

**Conclusion:** These findings suggest that while sex does not impact aerobic capacity, age significantly shapes cardiorespiratory fitness among preadolescents in Rivers State.

**Keywords:** Aerobic capacity, Rivers State, pre-adolescents, cardiovascular, Nigeria

**Introduction**

Aerobic capacity, commonly evaluated through a person's maximum oxygen uptake (VO₂max), serves as a vital measure of cardiovascular and respiratory efficiency (Buttar et al., 2019). In children and adolescents, this metric goes beyond physical performance it provides meaningful insights into overall health and wellness (Poitras et al., 2016). For preadolescents, typically between the ages of 9 and 12, aerobic fitness supports physical growth brain function, academic achievement, and long-term health (Latino and Tafuri, 2023). Assessing aerobic capacity during this developmental stage is especially important, as it lays the groundwork for lifelong healthy habits and identifies potential health risks, including obesity, cardiovascular issues, and metabolic imbalances (Bustamante-Sanchez et al., 2022).

Recently, there has been mounting concern worldwide over the steady decline in children’s physical activity levels and aerobic fitness (D’Anna et al., 2024). This trend has been largely driven by increasingly sedentary lifestyles, the influence of digital technology, and broader changes in daily routines (D’Anna et al., 2024). The impact is even more profound in countries like Nigeria, where physical education is often inconsistently delivered, and many communities lack access to safe, structured environments for exercise and play. Despite these challenges, there is still a significant lack of detailed data on the aerobic fitness levels of Nigerian children especially at the state or community level. This information gap, particularly when not broken down by age or sex, limits the ability of educators, health professionals, and policymakers to implement tailored strategies that promote physical health among the youth.

Although numerous studies from other parts of the world have explored how aerobic capacity develops with age and differs between boys and girls, these findings may not necessarily apply in the Nigerian context (McClain et al. (2006); Mahar et al. (2018); Blasingame’s (2012); and D'Agostino et al. (2023). Most of this research has relied on standardized tools such as the PACER test or VO₂max treadmill assessments, and while they often show that aerobic capacity improves with age and may vary by sex, cultural, environmental, and economic conditions can significantly shape these outcomes. In a region like Rivers State where children grow up in both urban and rural settings with varying access to resources there is a pressing need for context-specific data to better understand these patterns.

This study therefore aims to address this important knowledge gap. By examining aerobic capacity among preadolescents in Rivers State and comparing it across age groups and between boys and girls, the research provides much-needed evidence to guide decision-making. The findings can help shape school fitness programs, inform public health campaigns focused on disease prevention, and support sports development initiatives designed to identify and nurture talent from an early age. More importantly, it ensures that both boys and girls benefit from programs that are tailored to their specific developmental needs.

This research aims to assess and compare the aerobic capacity of children aged 8 to 12 in Rivers State, Nigeria. It seeks to determine whether significant differences exist based on age and sex, and to interpret these differences through the lens of the biological, social, and environmental factors that influence physical fitness in children.

**Materials and Methods**

**Study Design**

This study adopted a cross-sectional descriptive study design to gather data on the comparative analysis of aerobic capacity between sexes of the pre-adolescent population of Rivers State. The participants of this study include participants drawn from different Local Government Areas in Rivers State, Nigeria representing the pre-adolescent population of the Rivers State, Nigeria. Obio-Apkor was used as study areas to fully represent Rivers State, Rivers State population **Sampling techniques**

The study adopted multi-stage proportionate random sampling techniques to recruit the pre-adolescents of Rivers State, Nigeria without bias. According to RSMOYD, (2020) the pre-adolescent population of Rivers State, Nigeria is 1,214,221. However, the minimum sample size for the study was determined using the Taro-Yamane formula**,** $n=\frac{N}{1+N\left(e\right)^{2}}$**;**

where n = minimum sample size,

N = total population and

e = margin of error = 0.05.

$$n=\frac{1,214,221}{1+1,214,221\left(0.05\right)^{2}}=399.99$$

**selection criteria**

Study selection criteria were clearly defined to ensure appropriate participant inclusion and data reliability. To be eligible for participation, respondents had to meet several inclusion criteria: they must be between the ages of 8 and 12 years, be in good health, and have parents and grandparents who are originally from Rivers State. and consent for participation had to be obtained either from the parents and the respondents themselves. Any individual who did not meet these specified conditions was excluded from the study.

**Instrumentation and method of data collection**

The study examined the measurement of comparative analysis of aerobic capacity between sexes among the indigenous pre-adolescents of Rivers State. The FITNESSGRAM program offers two different types of tests to determine a child’s level of aerobic capacity, the PACER test and the one-mile run. FITNESSGRAM also offers two different alternatives for body composition (BMI). Detailed descriptions of the alternative assessments are provided below.

**Aerobic Capacity Assessments**

The PACER test, originally developed from the 20-meter shuttle run by Leger and colleagues in 1988, is a popular and practical way to measure aerobic endurance, especially among school-aged children (Marques et al., 2021). It works by having students run back and forth across a 20-meter space, keeping up with a series of beeps that get progressively faster each minute. The test continues until a student misses the line twice after the second miss, they stop and are encouraged to walk and stretch to cool down. This test is usually conducted on a safe, flat surface indoors or outdoors and requires some basic equipment like cones, measuring tape, a sound system, and score sheets. Each time a student successfully runs one length, it counts as a lap, and the total number of laps becomes their score. There are two ways to score: the standard method, which stops after two missed beeps, and an alternative method that allows students to keep going, using symbols to track performance (Blanke et al., 2022). No matter the method, the results are entered into a software program that factors in age to estimate the student’s aerobic capacity. For younger kids in kindergarten through third grade, there aren’t strict benchmarks they’re simply encouraged to try their best and enjoy the process. Older children, starting at age nine in fourth grade, do receive feedback based on performance standards. For students who can’t participate in the PACER or prefer a different challenge (Pacer, 2024), the one-mile run offers another way to measure endurance. This test involves running or walking if needed a full mile on a carefully measured course. The score is based on how long it takes to finish, with additional inputs like age, sex, and BMI to give a more personalized fitness assessment. Just like with the PACER, younger students are not judged against strict standards, but are given the chance to participate, build stamina, and learn pacing. Students aged nine and up are scored according to national benchmarks to help track their fitness progress.

**Body Mass Index (BMI)**

Body Mass Index (BMI) is a commonly used but limited method for assessing body composition, as it does not directly measure body fat but rather indicates weight in relation to height, calculated using the formula weight (kg) divided by height (m²). Accurate measurement is crucial, requiring the use of high-quality digital scales and stadiometers rather than less precise tools like tape measures. When collecting data, children should be measured without shoes to avoid added height or weight, and readings should be rounded down to the nearest whole number. Once height and weight are recorded, they are entered into software that calculates BMI. While a BMI below 25 is considered normal for adults, BMI assessments for children and adolescents must account for age and sex due to natural variations in growth and development. A BMI classified as “Needs Improvement” typically suggests that a child’s weight is too high for their height, but because BMI doesn’t distinguish between fat and lean mass, further testing, such as a skinfold assessment, is recommended to determine if excess fat is the cause.

**Statistical Analysis**

Data obtained was subjected to statistical analysis using the International Business Machine of Statistical Package for Social Science. Non-Parametric test Mann Whitney U Test was used to compare the distribution of aerobic capacity between male and female respondents, using median values. Additionally, Kruskal-Wallis Test was used to compare the distribution of aerobic capacity among the different age groups of respondents. A probability less than 0.05 was considered statistically significant and 95% was denoted as a confidential level

**Results**

A total of 400 respondents who participated in this study are pre adolescents within the ages 9 to 12 years. About 59.8% of the respondents are female while 40.3% are male. The various ages are fairly represented in the study with the least represented age being the 8 years old participants constituting 9.0 % of the population. Age distribution of respondents. Majority of the respondents 23.5% were 10 years of age, followed by 23.0% of the respondents who were aged 9 and 10 years respectively and 21.5% of the respondents were 12 years old (figure 1).

The summary statistics for the participants indicating the mean value for BMI, Aerobic capacity and percentage body fat by sex. Females were disproportionately more than the males. There was no missing value in the dataset and Kolmogrov-smirnov test was used to check for normality. Data is not normally distributed as p value using Kolmogrov-smirnov is <.001 which is less than 0.05 significant level. The skewness value of **0.311 is twice the standard error (0.127)** indicating the data is positively skewed (Table 1).

The study employed the used of Mann-Whitney U test to compare aerobic capacity between males and females and our result indicated that there was no significant difference in aerobic capacity between males (Median = 47.94) and females (Median = 47.04), U = 20.506.50, p = 0.263 (Table 2). While Kruskal-Wallis H test was conducted to assess whether aerobic capacity differed significantly across age groups (8–12 years) and the median %BF values for each age group were as follows: age 8 (Mdn = 47.48), age 9 (Mdn = 49.15), age 10 (Mdn = 48.67), age 11 (Mdn = 44.57), and age 12 (Mdn = 47.94). The results indicated a statistically significant difference aerobic capacity across age groups, H(4) = 26.54, p < .001.

Pairwise comparisons using the Bonferroni correction revealed that aerobic capacity significantly differed between certain age groups. Specifically, the 9-year-old group had significantly different aerobic capacity compared to the 11-year-old group (Test Statistic = 76.82, SE = 16.94, p < .001) and the 12-year-old group (Test Statistic = 54.27, SE = 17.33, p = .017). In addition, the 8-year-old group differed significantly from the 11-year-old group (Test Statistic = 77.88, SE = 22.64, p = .006). No other pairwise comparisons showed significant difference (all adjusted p-values ≥ .099). The Mann-Whitney U test indicated no significant difference in aerobic capacity between males (Mdn = 47.94) and females (Mdn = 47.04), U = 20506.50, p = .263. This result is consistent with our hypothesis that there is no difference in aerobic capacity between male and female. Post hoc comparisons showed that the 9-year-old group had significantly different aerobic capacity compared to the 11-year-old and 12-year-old groups. Additionally, the 8-year-old group differed significantly from the 11-year-old group.Therefore, we fail to reject the null hypothesis, which states that there is no significant difference in aerobic capacity across sex among preadolescents in Rivers State.

**Figure 1:Age Distribution of Respondents**

Table 1: Summary statistics for BMI, Aerobic capacity and percentage body fat by sex.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Mean ±SD | 95% Confidence Interval for Mean | SEX | Mean ±SD | Std. Error Mean |
| BMI | 15.6±1.4 | 15.5 - 15.8 | M (160) | 15.7±1.3 | 0.1049 |
|  |  |  | F (239) | 15.7±1.5 | 0.0942 |
| VO2max | 47.2±8.1 | 46.4 - 48.1 | M (161) | 48.8±9.2 | 0.7258 |
|  |  |  | F (239) | 47.7±8 | 0.5183 |
| %BF | 33.1±4.1 | 32.7 - 33.5 | M (161) | 37.6±4 | 0.3135 |
|  |  |  | F (239) | 30.5±0.9 | 0.0557 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Kolmogorov-Smirnova |  |  | Shapiro-Wilk |  |  |
|  | Statistic | df | Sig. | Statistic | df | Sig. |
| VO2max | 0.138 | 371 | .000 | 0.945 | 371 | .000 |
| % BF | 0.295 | 371 | .000 | 0.808 | 371 | .000 |
| BMI | 0.12 | 371 | .000 | 0.929 | 371 | .000 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable |  |  | Statistic | Std. Error |
| VO2max | Mean |  | 47.228 | 0.4214 |
|  | 95% Confidence Interval for Mean | Lower Bound | 46.4 |  |
|  |  | Upper Bound | 48.057 |  |
|  | 5% Trimmed Mean |  | 47.116 |  |
|  | Median |  | 45.402 |  |
|  | Variance |  | 65.892 |  |
|  | Std. Deviation |  | 8.1174 |  |
|  | Minimum |  | 32.7 |  |
|  | Maximum |  | 63.1 |  |
|  | Range |  | 30.4 |  |
|  | Interquartile Range |  | 13.4 |  |
|  | Skewness |  | 0.311 | 0.127 |
|  | Kurtosis |  | -1.093 | 0.253 |

**Table 2: Mann-Whitney U Test Results for Aerobic Capacity by Sex (N = 400)**

|  |  |  |
| --- | --- | --- |
| Groups | Sample Size (n) | Median |
| Male | 239 | 47.94 |
| Female | 161 | 47.04 |

**Overall Test Statistics**
U = 20506.50, Z = 1.11, p = .263.

Wilcoxon W = 33547.50, SE = 1133.03. Asymptotic Sig. (2-tailed) = .263.

**Overall Kruskal-Wallis Test**
H(4) = 26.54, p < .001

**Table 3:Kruskal-Wallis Test and Pairwise Comparisons by Age (N = 400)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Age Group Comparison | Test Statistic | Std. Error | Std. Test Statistics | P (2 tailed) | Adj. Sig (Bonferroni) |
| 11 vs 12 | -22.551 | 17.238 | -1.308 | .191 | 1.000 |
| 10 vs 12 | 21.132 | 17.327 | 1.220 | .223 | 1.000 |
| 10 vs 11 | 43.683 | 16.942 | 2.578 | .010 | .099 |
| 9 vs 12 | 54.273 | 17.327 | 3.132 | .002 | .017 |
| 9 vs 11 | 76.824 | 16.942 | 4.535 | <.001 | .000 |
| 9 vs 10 | 33.141 | 17.033 | 1.946 | .052 | .517 |
| 8 vs 12 | 55.329 | 22.932 | 2.413 | .016 | .158 |
| 8 vs 11 | 77.880 | 22.642 | 3.440 | <.001 | .006 |
| 8 vs 10 | 34.197 | 22.710 | 1.506 | .132 | 1.000 |
| 8 vs 9 | 1.056 | 22.710 | .046 | .963 | 1.000 |

**Discussion**

The findings of this study provide a comprehensive overview of aerobic capacity, body composition, and gender and age-related differences among preadolescents aged 8 to 12 years in Rivers State. With a sample size of 400 children predominantly female (59.8%) the data were distributed across all relevant age groups, though 8-year-olds were the least represented. The age group most represented were the 10-year-olds (23.5%), followed closely by 9- and 11-year-olds. This distribution enhances the reliability of inter-age comparisons in assessing developmental and physiological differences in aerobic capacity and body composition.

The study's statistical analyses reveal several notable patterns. While the Mann-Whitney U test showed no significant difference in aerobic capacity between male and female participants, suggesting similar cardiorespiratory fitness regardless of sex, the Kruskal-Wallis H test identified statistically significant differences in aerobic capacity across age groups. Specifically, 9-year-olds exhibited significantly different aerobic capacity compared to 11- and 12-year-olds, while 8-year-olds also differed significantly from 11-year-olds. These differences may reflect natural physiological development, including musculoskeletal growth, maturation of the cardiovascular system, and increased muscular strength and endurance, which tend to improve with age and physical development. The absence of sex-based differences aligns with preadolescent developmental norms, as physiological differences between sexes are minimal before puberty, particularly in aerobic performance.

The implications of these findings are significant from a physiological and anatomical perspective. During preadolescence, children are undergoing steady but not rapid changes in body composition and cardiorespiratory efficiency. Since no significant differences were observed between sexes, this reinforces the notion that training programs for children in this age group can be relatively uniform, regardless of gender. However, the significant variation across age groups underscores the importance of age-appropriate programming in physical education and youth sports to accommodate varying levels of aerobic development. When compared with McClain et al. (2006), who examined differences in aerobic capacity assessments using the PACER test protocols, the current study complements their findings by confirming that even minor procedural or age differences can affect fitness outcomes. While McClain et al. noted small, likely non-significant sex-based differences in VO₂ max between boys and girls using different PACER lengths, our study shows no significant sex difference using a consistent test format. This further supports the reliability of PACER testing for evaluating youth aerobic fitness and highlights that results may be more influenced by developmental age than by sex during this life stage.

Similarly, Mahar et al. (2018) found that BMI had minimal added predictive value in estimating VO₂ max from PACER scores in youth. In the current study, although summary statistics by BMI and % body fat were presented, the primary focus was on aerobic capacity. These results are in line with Mahar’s conclusion that age and PACER performance are sufficient predictors of aerobic fitness, which aligns with the current study’s focus on age as a more significant factor than BMI or sex in determining aerobic capacity.

Blasingame’s (2012) research also corroborates the reliability of the PACER as a measure of aerobic capacity and supports the conclusion that agreement between various fitness assessments is strong. The current study’s emphasis on the Kruskal-Wallis test to identify significant inter-age differences aligns with Blasingame’s findings that student fitness varies significantly with age, reaffirming the importance of developmentally calibrated fitness benchmarks.

Furthermore, the longitudinal study by D'Agostino et al. (2023) offers valuable context for interpreting these results. D’Agostino et al. found that higher weight status is consistently associated with lower aerobic fitness scores, with the strongest effects observed in children with severe obesity. While the current study did not directly correlate aerobic capacity with weight categories, the absence of sex-based differences and the observed age-based variance are consistent with the trajectory D’Agostino described: fitness levels evolve with both age and weight status. It highlights the need for early interventions to support healthy weight and fitness patterns before adolescence.

**Conclusion**

This study offers a clearer understanding of how aerobic capacity develops among children aged 8 to 12 in Rivers State, showing that age has a greater impact than gender on their cardiorespiratory fitness. These findings, which align with earlier research, support the use of age-appropriate fitness tools like the PACER test in schools. The fact that boys and girls showed similar results highlights the importance of giving all children equal opportunities to participate in physical activities, especially before puberty. Given the differences seen across age groups, teachers and health professionals should design fitness programs that match each child’s stage of development. While BMI and body fat are still useful for general health checks, they don’t say much about a child’s fitness on their own. That’s why it's important to keep tracking aerobic fitness over time, using age and performance data, to help children stay healthy and active as they grow.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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