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Original Article

Breath and bounce: How pulmonary capacity influences basketball performance in children

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Abstract
Introduction: Basketball performance in children relies on coordination, speed, endurance, and overall physical fitness, yet the specific contribution of respiratory function in young athletes remains insufficiently explored. Understanding whether lung function supports superior game performance may help coaches and clinicians better evaluate respiratory readiness in pediatric sports contexts. While previous studies have focused mainly on cardiovascular fitness, the role of spirometric indices as predictors of sport-specific performance is still unclear. **Objective:** This study examined the relationship between spirometric lung function and basketball performance in school-aged boys, with the aim of determining whether lung function parameters could reliably discriminate higher-performing young athletes. **Methods:** Sixty-three healthy Caucasian boys aged 7–12 years, all of whom regularly practiced basketball, underwent spirometry following ATS/ERS 2019 guidelines. Measured parameters included FVC, FEV_1, PEF, and FEF25–75%, with corresponding z-scores calculated using GLI-2012 reference values. Basketball performance was defined as the average points scored across three official games. Participants were divided into tertiles based on performance. In addition to standard comparisons, we evaluated age-adjusted effects, predictive accuracy, and practical applicability of spirometric measures. Statistical analyses included Pearson correlations, ANOVA with post hoc tests, multivariable linear regression, logistic regression, and ROC analysis. **Results:** FVC z-score showed a strong positive correlation with basketball performance ($r = 0.51$, $p < 0.001$) and remained a significant independent predictor in multivariable regression ($\beta = 0.42$, $p < 0.001$), while FEV_1 was not. ROC analysis indicated good discriminative accuracy of FVC z-scores for identifying high performers (AUC = 0.79). Post hoc comparisons confirmed significantly higher FVC z-scores in the high-performance group. Additional analyses showed no significant age interaction and highlighted that FVC outperformed all other spirometric parameters in predicting player performance. **Discussion:** These findings suggest that respiratory capacity—particularly lung volume—is meaningfully related to functional output during competitive play in children. Spirometry, therefore, may offer insight not only into respiratory health but also into sport-related physiological readiness. **Conclusion:** Better lung function, especially higher FVC, is associated with superior basketball performance in school-aged boys. Spirometry may serve as a practical, non-invasive tool to assess respiratory fitness and physical readiness in pediatric sports contexts, supporting early identification of players who may benefit from targeted respiratory training programs.
Keywords: respiratory fitness; pediatric athletes; spirometry; lung volumes; performance assessment; exercise physiology.

Introduction

Physical performance in childhood results from the coordinated maturation of several physiological systems, including cardiovascular endurance, neuromuscular power, and respiratory efficiency (Beunen et al., 1992). Among these contributors, respiratory function plays a fundamental role in sustaining aerobic metabolism and supporting adequate oxygen delivery during intermittent and high-intensity physical activity. In pediatric athletes, ventilatory development proceeds rapidly during late childhood, and regular training can enhance both lung volumes and ventilatory control, even before pubertal maturation (Armstrong & Barker, 2009; Williams et al., 2020). Understanding whether lung function provides a measurable advantage in sport-specific performance is therefore central to pediatric exercise physiology.

Although aerobic fitness has been widely studied in children, significantly fewer studies have examined how spirometric indices—such as forced vital capacity (FVC) and forced expiratory volume in one second

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(FEV_1)—relate to sport performance in real competitive environments. Spirometry is traditionally used to assess respiratory health, but recent research suggests it may also act as a proxy for pulmonary reserve, ventilatory mechanics, and recovery capacity during intermittent exercise (Cai et al., 2024; Rupp et al., 2019). Higher lung volumes might support superior oxygen uptake, tolerance to repeated sprints, and efficient acid–base regulation—all of which could influence performance in sports like basketball.

Despite these theoretical links, evidence specifically addressing youth team sports remains scarce. Most existing data focus on endurance disciplines such as running, swimming, or cycling, where aerobic capacity is a primary determinant of performance (Faigenbaum et al., 2020). However, basketball uniquely combines short high-intensity bursts, rapid changes of direction, moderate aerobic load, and repeated accelerations, making ventilatory efficiency a potentially relevant factor for sustaining performance across a whole match (Lazović-Popović et al., 2016; Stojanović et al., 2018). Yet, to date, it is unclear whether baseline lung function predicts the ability to perform and maintain effort in competitive basketball among preadolescent players.

There is limited scientific evidence on whether respiratory function contributes meaningfully to performance in young basketball players. The absence of normative data linking spirometry to sport performance in school-aged children limits coaches' and clinicians' ability to interpret lung function in practical contexts. Furthermore, preadolescent athletes represent a unique developmental group: they exhibit considerable interindividual variation in lung growth and motor skills, but they engage increasingly in organized competitive sport. Therefore, clarifying the relationship between lung function and real-game performance may provide important insights for early talent identification, training adjustments, and health monitoring.

This study is situated at the intersection of pediatric physiology, respiratory assessment, and applied sports science. Modern spirometric standards (GLI-2012) allow precise computation of age-specific z-scores across childhood (Quanjer et al., 2012). These tools offer an opportunity to evaluate lung function relative to normative developmental trajectories and examine its relevance in athletic performance.

To address this knowledge gap, we examined spirometric lung function in a sample of healthy boys aged 7–12 years who were actively and regularly practicing basketball. Spirometric parameters were converted into GLI-2012 z-scores to standardize lung function relative to age, sex, and height. Basketball performance was quantified based on objective game statistics, specifically the mean points scored across official competitions, allowing us to link physiological variables with real competitive outcomes. Statistical analyses included correlation testing, group-based comparisons, multivariable linear regression, and ROC analysis to evaluate predictive accuracy.

By integrating standardized spirometry with performance metrics, this study seeks to clarify whether lung volumes and expiratory flows are associated with basketball performance in children, and whether spirometric assessment may serve as a useful, non-invasive tool to evaluate physical readiness in pediatric sports environments.

Methods

Participants

Sixty-three healthy Caucasian male children aged 7 to 12 years (mean ± SD: 9.11 ± 1.59 years; height 133.97 ± 0.22 cm), all regularly engaged in basketball training (2–3 times per week), were recruited. Exclusion criteria included any history of respiratory disease, recent upper respiratory tract infection, or cardiac/musculoskeletal conditions.

Table 1. Descriptive characteristics of the study sample.

Variable	Mean ± SD
FVC (L)	2.14 ± 0.34
FEV_1 (L)	1.96 ± 0.31
Basketball Points	7.20 ± 3.90
Age (y)	9.11 ± 1.59
Height (cm)	133.97 ± 0.22
Performance Group	Low: 23; Medium: 20; High: 20

Spirometry

Lung function was assessed using a portable, calibrated spirometer Spirolab II" MIR 010, a product of Medical International Research (MIR). following ATS/ERS 2019 guidelines. The best of three reproducible trials was recorded. Collected parameters included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV_1/FVC ratio, peak expiratory flow (PEF), and forced expiratory flow between 25–75% (FEF25–75%). Reference values were estimated using the GLI-2012 prediction equations for Caucasian children, and z-scores were calculated for FVC and FEV_1.

Basketball Performance

Performance was evaluated as the average number of points scored over three official matches. Participants were classified into tertiles based on their average score: low (≤4 points/game, n = 23), medium (5–9, n = 20), and high (≥10, n = 20).

Statistical Analysis

Descriptive statistics were computed for demographic and spirometric variables. Pearson correlation coefficients assessed the linear relationship between lung function and basketball points. Group comparisons were conducted using one-way ANOVA with Tukey's post hoc tests. Multiple linear regression models were applied to evaluate the predictive role of FVC and FEV_1 on performance, adjusting for age and height. In addition, logistic regression and ROC analysis were used to assess the ability of FVC z-scores to discriminate high performers. An interaction model was tested to examine whether age group modified the FVC–performance relationship. Residuals were examined to verify normality and homoscedasticity. Analyses were performed using SPSS version 27 (IBM Corp.) and R version 4.3.2 (R Foundation for Statistical Computing).

Results

Descriptive statistics revealed a mean FVC of 2.14 ± 0.34 L and a mean FEV_1 of 1.96 ± 0.31 L. Average basketball performance was 7.2 ± 3.9 points per game. All spirometry values were within normal ranges for age and height.

Pearson's correlation showed a strong positive association between FVC z-score and basketball points ($r = 0.51$, $p < 0.001$, **Figure 1**), while FEV_1 showed a weaker, non-significant trend ($r = 0.24$, $p = 0.06$).

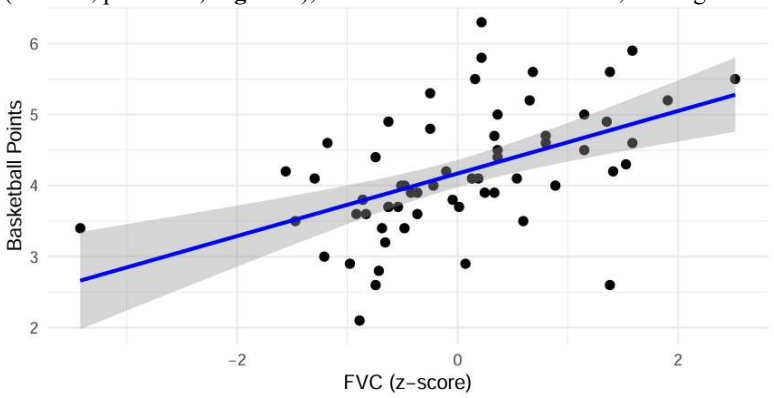

Figure 1. Scatterplot showing the linear association between FVC z-score and basketball performance. Higher FVC values were associated with better sport outcomes. The regression line and 95% confidence interval are shown.

To provide a broader overview of the relationships among spirometric parameters and performance, we generated a correlation matrix (**Figure 2**). FVC emerged as the parameter most strongly associated with basketball points, while other indices—such as FEV_1, PEF, and FEF25–75%—showed weaker or negligible correlations. These findings suggest that lung volume, rather than expiratory flow or airway patency, plays a more prominent role in determining performance in this population.

In simple linear regression, FVC was a significant predictor of performance ($\beta = 3.15$, $p < 0.001$), while FEV_1 showed a non-significant trend ($\beta = 0.82$, $p = 0.14$).

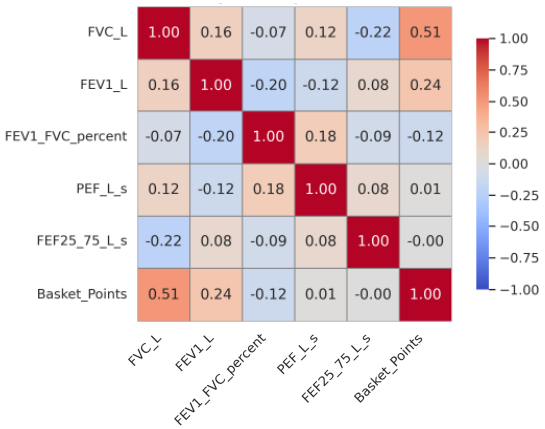

Figure 2. Correlation matrix between spirometric parameters and basketball performance in boys aged 7–12 years.

In multivariable linear regression adjusting for age and height, FVC z-score remained the only significant independent predictor of basketball performance ($\beta = 0.42$, $p < 0.001$), while FEV_1 z-score, age, and height were not significant. The model explained 29% of the variance in basketball scores (adjusted $R^2 = 0.24$).

ROC analysis showed good discriminative accuracy of FVC_z in identifying high performers (AUC = 0.79, **Figure 3**). Logistic regression confirmed this, with FVC_z significantly increasing the odds of belonging to the high-performance group (OR ≈ 3.8, $p < 0.001$), after controlling for age and height.

Boxplot analysis revealed a significant increase in both FVC and FEV_1 values across performance tertiles ($p < 0.01$). Z-score comparisons confirmed that children in the high-performance group had above-average lung function (mean FVC z = +0.61; mean FEV_1 z = +0.48).

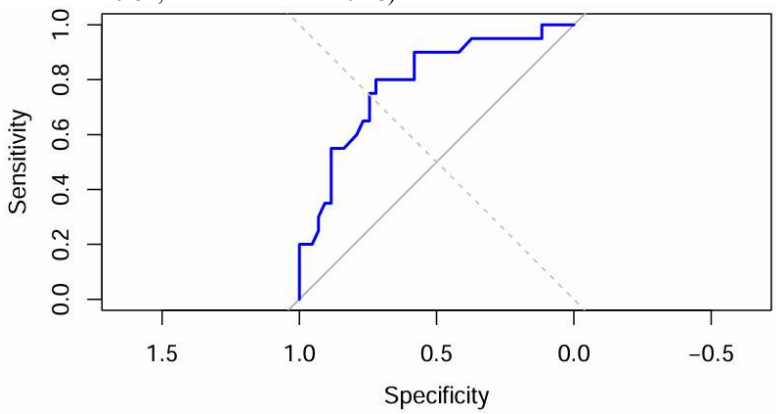

Figure 3. Receiver Operating Characteristic (ROC) curve for FVC z-score predicting high basketball performance. The area under the curve (AUC) was 0.79, indicating good discriminative ability of FVC_z to classify children with high performance (≥10 points/game).

ANOVA confirmed significant differences in FVC z-score across performance groups ($F(2,60) = 12.64$, $p < 0.001$), with post-hoc Tukey tests indicating that the high-performance group had significantly higher FVC_z-score than both the low ($\Delta = +1.32$, $p < 0.0001$) and medium groups ($\Delta = +0.60$, $p = 0.079$). The medium group was also significantly higher than the low group ($\Delta = +0.72$, $p = 0.022$) (**Figure 4**).

A regression model including an interaction between FVC_z score and age group showed no significant interaction effect, suggesting that the association between lung function and performance was consistent across age strata. Diagnostic plots and residual analysis supported the assumptions of the regression model.

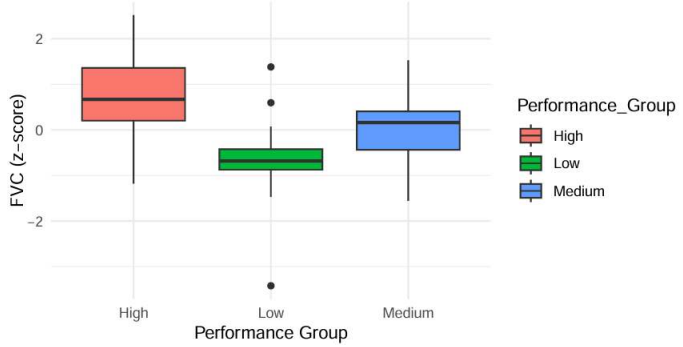

Figure 4. Distribution of FVC z-scores across performance groups. Children in the high-performance group showed significantly higher FVC z-scores compared to both the low ($\Delta = +1.32$, $p < 0.0001$) and medium performance groups ($\Delta = +0.60$, $p = 0.079$). The medium group also scored higher than the low group ($\Delta = +0.72$, $p = 0.022$). Boxes represent interquartile ranges, with medians and whiskers indicating 1.5×IQR.

Discussion

This study demonstrates a consistent, positive association between lung function—particularly forced vital capacity (FVC)—and basketball performance in healthy male children. FVC emerged as the most relevant spirometric measure across different statistical models, supporting its role as a physiological correlate of athletic output even at a young age.

Our findings suggest that pulmonary capacity may contribute to efficiency in sports like basketball, which combine aerobic endurance with short bursts of high-intensity effort (Stojanović E. et al., 2018). The absence of association with flow-related parameters (such as PEF and FEF25–75%) reinforces the idea that lung volume, rather than expiratory airflow limitation, better reflects performance potential in this setting. These

results are consistent with studies suggesting that FVC reflects ventilatory reserve and lung compliance, which may be crucial for sustaining physical performance under repeated dynamic loads (Torres-Castro R. et al., 2020).

The use of normalized z-scores allowed us to identify children with above-average ventilatory profiles in the high-performance group, suggesting a link between somatic development and sport efficiency. The consistent pattern across performance tertiles, without age-dependent interaction, indicates that this association may be robust across the 7–10 age range, a key phase for both physiological and motor development (Bozzetto S. et al., 2021).

Moreover, the correlation matrix confirmed that FVC was the most strongly associated parameter with basketball performance, while other spirometric indices contributed little to the predictive model. This emphasizes the value of evaluating lung volume specifically when assessing sport readiness in children (Mancha-Triguero D. et al., 2021).

From a practical perspective, spirometry offers a low-cost, reproducible, and non-invasive tool to assess respiratory fitness or training impact in pediatric athletes. Routine inclusion of spirometric evaluation in youth sport settings may aid in tailoring training intensity, detecting latent limitations in ventilatory capacity, and identifying young athletes with superior respiratory profiles. While this cross-sectional design cannot confirm causality, these data provide a strong rationale for longitudinal studies aimed at monitoring how respiratory development interacts with physical performance over time (Jones M. et al., 2021).

Conclusion

The present study provides clear evidence that respiratory function—particularly forced vital capacity (FVC)—is meaningfully associated with basketball performance in school-aged boys. Among all spirometric indicators, FVC consistently emerged as the strongest and most reliable predictor of higher scoring performance, highlighting its potential role as a physiological marker of ventilatory efficiency and sport-specific readiness. This finding reinforces the growing recognition that respiratory capacity contributes to the complex physiological demands of intermittent, high-intensity team sports such as basketball, even at preadolescent ages.

Importantly, the results of this study demonstrate that spirometry, a widely accessible, non-invasive, and cost-effective clinical tool, may carry practical value beyond the traditional medical setting. Incorporating standardized pulmonary assessments into youth sport evaluations could support coaches, physical trainers, and clinicians in identifying young athletes with more favorable ventilatory profiles, monitoring developmental changes during growth, and detecting early signs of respiratory limitations that may hinder athletic progression. From an applied perspective, the ability to quantify respiratory efficiency through objective measures such as FVC provides a data-driven approach to complement subjective observations of performance and effort tolerance.

These findings also have theoretical implications. They contribute to a more integrated understanding of pediatric athletic performance by emphasizing the relevance of respiratory mechanics—an area that has received less attention compared to neuromuscular strength or cardiovascular fitness. Recognizing lung function as an additional determinant of sport performance opens new avenues for multidisciplinary training approaches and encourages further exploration of the interplay between pulmonary development and athletic capability during childhood.

Future research should prioritize longitudinal designs to clarify whether superior lung function directly contributes to performance improvements or simply accompanies favorable growth patterns and training effects. Moreover, interventional studies aimed at enhancing ventilatory function—such as respiratory muscle training, aerobic conditioning, or structured breathing exercises—may help determine whether targeted respiratory interventions can produce measurable gains in basketball performance and other mixed-intensity sports.

In conclusion, this study highlights the potential value of spirometry as a practical and informative component of pediatric sport science. By integrating respiratory assessment into routine evaluations of young athletes, stakeholders may gain more comprehensive insights into physical readiness, support individualized training strategies, and ultimately promote healthier and more effective athletic development.

Conflict of interest

The authors declare that there is no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT (OpenAI) in order to improve the clarity, grammar, and overall quality of the English language in the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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