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Comparison of ERS/ATS guidelines across versions: differences in the application of bronchodilator responsiveness criteria in pediatric asthma by age subgroups (2005 vs 2021)

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Abstract

Background The 2021 updated guidelines revised the bronchodilator responsiveness (BDR) positivity criteria to an increase in FEV_1 or FVC of > 10% of the predicted value. This new standard aims to reduce the impact of baseline lung function variability in determining BDR. However, it should be noted that supporting evidence for children and young adults is limited and thus cannot provide fully substantiated recommendations. The study systematically compare the test results of the BDR diagnostic criteria in the 2005 and 2021 versions of the ERS/ATS guidelines in a clinical setting in children of different age groups with asthma and to explore the reasons for the differences.

Methods This was a single-center, retrospective, cross-sectional study. The applications of the 2005 and 2021 versions of BDR standards in different age groups(4–5 years, 6–11 years, 12–18 years) with asthma was compared, the lung-function characteristics of children with inconsistent results were analyzed, and the trend of the proportion of BDR + changing with the degree of airflow obstruction was analyzed.

Results A total of 1,525 children with asthma were included in this study. There is a significant difference in the number of inconsistent group between the two methods ($P < 0.01$). In each age group, the number of people in the 2005 + 2021- group was higher than that in the 2005–2021 + group. The kappa consistency test revealed the kappa values of all age groups to be > 0.80 ($P < 0.01$) and consistent. The inconsistent group had lower lung-function values than the consistent group. The 2005BDR–2021BDR + group of lung-function values were higher than 2005BDR + 2021BDR– group. The analysis revealed that only Z-FEV1 (OR = 0.773, 95% CI: 0.650 to 0.919, $p = 0.004$) was an independent factor of Inconsistent results.The trends of 2005BDR + and 2021BDR + were consistent with the degree of airflow obstruction, indicating a weak positive correlation.

Conclusions The kappa test showed that the results of 2005BDR and 2021BDR were consistent, but there were differences between the inconsistent groups. Z-FEV1 is an independent factor affecting the inconsistent results, so

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baseline data is the main reason for the inconsistent results of the two methods. The 2021BDR standard may reduce the influence of baseline lung function when determining the results. The positive rate obtained based on the two evaluation criteria maintained the same trend with the degree of airflow obstruction. All showed a weak positive correlation.

Keywords 2005BDR, 2021BDR, Bronchodilator responsiveness, Asthma, Airway obstruction, Children

Introduction

The bronchodilator responsiveness (BDR) test is an important method to diagnose asthma; however, the criteria for determining BDR remain controversial. In 2005, the European Respiratory Society (ERS)/American Thoracic Society (ATS) pulmonary function test interpretation strategy recommended that an increase in forced expiratory volume in 1 s (FEV_1) and/or forced vital capacity (FVC) of > 200 mL and ≥ 12% of the baseline value to be used as the criteria for positive BDR [1]. The criteria are limited to absolute and relative changes in FEV_1 and FVC, which are inversely proportional to baseline lung function and related to height, age, and sex, all of which affect the accuracy of identifying the BDR [2]. The 2021 ERS/ATS updated pulmonary function test interpretation strategy recommends defining a positive BDR as an increase in FEV_1 or FVC > 10% of the predicted (pred) value [3]. This standard avoids misjudgment caused by different baseline lung function levels and minimizes the impact of height and gender [2]. While ensuring data availability, the recommendation also considers consistency across age groups. However, the recommendation also emphasizes that data for children and young adults on which this recommendation is based are limited and cannot provide a basis for the recommendation. Further evidence is therefore needed to verify its applicability in children [3]. To date, only a few studies have compared the two versions of the criteria [4–8]; however, most studies focus on adult asthma and chronic obstructive pulmonary disease, with very few studies evaluating children with asthma. This retrospective, cross-sectional study compared the differences between the 2005 and 2021 BDR standards in children of different age groups having asthma and analyzed the lung-function characteristics of children with inconsistent results, aiming to provide a basis for evaluating the applicability of the 2021 standard in the pediatric population.

Patients and methods

Subjects

This single-center, retrospective study used the database resources of the Department of Pulmonary Function, Children's Hospital of Chongqing Medical University to retrieve and collect all BDR test reports from January 2023 to April 2024. Patients were screened by reviewing their electronic medical records. The clinical diagnosis of patients with asthma was based on the Global Initiative for Asthma (GINA) 2024 guidelines. Only the initial report was selected for patients who underwent multiple BDR tests. Inclusion criteria: (1) patients aged 4–18 years; (2) patients diagnosed with bronchial asthma; and (3) BDR test quality control meeting the standards. Exclusion criteria: (1) children with other lung diseases including bronchopulmonary dysplasia, obliterative bronchiolitis, and interstitial lung disease; (2) patients with an unclear diagnosis; (3) patients who had undergone lung or chest surgery; and (4) patients with incomplete general information or missing parameters. This study was approved by the Medical Ethics Committee of the Children's Hospital of Chongqing Medical University [(2025) Ethics Review (Clinical Research) Approval No. (68)]. Informed consent from patients/their legal guardians was not required owing to the retrospective nature of this study.

Methods

Pulmonary function test methods

The German Jaeger pulmonary function instrument (MasterScreen Pedia, German) was used and the guidelines set by the ERS/ATS and the Chinese Medical Association Pediatrics Branch Respiratory Group Pulmonary Function Collaboration Group were strictly adhered to. Pulmonary ventilation function testing was performed by trained professional technicians. Before the bronchodilator test, clinicians instructed patients to discontinue bronchodilators. The duration of discontinuation was determined based on the duration of the drug's bronchodilator effect: 6 h for SABAs (such as albuterol), 12 h for SAMAs (such as ipratropium bromide), and 24 h for LABAs (such as formoterol or salmeterol). All nebulized medications used the short-acting β2-agonist albuterol (5 mg:2.5 mL). Children under 6 years of age received 1.25 mL, children 6–12 years of age received 1.875 mL, and children over 12 years of age received 2.5 mL. The solution was diluted to 3 mL with 9 g/L normal saline and inhaled using a nebulizer (PARITurboBOY N, German). Waiting for 15 min, pulmonary ventilation function testing was performed again.

Pulmonary function indices and variable definitions

Lung function parameters were expressed as percent predicted and z-scores using the Global Lung Function Initiative (GLI) 2012 reference equations (South east Asia).Values of pulmonary ventilation function indicators, including FVC, Z-FVC, FEV_1, Z-FEV_1, FEV_1/FVC, Z- FEV_1/FVC, forced expiratory flow at 75% vital capacity(FEF75), Z-FEF75 and forced expiratory flow from 25–75% (FEF25-75), Z-FEF25-75, were recorded before and after bronchodilator use. Data before bronchodilator use were defined as baseline pulmonary function data. The difference between the best baseline FEV_1 value and the best value after the use of bronchodilators was designated as ΔFEV_1; the ratio of ΔFEV_1 to baseline FEV_1 was called ΔFEV_1% initial (init); the ratio of ΔFEV_1 to FEV_1pred was called ΔFEV_1%pred. To simplify expression, BDR results defined by the 2005 and 2021 ERS/ATS standards were named 2005BDR and 2021BDR, respectively; positive and negative BDRs were designated as BDR + and BDR–, respectively. Parameters with the same results in 2005BDR and 2021BDR formed a consistent group and those with different results formed an inconsistent group.

Interpretation and quality control of results

Senior pulmonary function specialists reviewed the report quality and selected the best test values; respiratory specialists reviewed and determined the rationality of the diagnosis; two independent researchers interpreted the results of 2005BDR and 2021BDR, respectively, and calculated the BDR + rate; statisticians divided all enrolled children by age subgroups based on the age-stratification criteria for asthma diagnosis and treatment in the GINA guidelines, and the age groups were accurately calculated based on the date of birth; statisticians analyzed the data.

The 2005 BDR + standard is defined as ΔFEV_1%init ≥ 12% [9],(Refer to the formula recommended by GINA, and the following formula applies to all ages) and the 2021 BDR + standard is defined as ΔFEV_1%pred > 10% [3].

Obstructive ventilatory dysfunction is determined by Z-FEV_1/FVC < –1.64 [10]. The severity of obstruction is assessed by Z-FEV_1, with three critical values of-1.64, –2.50, and –4.0: –1.64 ~ –2.50 for mild obstruction, –2.51 ~ –4.0 for moderate obstruction, and < –4.1 for severe obstruction [11].

Statistical analysis

SPSS 25.0 statistical software was used for data analysis. Normally distributed quantitative data are described as mean ± standard deviation. Independent samples t-test was used to compare the means between the two groups. One-way analysis of variance was used to compare means of multiple groups. The Benjamini–Hochberg procedure to correct for multiple testing was applied. Count data are described by frequency and percentage, and the McNemar's test was used for the comparison of rates. Analyzing the relationship between ordered categorical variables using trend tests。Multivariate logistic regression was used to analyze the relationship between variables and outcomes. The kappa (κ) value was used to test the consistency between the two. The value of the κ coefficient ranged from –1 to 1. If κ was < 0, the two observations were inconsistent; a κ value of –1 indicated that there was no consistency. If the κ value was 0, the consistency rate of the observations was completely caused by random factors, and if the κ value was > 0, the two observations were more likely to be consistent and the possibility of being caused by random factors was small; the larger the κ value, the more consistent were the two results. When the κ value was ≥ 0.75, the consistency of the results was good. A κ value of < 0.4 indicated that there was no consistency [12]. $P < 0.05$ was considered to indicate significant difference.

Results

Screening process

Using the database resources of the Pulmonary Function Laboratory of the Children's Hospital of Chongqing Medical University, all BDR test reports from January 2023 to April 2024 were retrieved and collected, with a total of 6,659 BDR reports. A total of 5,134 cases were excluded based on age, diagnosis, and other reasons, and 1,525 cases were finally included. The flowchart is presented in Fig. 1.

Comparison of positive rates between the 2005BDR and 2021BDR criteria across age groups

A total of 1,525 children were included in this study, including 368 children in the ≤ 5-year-old group, 1,004 children in the 6–11-year-old group, and 153 children in the 12–18-year-old group.

The McNemar Test was used to compare the two methods. The results showed that the 2005BDR-2021BDR + (1.4%) of the 4–18 year old population was significantly lower than the 2005BDR + 2021BDR-(6.0%), and the difference was scientifically significant ($p < 0.001$). The odds ratio (OR) calculated based on discordant pairs was 0.239 (95% CI [0.156, 0.339]), indicating that the possibility of detecting additional positives by 2021BDR was 0.239 times the possibility of missing a diagnosis by 2005BDR. The kappa values were all > 0.8 ($p < 0.001$) after consistency testing. The results were also consistent across age groups.Comparison of the number of 2005BDR/2021BDR-positive and -negative groups in different age groups is shown in Table 1.

Comparison of lung-function values between the BDR + and BDR– groups among different age groups (2005BDR/2021BDR)

The differences in baseline and lung function indicators between 2005BDR + and 2021BDR +, and 2005BDR- and 2021BDR- in different age groups (≤ 5 years,

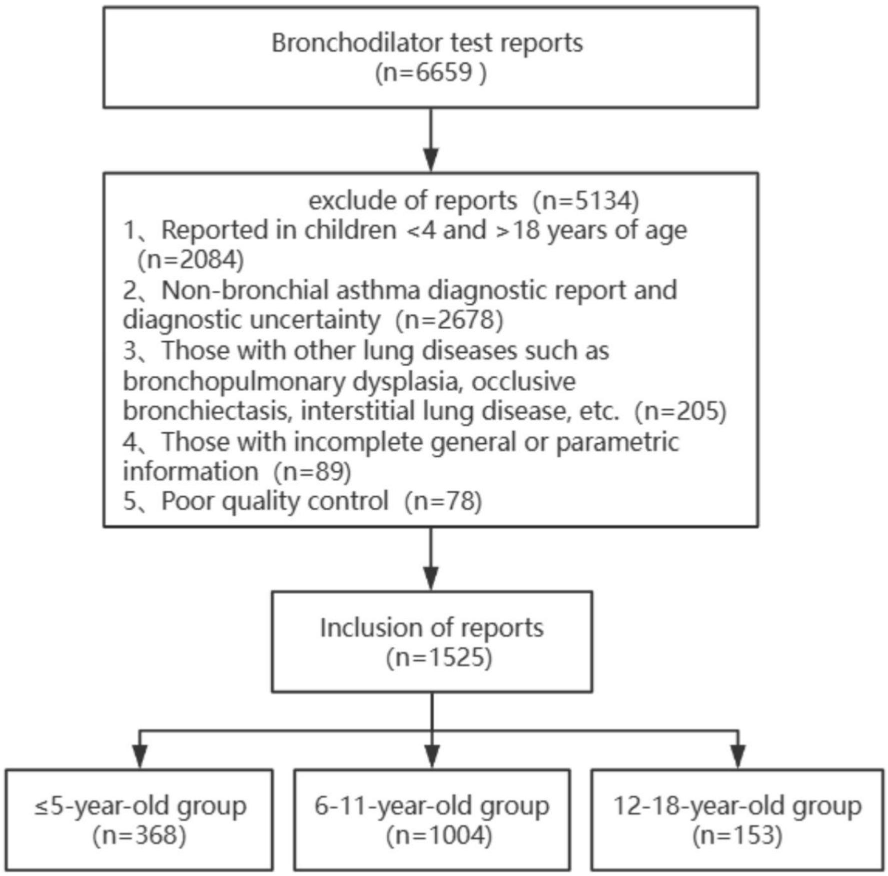

Fig. 1 Data inclusion and exclusion flow chart

Table 1 Comparison of the number of 2005BDR/2021BDR positive and negative groups in different age groups

4–18 years ($n = 1525$)	**2021BDR +**	**2021BDR-**	**total**	***P*-value**	**OR(95%CI)**
2005BDR +	558(36.6%)	92(6.0%)	650(42.6%)	**< 0.001**	0.239 [0.156, 0.339]
2005BDR-	22(1.4%)	853(55.9%)	858(57.4%)		
Total	580(38.0%)	945(62.0%)	1525(100%)		
Kappa = 0.845, 95%CI [0.818, 0.872], $p < 0.001$					
≤5years (n=368)					
2005BDR +	139 (37.8%)	17 (4.6%)	156 (42.4%)	**< 0.017**	0.294 [0.103, 0.560]
2005BDR-	5 (1.4%)	207 (56.3%)	212 (57.6%)		
total	144 (39.1%)	224 (56.3%)	368(100%)		
Kappa = 0.876, 95%CI [0.825, 0.927], $p < 0.001$					
6–11 years ($n = 1004$)					
2005BDR +	368 (36.7%)	65 (6.5%)	433(43.1%)	**< 0.001**	0.231 [0.135, 0.352]
2005BDR-	15 (1.5%)	556 (55.4%)	571(56.9%)		
total	383(38.1%)	621(61.9%)	1004(100%)		
Kappa = 0.835, 95%CI [0.817, 0.852], $p < 0.001$					
12–18 years ($n = 153$)					
2005BDR +	51 (33.3%)	10 (6.5%)	61(39.9%)	**0.039**	0.200 [0.025, 0.556]
2005BDR-	2 (1.3%)	90 (59.5%)	92(60.1%)		
total	53(34.6%)	100(65.4%)	153(100%)		
Kappa = 0.833, 95%CI [0.743, 0.923], $p < 0.001$					

6–11 years, and 12–18 years) were compared using independent sample t-test. The results showed that in the population ≤ 5 years old, the △FEV1%init of 2021BDR- (5.16 ± 4.95L) was significantly higher than that of 2005BDR- (4.32 ± 2.88 L), and the difference was statistically significant ($p < 0.028$). In the 6–11 year old population, Z-FEV1 and △FEV1%pred in the 2021BDR + group were significantly higher than those in the 2005BDR + group ($p < 0.05$), and the number of cases with Z-FEV1 < LLN in the 2021BDR + group (159) was significantly lower than that in the 2005BDR + group (217) ($p = 0.014$). In the 2021BDR- group, FEV1, Z-FEV1, FEV1/FVC, FEF75, and FEF25-75 were significantly lower than those in the 2005BDR- group ($p < 0.05$). In the 2021BDR- group, Z-FEV1 < LLN, ΔFEV1%init, and ΔFEV1%pred were significantly higher than those in the 2005BDR- group ($p < 0.05$). There were no significant differences between the two groups in the 12–18 age group. The comparison of lung function values between the 2005BDR and 2021BDR-positive and -negative groups in different age groups is shown in Table 2.

Lung function comparison: 2005BDR +/2021BDR + consistent vs inconsistent groups by age stratification

The inconsistency rates between 2005BDR + and 2021BDR + in the ≤ 5-year-old group, 6–11-year-old group, and 12–18-year-old group were 5.98%, 7.97%, and 0.65%, respectively. However, the inconsistency was unevenly distributed across populations with different characteristics (as shown in Appendix Table 3). The analysis showed that there were significant differences in gender in the 6–11-year-old group, and 12–18-year-old group (all $p < 0.05$). In both the ≤ 5-year-old and 6–11-year-old groups, the incidence of Z-FEV1 < LLN was significantly higher in the discordant group than in the concordant group (all $p < 0.05$). In the 6–11-year-old group, Z-FEV1 was significantly lower in the discordant group (−1.90 ± 1.93) than in the concordant group (−1.20 ± 1.70) ($p = 0.001$). Across all populations, the discordant group had significantly lower ΔFEV1, ΔFEV1%init, and ΔFEV1%pred values than the concordant group ($p < 0.01$).

Pulmonary function profiles of the 2005BDR +/2021BDR + inconsistent group

As shown in Table 4, Analysis of variance revealed significant differences in FVC, FEV1, Z-FEV1, FEV1/FVC, FEF75, FEF25-75, and Z-FEF25-75 among the 2005 + 2021 +, 2005–2021 +, and 2005 + 2021- groups. After Beniamini-Hochberg correction for multiple group differences (Table 5), the differences in FVC, FEV1, Z-FEV1, FEV1/FVC, FEF75, and FEF25-75 remained significant. The baseline value data shown 2005–2021 + > 2005 + 2021 + > 2005 + 2021-.

Multivariate analysis between discordant groups

As shown in Table 6. To investigate independent factors influencing discordant positive results, a multivariate logistic regression analysis was performed. We first tested the interaction between age and obstruction severity, but this was not statistically significant ($p = 0.242$). Therefore, the final model included only the main effects. The analysis revealed that only Z-FEV1 (OR = 0.773, 95% CI: 0.650 to 0.919, $p = 0.004$) was an independent protective factor against discordance. Specifically, each unit increase in Z-FEV1 was associated with an increased likelihood of concordant BDR results (more precisely, a decreased risk of discordance).

Age-stratified correlation of BDR + rates with severity in airflow limitation

As shown in Table 7, a trend test was used to analyze the relationship between age group and obstruction severity. The results showed a significant trend ($\chi^2 = 10.101$, $p = 0.01$) (Gamma = 0.125, $p = 0.001$) between the two groups in the 2005BDR + group, indicating a weak positive correlation. The trend in the 2021BDR + group was consistent with that in the 2005BDR + group. As shown in Table 8, a chi-square test for trend was used to analyze the relationship between age group and the discordant group. The results showed a significant linear trend ($\chi^2 = 8.657$, $p < 0.003$; OR = −0.142, $p = -0.114$, $p < 0.003$), indicating a weak negative correlation.

Discussion

Our study found that the 2021BDR positive rate was significantly lower compared with the 2005BDR positive rate. This trend was noted in all three age groups, which was consistent with the results of Lázár et al. [7, 13]. However, some studies reached an opposite conclusion, such as the study by Li, Beydon et al. [8, 14], which reported that the 2021BDR + rate was higher than the 2005BDR + rate. This may be attributed to the slightly different calculation formula of 2005BDR +. The difference in research results may also be attributed to the heterogeneity of subjects, including their age, underlying diseases, race, and sample size. This study used the 2005BDR + standard in this article is based on the pediatric guidelines and is defined as ΔFEV_1/init ≥ 12% with reference to the GINA guidelines [15]. The unique physiological and anatomical characteristics of children, such as their short exhalation time and low vital capacity, make it difficult to mandate the absolute value of the increase of ≥ 200 mL when evaluating bronchodilator responsiveness while requiring the change rate of ΔFVC or ΔFEV1 (especially in younger children). Leading to a

Table 2 Comparison of lung function values between 2005BDR/2021BDR positive and negative groups in different age groups

	BDR+				BDR-			
	2005BDR+	**2021BDR+**	***p***	**95%CI**	**2005BDR-**	**2021BDR-**	***p***	**95%CI**
≤5 years								
Male	84(53.8%)	74(51.4%)	0.670	1.104[0.701,1.737]	134(63.2%)	144(64.3%)	0.815	0.954[0.646,1.411]
Female	72 (46.2%)	70 (48.6%)			78 (36.8%)	80 (36.2%)		
Height	109.40 ± 5.94	109.33 ± 5.93	0.918	0.071[−1.280,1.421]	109.20 ± 5.57	109.26 ± 5.59	0.917	−0.056[−1.107,0.995]
Weight	18.48 ± 3.21	18.48 ± 3.07	0.993	0.993[−0.711,0.717]	18.48 ± 3.01	18.48 ± 3.11	0.995	−0.002[−0.579,0.575]
FVC (Mean ± SD)	0.90 ± 0.29	0.92 ± 0.29	0.488	0.488[−0.089,0.043]	1.07 ± 0.22	1.05 ± 0.23	0.271	0.024[−0.019,0.067]
Z-FVC (Mean ± SD)	0.04 ± 1.53	0.06 ± 1.53	0.908	0.908[−0.39,0.30]	0.13 ± 1.63	0.11 ± 1.63	0.907	0.018[−0.288,0.325]
N(%) < LLN	20 (12.8%)	18(12.5%)	0.934	0.971[0.491,1920]	28(13.2%)	30 (13.6%)	0.955	1.016[0.584,1.767]
FEV1 (Mean ± SD)	0.72 ± 0.23	0.75 ± 0.24	0.286	−0.028[−0.089,0.024]	0.96 ± 0.21	0.93 ± 0.23	0.137	0.021[−0.010,0.073]
Z-FEV1(Mean ± SD)	−1.46 ± 1.62	−1.20 ± 1.65	0.160	−0.29[−0.66,0.08]	−0.05 ± 1.44	−0.30 ± 1.59	0.092	0.146[−0.040,0.533]
N(%) < LLN	74(47.4%)	59(41.0%)	0.260	0.769[0.487,1.215]	26(12.3%)	41 (18.3%)	0.081	1.603[0.941,2.729]
FEV1/FVC(Mean ± SD)	80.73 ± 10.44	81.69 ± 10.49	0.482	−0.960[−3.34,1.42]	89.67 ± 7.83	88.58 ± 8.76	0.092	0.798[−0.472,2.663]
Z- FEV1/FVC (Mean ± SD)	−1.19 ± 1.39	−1.23 ± 1.40	0.772	0.047[−0.270,0.363]	−1.26 ± 1.34	−1.23 ± 1.34	0.790	0.128[−0.286,0.218]
N(%) < LLN	61(39.1%)	58(40.3%)	0.835	1.050[0.661,1.669]	81 (38.2%)	84(37.5%)	0.879	0.970[0.659,1.429]
FEF75(Mean ± SD)	0.38 ± 0.22	0.41 ± 0.24	0.257	−0.030[−0.08,0.022]	0.69 ± 0.30	0.65 ± 0.31	0.233	0.036[−0.022,0.095]
Z-FEF75(Mean ± SD)	−1.47 ± 1.56	−1.51 ± 1.57	0.832	0.038[−0.318,0.395]	−1.42 ± 1.60	−1.40 ± −1.59	0.886	−0.022[−0.323,0.279]
N(%) < LLN	68(43.6%)	64(44.4%)	0.882	1.035[0.656,1.634]	97(45.8%)	101(45.1%)	0.889	0.974[0.668,1.420]
FEF25-75(Mean ± SD)	0.68 ± 0.33	0.73 ± 0.35	0.220	−0.048[−0.126,0.029]	1.22 ± 0.44	1.16 ± 0.47	0.172	0.060[−0.026,0.146]
Z-FEF25-75(Mean ± SD)	−1.36 ± 1.46	−1.39 ± 1.43	0.847	0.038[−0.318,0.395]	−1.33 ± 1.56	−1.31 ± 1.57	0.898	−0.019[−0.314,0.276]
N(%) < LLN	65(41.7%)	61(42.4%)	0.903	1.029[0.650,1.628]	96(45.3%)	100(44.6%)	0.893	0.974[0.668,1.421]
△FEV1	175.55 ± 86.21	183.07 ± 85.50	0.449	−7.518[−27.047,12.005]	41.04 ± 28.61	43.41 ± 29.62	0.396	−2.37[−7.860,3.113]
△FEV1%init	28.12 ± 22.54	28.80 ± 23.21	0.802	−0.664[−5.864,4.537]	4.32 ± 2.88	5.16 ± 4.95	**0.028**	−0.848[−1.616,−0.080]
△FEV1%pred	17.87 ± 8.17	18.62 ± 8.13	0.403	−0.794[−2.660,1.072]	4.21 ± 2.87	4.38 ± 2.89	0.420	−0.222[−0.762,0.318]
6–11 years								
Male	257 (59.4%)	217 (56.7%)	0.436	1.117 [0.845,1.476]	344(60.2%)	384(61.8%)	0.574	0.935[0.741,1.181]
Female	176 (40.6%)	166(43.3%)			227(39.8%)	237(38.2%)		
Height	126.70 ± 11.91	126.12 ± 11.57	0.982	0.019[−1.617,1.654]	128.08 ± 12.27	127.98 ± 12.28	0.889	0.099[−1.297,1.496]
Weight	26.76 ± 9.27	26.27 ± 8.57	0.934	0.053[−1.212,1.319]	27.94 ± 9.71	27.87 ± 9.77	0.913	0.062[−1.046,1.170]
FVC (Mean ± SD)	1.45 ± 0.51	1.48 ± 0.50	0.124	−0.055[−0.126,0.015]	1.71 ± 0.57	1.65 ± 0.58	0.099	0.055[−0.010,0.121]
Z-FVC (Mean ± SD)	0.15 ± 1.63	0.07 ± 1.67	0.775	0.033[−0.194,0.260]	0.01 ± 1.52	0.04 ± 1.51	0.718	−0.32[−0.203,0.140]
N(%) < LLN	59(13.6%)	54(14.1%)	0.845	1.040[0.699,1.549]	80(14.0%)	85(13.7%)	0.872	0.973[0.700,1.352]
FEV1 (Mean ± SD)	1.07 ± 0.38	1.10 ± 0.38	0.075	−0.049[−0.102,0.005]	**1.47 ± 0.48**	1.41 ± 0.50	**0.028**	0.062[0.007,0.118]
Z-FEV1 (Mean ± SD)	−1.43 ± 1.69	−1.09 ± 1.75	**0.006**	−0.337[−0.574,−0.098]	0.16 ± 1.59	−0.17 ± 1.78	**0.001**	0.335[0.145,0.526]
N(%) < LLN	217(50.1%)	159(41.5%)	**0.014**	0.707[0.536,0.932]	92(16.1%)	150(24.2%)	**0.001**	1.658[1.242,2.214]
FEV1/FVC (Mean ± SD)	74.72 ± 10.11	75.01 ± 10.21	0.076	−0.270[−1.668,1.127]	86.49 ± 7.56	85.37 ± 8.58	**0.018**	1.115[0.197,2.032]
Z- FEV1/FVC (Mean ± SD)	−1.28 ± 1.39	−1.28 ± 1.38	0.891	−0.013[−0.204,0.177]	−1.28 ± 1.32	−1.28 ± 1.34	0.914	0.008[−0.143,0.160]
N(%) < LLN	164(37.9%)	139(36.3%)	0.640	0.934[0.703,1.242]	215(37.7%)	240(38.6%)	0.724	1.043[0.825,1.318]
FEF75 (Mean ± SD)	0.44 ± 0.24	0.46 ± 0.26	0.075	−0.018[−0.066, 0.003]	0.87 ± 0.38	0.82 ± 0.40	**0.016**	0.054[0.010,0.099]

Table 2 (continued)

	BDR+				BDR-			
	2005BDR+	**2021BDR+**	***p***	**95%CI**	**2005BDR-**	**2021BDR-**	***p***	**95%CI**
Z-FEF75 (Mean ± SD)	−1.47 ± 1.63	−1.49 ± 1.61	0.959	0.006[−0.230,0.218]	−1.51 ± 1.60	−1.51 ± 1.61	0.998	−0.001[−0.183,0.182]
N(%) < LLN	182(42.0%)	156(40.7%)	0.706	0.948[0.717,1.253]	254(44.5%)	280(445.1%)	0.834	1.025[0.815,1.288]
FEF25-75 (Mean ± SD)	0.86 ± 0.42	0.90 ± 0.45	0.059	−0.09[−0.119,0.002]	1.63 ± 0.61	1.53 ± 0.66	**0.008**	0.098[0.026,0.171]
Z-FEF25-75 (Mean ± SD)	−1.34 ± 1.57	−1.36 ± 1.52	0.887	0.016[−0.231,0.199]	−1.38 ± 1.54	−1.39 ± 1.55	0.946	0.006[0.170,0.182]
N(%) < LLN	183(42.3%)	157(41.0%)	0.713	0.949[0.718,1.254]	257(45.0%)	283(45.6%)	0.845	1.023[0.814,1.285]
△FEV1	226.01 ± 105.36	243.75 ± 104.59	0.053	−14.179[−28.550,0.192]	56.50 ± 43.65	61.40 ± 46.03	0.060	−4.904[−10.011,0.204]
△FEV1%init	23.47 ± 19.39	25.11 ± 20.77	0.463	−1.024[−3.758,1.710]	3.94 ± 2.74	4.88 ± 4.18	**< 0.001**	−0.941[−1.340,−0.542]
△FEV1%pred	15.21 ± 6.52	16.59 ± 6.26	**0.024**	−1.060[−1.980,−0.139]	3.63 ± 2.56	4.19 ± 2.82	**0.038**	−0.332[−0.647,−0.181]
12–18 years								
Male	40(65.6%)	36(67.9%)	0.791	0.899[0.411,1.966]	56(60.9%)	60(60.0%)	0.902	1.037[0.581,1.851]
Female	21(34.4%)	17(32.1%)			36(39.1%)	40(40.0%)		
Height	156.33 ± 12.03	156.28 ± 11.21	0.984	0.045[−4.270,4.359]	156.86 ± 10.20	156.84 ± 10.83	0.990	0.019[−2.982,3.020]
Weight	49.00 ± 16.28	49.34 ± 16.77	0.914	0.045[−4.270,4.359]	49.39 ± 14.89	49.19 ± 14.72	0.922	0.208[−4.010,4.427]
FVC(Mean ± SD)	2.78 ± 0.92	2.88 ± 0.91	0.551	−0.103[−0.443,0.238]	2.91 ± 0.75	2.85 ± 0.78	0.560	0.065[−0.154,0.284]
Z-FVC(Mean ± SD)	−0.38 ± 1.47	−0.44 ± 1.48	0.838	0.057[−0.491,0.604]	0.23 ± 1.43	0.21 ± 1.42	0.927	0.019[−0.387,0.425]
N(%) < LLN	11(18.0%)	10(18.9%)	0.909	1.057[0.409,2.729]	8(8.7%)	9(9.0%)	0.941	1.038[0.383,2.816]
FEV1(Mean ± SD)	1.87 ± 0.66	1.95 ± 0.65	0.506	−0.083[−0.328,0.162]	2.49 ± 0.67	2.40 ± 0.73	0.355	0.094[−0.106,0.293]
Z-FEV1(Mean ± SD)	−1.92 ± 1.61	−1.61 ± 1.69	0.321	0.309[−0.923,0.305]	−0.23 ± 1.67	−0.53 ± 1.81	0.238	0.299[−0.199,0.796]
N(%) < LLN	36(59.0%)	27(50.9%)	0.387	0.721[0.343,1.514]	18(19.6%)	27(27.0%)	0.224	1.521[0.772,2.997]
FEV1/FVC(Mean ± SD)	67.64 ± 10.81	68.15 ± 10.57	0.802	−0.505[−4.481,3.470]	85.62 ± 8.39	83.92 ± 10.46	0.217	1.706[−1.008,4.421]
Z- FEV1/FVC (Mean ± SD)	−1.68 ± 1.35	−1.67 ± 1.30	0.962	−0.012[−0.504,0.481]	−1.40 ± 1.31	−1.43 ± 1.34	0.882	0.029[−0.350,0.407]
N(%) < LLN	34(55.7%)	30(56.6%)	0.926	1.036[0.493,2.175]	40(43.5%)	44(44.0%)	0.942	1.021[0.577,1.808]
FEF75(Mean ± SD)	0.66 ± 0.38	0.71 ± 0.39	0.492	−0.050[−0.193,0.094]	1.50 ± 0.63	1.41 ± 0.68	0.324	0.094[−0.093,0.281]
Z-FEF75(Mean ± SD)	−2.10 ± 1.69	−2.09 ± 1.68	0.982	−0.007[−0.632,0.617]	−1.45 ± 1.55	−1.50 ± 1.59	0.804	0.056[−0.391,0.504]
N(%) < LLN	40(65.6%)	34(64.2%)	0.874	0.939[0.435,2.031]	39(42.4%)	45(45.0%)	0.716	1.112[0.628,1.968]
FEF25-75(Mean ± SD)	1.32 ± 0.67	1.39 ± 0.67	0.555	−0.075[−0.325,0.175]	2.71 ± 0.96	2.55 ± 1.06	0.305	0.151[−0.138,0.441]
Z-FEF25-75 (Mean ± SD)	−1.92 ± 1.54	−1.91 ± 1.52	0.998	0.001[−0.570,0.568]	−1.35 ± 1.47	−1.39 ± 1.50	0.832	0.046[−0.378,0.470]
N(%) < LLN	39(63.9)	33(62.3%)	0.854	0.931[0.434,1.995]	39(42.4%)	45(45.0%)	0.716	1.112[0.628,1.968]
△FEV1	389.80 ± 183.43	419.55 ± 183.43	0.381	−29.74[−96.822,37.333]	91.74 ± 66.62	99.82 ± 71.24	0.419	−8.081[−27.76,11.60]
△FEV1%init	22.85 ± 12.77	23.94 ± 13.29	0.655	−1.095[−5.937,3.748]	3.70 ± 2.54	4.65 ± 4.20	0.057	−0.952[−1.951,0.047]
△FEV1%pred	14.45 ± 6.33	16.31 ± 6.05	0.312	−1.192[−3.518,1.133]	3.51 ± 2.50	3.81 ± 2.59	0.422	−0.297[−1.024,0.431]

Table 3 Comparison of lung function values between the 2005BDR+/2021BDR+consistent group and the inconsistent group in different age groups

	≤5years				6–11 years				12–18 years			
	Consistent 2005+&2021+ [139(37.78%)]	**Inconsistent 2005+/2021+ [22(5.98%)]**	***P***	**95%CI**	**Consistent 2005+&2021+ [368(36.65%)]**	**Inconsistent 2005+/2021+ [80(7.97%)]**	***p***	**95%CI**	**Consistent 2005+&2021+ [51(33.33%)]**	**Inconsistent 2005+/2021+ [12(0.65%)]**	***p***	**95%CI**
Male (n, %)	71 (51.1%)	16 (72.7%)	0.058	0.392[0.145,1.060]	209 (56.8%)	56 (70.0%)	**0.029**	0.563[0.335,0.948]	36 (70.6%)	4 (33.3%)	**0.016**	4.800[1.253,18.384]
Female (n, %)	68 (48.9%)	6(27.3%)			159(43.2%)	24(30.0%)			15(29.4%)	8(66.7%)		
Height (cm)	109.37 ± 5.98	109.41 ± 5.46	0.975	−0.042[−2.723, 2.638]	126.63 ± 11.75	127.25 ± 13.06	0.674	−0.622[−3.530,2.286]	156.55 ± 11.33	154.25 ± 14.48	0.551	2.299[−5.376,9,975]
Weight(kg)	18.48 ± 3.09	18.52 ± 3.82	0.974	−0.043[−1.491, 1.406]	26.70 ± 9.17	27.10 ± 9.44	0.720	−0.409[−2.644,1.827]	49.68 ± 17.00	44.71 ± 11.06	0.339	4.972[−5.354,15.298]
FVC(L)	0.91 ± 0.29	0.89 ± 0.28	0.824	0.015[−0.116, 0.146]	1.48 ± 0.51	1.38 ± 0.55	0.095	0.107[−0.019,0.232]	2.88 ± 0.93	2.39 ± 0.75	0.093	0.491[−0.084,1.066]
Z-FVC	0.05 ± 1.55	0.07 ± 1.32	0.945	−0.024[−0.713, 0.665]	0.11 ± 1.65	0.31 ± 1.63	0.334	−0.196[−0.595,0.203]	−0.48 ± 1.47	0.25 ± 1.39	0.119	−0.737[−1.671,0.196]
N(%) < LLN	18(12.9%)	2(9.1%)	0.610	0.672[0.145,3.122]	50(13.6%)	13(16.3%)	0.535	1.234[0.635,2.399]	10(19.6%)	1(8.3%)	0.355	0.373[0.043,3.234]
FEV1(L)	0.72 ± 0.23	0.71 ± 0.26	0.705	0.020[−0.086, 0.127]	1.10 ± 0.38	1.05 ± 0.44	0.371	0.044[−0.052,0.139]	1.94 ± 0.67	1.65 ± 0.58	0.174	0.288[−0.130,0.706]
Z- FEV1	−1.29 ± 1.60	−1.90 ± 2.10	0.111	0.615[−0.143, 1.373]	−1.20 ± 1.70	−1.90 ± 1.93	**0.001**	0.695[0.273,1.118]	−1.72 ± 1.62	−2.21 ± 1.78	0.373	0.487[−0.598,1.572]
N(%) < LLN	59(42.4%)	15(68.2%)	**0.024**	2.906[1.115,7.574]	159(43.2%)	58(72.5%)	**< 0.01**	3.465[2.035,5.901]	27(52.9%)	9(75.0%)	0.165	2.667[0.646,11.006]
FEV1/FVC(L)	81.35 ± 10.48	79.22 ± 10.47	0.379	2.123[−2.625, 6.872]	74.60 ± 10.16	77.06 ± 9.82	0.050	−2.453[−4.903,−0.004]	67.77 ± 10.58	68.76 ± 12.14	0.778	−0.990[−7.970,5.990]
Z- FEV1/FVC	−1.24 ± 1.40	−0.80 ± 1.25	0.166	−0.441[−1.067, 0.186]	−1.30 ± 1.38	−1.04 ± 1.39	0.132	−0.258[−0.593,0.078]	−1.67 ± 1.32	−1.76 ± 1.40	0.838	0.088[−0.769,0.945]
N(%) < LLN	57(41.0%)	5(22.7%)	0.102	0.423[0.148,1.213]	138(37.5%)	27(33.8%)	0.529	0.849[0.510,1.413]	29(56.9%)	6(50.0%)	0.667	0.759[0.215,2.574]
FEF75(L)	0.40 ± 0.23	0.35 ± 0.25	0.367	0.048[−0.057, 0.154]	0.45 ± 0.25	0.45 ± 0.27	0.988	−0.01[−0.066,0.065]	0.69 ± 0.39	0.59 ± 0.37	0.409	0.103[0.144,0.350]
Z-FEF75	−1.53 ± 1.57	−1.04 ± 1.56	0.182	−0.481[−1.190, 0.228]	−1.50 ± 1.62	−1.20 ± 1.70	0.143	−0.296[−0.692,0.100]	−2.11 ± 1.69	−1.98 ± 1.68	0.805	−0.134[−1.216,0.948]
N(%) < LLN	63(38.4%)	8(4.9%)	0.112	0.452[0.167,1.225]	153(41.6%)	32(40.0%)	0.795	0.937[0.572,1.534]	33(64.7%)	8(66.7%)	0.898	1.091[0.288,4127]
FEF25-75(L)	0.70 ± 0.33	0.66 ± 0.42	0.618	0.040[−0.117, 0.197]	0.88 ± 0.44	0.88 ± 0.48	0.952	0.003[−0.105,0.112]	1.37 ± 0.67	1.20 ± 0.67	0.449	0.165[−0.268,0.597]
Z- FEF25-75	−1.41 ± 1.43	−0.93 ± 1.59	0.152	0.480[−1.137,0.178]	−1.36 ± 1.54	−1.08 ± 1.72	0.154	−0.278[−0.660,0.104]	−1.98 ± 1.53	−1.66 ± 1.59	0.796	−0.128[−1.112,0.856]
N(%) < LLN	60(43.2%)	6(27.3%)	0.159	0.494[0.182,1.337]	153(41.6%)	34(42.5%)	0.879	1.039[0.637,1.694]	32(62.7%)	8(66.7%)	0.800	1.188[0.315,4.480]
△FEV1	185.81 ± 85.77	95.18 ± 13.99	**< 0.01**	90.624[75.096,106.152]	243.50 ± 103.716	133.03 ± 40.958	**< 0.01**	110.472[96.533,124.412]	426.88 ± 176.89	206.00 ± 51.207	**< 0.01**	**220.882[163.150,278.615]**
△FEV1%init	29.47 ± 23.34	15.36 ± 8.43	**< 0.01**	14.108[8.791,19.426]	25.09 ± 20.56	13.41 ± 3.49	**< 0.01**	11.685[9.443,13.927]	24.488 ± 13.25	14.40 ± 4.18	**< 0.01**	**10.731[6.269,11.312]**
△FEV1%pred	18.92 ± 8.04	9.72 ± 1.13	**< 0.01**	9.203[7.773, 10.632]	16.44 ± 6.30	8.68 ± 1.32	**< 0.01**	7.759[7.052,8.467]	15.79 ± 6.05	8.02 ± 1.38	**< 0.01**	**7.776[5.904,9.648]**

Table 4 Comparison between BDR + consistent group and inconsistent group

Indicators	Groups	Mean ± SD	F	P
FVC	2005 + 2021 +	1.47 ± 0.73	7.317	**0.001**
	2005–2021 +	1.89 ± 0.64		
	2005 + 2021-	1.27 ± 0.610		
Z-FVC	2005 + 2021 +	0.04 ± 1.62	0.854	0.426
	2005–2021 +	0.27 ± 1.78		
	2005 + 2021-	0.25 ± 1.49		
FEV1	2005 + 2021 +	1.08 ± 0.50	16.926	**< 0.001**
	2005–2021 +	1.59 ± 0.48		
	2005 + 2021-	0.92 ± 0.40		
Z-FEV1	2005 + 2021 +	−1.27 ± 1.67	74.511	**< 0.001**
	2005–2021 +	1.54 ± 0.94		
	2005 + 2021-	−2.76 ± 0.96		
FEV1/FVC	2005 + 2021 +	75.66 ± 10.95	9.413	**< 0.001**
	2005–2021 +	85.34 ± 6.22		
	2005 + 2021-	74.51 ± 10.25		
Z-FEV1/FVC	2005 + 2021 +	−1.32 ± 1.38	2.447	0.087
	2005–2021 +	−0.71 ± 1.05		
	2005 + 2021-	−1.16 ± 1.44		
FEF75	2005 + 2021 +	0.46 ± 0.27	36.404	**< 0.001**
	2005–2021 +	0.87 ± 0.24		
	2005 + 2021-	0.34 ± 0.18		
Z-FEF75	2005 + 2021 +	−1.56 ± 1.62	2.498	0.083
	2005–2021 +	−0.85 ± 1.55		
	2005 + 2021-	−1.35 ± 1.70		
FEF25-75	2005 + 2021 +	0.88 ± 0.47	36.726	**< 0.001**
	2005–2021 +	1.62 ± 0.41		
	2005 + 2021-	0.69 ± 0.35		
Z- FEF25-75	2005 + 2021 +	−1.42 ± 1.52	3.035	**0.049**
	2005–2021 +	−0.65 ± 1.63		
	2005 + 2021-	−1.24 ± 1.68		

high number of false negatives, meaning that children with asthma who actually have reversible airflow obstruction are mistakenly diagnosed as having a negative result. The ATS/ERS guidelines explicitly state that the 200 mL threshold is not applicable to children. FEV_1 is the most sensitive and specific indicator of airflow obstruction in asthma. A significant improvement in FVC may also be related to other factors, such as improved test technique (children becoming more cooperative after repeated testing) or certain manifestations of restrictive lung disease. Therefore, relying solely on FVC to define a positive test increases diagnostic uncertainty. Therefore, using a change in FEV_1 of ≥ 12% has better diagnostic accuracy than combined criteria.

The κ test showed that 2005BDR and 2021BDR had good consistency, with κ values being > 0.80, which was consistent with the conclusions in previous studies [4, 5]. Chaiwong et al. [5] believed that 2021BDR did not significantly change the BDR results of most patients with asthma, ensuring diagnostic stability. Furthermore, they reported that the 2005BDR and 2021BDR standards could be used interchangeably. Trepić et al. [4] reported that regardless of the standard that was used, positive BDR was associated with the degree of FEV_1 impairment.

This study further analyzed the age groups of children with asthma and found that only in the 6–11-year-old group, there were significant differences in baseline lung-function indicators between 2005BDR + and 2021BDR +, and between 2005BDR– and 2021BDR–. Specifically, the Z-FEV1, △FEV1%pred in the 2021BDR + group were significantly higher than those in the 2005BDR + group; The number of cases with Z-FEV1 < LLN in the 2021BDR + group (159) was significantly lower than that in the 2005BDR + group (217). These findings suggest that the difference between the two evaluation criteria is more likely to occur in children aged 6–11 years. Among the two standards, 2021BDR + is associated with better baseline lung function, whereas 2021BDR– is associated with worse baseline lung function. This result demonstrates that compared with the 2005BDR standard, the 2021 version of the standard May reduce the influence of baseline lung function in BDR results.

The indicators with differences in children in all age groups showed a decrease in the inconsistent group and were similar to the findings reported by Li et al. [8], children with worse baseline lung function are more likely to show inconsistent results.

Children exhibiting inconsistent results were divided into two outcomes, changing from 2005BDR + to 2021BDR–, or changing from 2005BDR– to 2021BDR +. Comparison of baseline pulmonary-function data showed that the baseline pulmonary function of children who exhibited a change from 2005BDR + to 2021BDR– was generally poor, and the values for each parameter were significantly lower than those for children with consistent results in the two evaluations. On the other hand, the baseline pulmonary-function data of children who showed a change from 2005BDR– to 2021BDR + were significantly higher than those of children in the consistent group. In general, 2021BDR + children had better baseline pulmonary function, and those with inconsistent results generally showed lower ΔFEV1 values.

We further analyzed the relationship between the positive rate and the degree of baseline airflow obstruction using the two evaluation criteria. The positive rates of 2005BDR and 2021BDR were both positively correlated with the severity of airflow obstruction for children, which was similar to the conclusions of Beasle et al. [13, 16]. From the table, we can see that the severity is inversely proportional to the age, but the trend test shows a weak positive correlation, which may be related to the sample size. BDR + is mainly concentrated in the normal and mild obstruction population. The analysis revealed that only Z-FEV1 was an independent protective factor against discordance. Trepić et al. [4] reported that

Table 5 Pairwise comparisons between inconsistent groups

Indicators	Groups		95%CI	Adjusted p
FVC	2005 + 2021 +	2005–2021 +	0.421[0.112,0.730]	**0.019**
	2005 + 2021 +	2005 + 2021-	−0.197[−0.354,−0.040]	**0.040**
	2005 + 2021-	2005–2021 +	−0.618[−1.021,−0.215]	**0.001**
Z-FVC	2005 + 2021 +	2005–2021 +	0.227[−0.465,0.919]	0.560
	2005 + 2021 +	2005 + 2021-	0.213[−0.141,0.566]	0.886
	2005 + 2021-	2005–2021 +	−0.015[−0.926,0.897]	1.000
FEV1	2005 + 2021 +	2005–2021 +	0.505[0.293,0.717]	**< 0.001**
	2005 + 2021 +	2005 + 2021-	−0.162[−0.269,−0.054]	0.10
	2005 + 2021-	2005–2021 +	−0.666[−0.942,−0.390]	**< 0.001**
Z-FEV1	2005 + 2021 +	2005–2021 +	0.213[2.37,3.25]	**< 0.001**
	2005 + 2021 +	2005 + 2021-	−1.490[−1.731,−1.249]	**< 0.001**
	2005 + 2021-	2005–2021 +	−4.302[−5.197,−3.407]	**< 0.001**
FEV1/FVC	2005 + 2021 +	2005–2021 +	9.69[6.804,12.576]	**< 0.001**
	2005 + 2021 +	2005 + 2021-	−1.149[−3.546,1.249]	0.715
	2005 + 2021-	2005–2021 +	−10.838[−16.937,−4.740]	**< 0.001**
Z-FEV1/FVC	2005 + 2021 +	2005–2021 +	0.608[0.131,1.085]	0.125
	2005 + 2021 +	2005 + 2021-	0.162[−0.145,0.470]	0.653
	2005 + 2021-	2005–2021 +	−0.445[−1.231,0.340]	0.438
FEF75	2005 + 2021 +	2005–2021 +	0.411[0.295,0.527]	**< 0.001**
	2005 + 2021 +	2005 + 2021-	−0.115[−0.158,−0.072]	**< 0.001**
	2005 + 2021-	2005–2021 +	−0.526[−0.674,−0.379]	**< 0.001**
Z-FEF75	2005 + 2021 +	2005–2021 +	0.704[0.014,1.394]	0.135
	2005 + 2021 +	2005 + 2021-	0.213[−0.147,0.573]	0.570
	2005 + 2021-	2005–2021 +	−0.491[−1.4156,0.434]	0.496
FEF25-75	2005 + 2021 +	2005–2021 +	0.738[0.537,0.939]	**< 0.001**
	2005 + 2021 +	2005 + 2021-	−0.190[−0.271,−0.108]	**0.001**
	2005 + 2021-	2005–2021 +	−0.928[−1.187,−0.669]	**< 0.001**
Z- FEF25-75	2005 + 2021 +	2005–2021 +	0.774[0.123,1.425]	0.063
	2005 + 2021 +	2005 + 2021-	0.182[−0.159,0.523]	0.652
	2005 + 2021-	2005–2021 +	−0.592[−1.471,0.286]	0.288

Table 6 Multivariate logistic regression analysis of inconsistent

2005BDR + 2021BDR + vs2005BDR +/2021BDR +	B	S.E	Wald	*p*	OR	95%CI
Z-FEV1	−0.258	0.088	8.514	**0.004**	0.773	[0.650, 0.919]
Sex	−0.100	0.248	0.162	0.687	0.905	[0.556,1.472]
Age	0.383	0.777	0.243	0.622	0.612	[0.320, 6.719]
Normal vs Severe	0.169	1.813	0.009	0.926	1.184	[0.034, 41.332]
Mild vs Severe	0.397	1.833	0.047	0.829	1.488	[0.041,54.086]
Moderate vs Severe	1.872	1.855	1.018	0.313	6.505	[0.171,246.844]
Age × degree of obstruction			4.190	**0.242**		

Table 7 Distribution of 2005BDR +/2021BDR + in populations with different baseline pulmonary ventilation functions

2005BDR +	Normal (n,%)	Mild	Moderate	Severe
≤ 5years	63 (40.4%)	67 (42.9%)	22 (14.1%)	4 (2.6%)
6-11years	155 (35.8%)	163 (37.6%)	97 (22.4%)	18 (4.2%)
12-18years	15 (24.6%)	24 (39.3%)	17 (27.9%)	5 (8.2%)
$\chi^2 = 10.101$, $p = 0.01$. Gamma = 0.186, $p = 0.002$				
2021BDR +				
≤ 5years	64(44.4%)	62(43.1%)	15(10.4%)	3(2.1%)
6-11years	147(38.4%)	148(38.6%)	74(19.3%)	14(3.7%)
12-18years	14(26.4%)	22(41.5%)	14(26.4%)	3(5.7%)
$\chi^2 = 10.437$, $p = 0.001$. Gamma = 0.206, $p = 0.01$				

regardless of the standard that was used, positive BDR was associated with the degree of FEV1 impairment.

This study focused on the differences in baseline lung-function indicators, BDR + ratio, and trends in airflow obstruction but did not involve clinically relevant indicators such as asthma staging, allergic status, comorbidities, and airway inflammation. Whether the 2021 BDR guidelines are better than the 2005 BDR guidelines cannot be judged from the existing results, thereby warranting further studies. BDR results may be affected by several factors such as disease phenotype, comorbidities, and bronchodilator-dosing regimens. More relevant

Table 8 Characteristics of baseline pulmonary ventilation function in the inconsistent group

Baseline	2005BDR + 2021BDR + (558)	2005BDR-2021BDR + (22)	2005BDR + 2021BDR-(92)
normal	208(37.3%)	17(77.3%)	25(27.2%)
Mild	227(40.7%)	5(22.7%)	27(33.0%)
Moderate	103(18.5%)	0(0%)	33(35.9%)
Severe	20(3.6%)	0(0%)	7(7.6%)

$\chi^2 = 8.657$, $p < 0.003$. OR = -.142, $p = -0.114$ $p < 0.003$

factors will be considered in our future analyses. In addition, data for this study were obtained from a single center and lacked retention time data and potential dose heterogeneity。Although the data were rigorously screened, it lacks representativeness. Thus, Subsequent clinical verification of the results of asthma control, exacerbation or treatment response is still needed. And multicenter data from other public databases are required for subsequent universal verification or external verification.

Conclusions

The kappa test showed that the results of 2005BDR and 2021BDR were consistent, but there were differences between the inconsistent groups. The change from 2005BDR + to 2021BDR– is more likely to occur in children with poor baseline lung function, whereas the change from 2005BDR– to 2021BDR + is more likely to occur in those with better baseline pulmonary ventilation function. The 2021BDR standard may reduce the influence of baseline lung function when determining the results. The positive rate obtained based on the two evaluation criteria maintained the same trend with the degree of airflow obstruction. All showed a weak positive correlation.

Abbreviations

BDR	Bronchodilator responsiveness
ERS/ATS	European Respiratory Society /American Thoracic Society
FEV_1	Forced expiratory volume in 1 s
Z-FEV1	Z-scores of Forced Expiratory Volume in 1 s
FVC	Forced vital capacity
Z-FVC	Z-scores of Forced vital capacity
FEF75	Forced Expiratory Flow at 75% of FVC
Z-FEF75	Z-scores of Forced Expiratory Flow at 75% of FVC
FEF25-75	Forced Expiratory Flow between 25 and 75% of FVC
Z- FEF25-75	Z-scores of Forced Expiratory Flow between 25 and 75% of FVC
LLN	Lower Limit of Normal
GINA	Global Initiative for Asthma
Pred	Predicted
init	Initial
ΔFEV_1	The difference between the best baseline FEV_1 value and the best value after the use of bronchodilators
ΔFEV_1%init	The ratio of ΔFEV_1 to baseline FEV_1
ΔFEV_1%pred	The ratio of ΔFEV_1 to FEV_1pred
2005BDR	BDR results defined by the 2005 ERS/ATS standards
2021BDR	BDR results defined by the 2021 ERS/ATS standards
BDR+	Positive BDR
BDR–	Negative BDR

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Authors' contributions
JZ designed schemes and writed manuscript. SL Guided and revised the manuscript. FJL, YL Collected and organized data. JJQ analyzed data. XW Translated papers. JL Provided clinically relevant guidance.

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Data availability
The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Medical Ethics Committee of the Children's Hospital of Chongqing Medical University [(2025) Ethics Review (Clinical Research) Approval No. (68)]. Informed consent from patients/their legal guardians was not required owing to the retrospective nature of this study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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