Original Article

Pulse Oximetry and Peak Expiratory Flow Rate Correlations in Acute Asthma Exacerbation in Children

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Abstract

Background: The relationship between oxygen saturation (SpO_2) and peak expiratory flow rate (PEFR) in patients with acute asthma is variable. **Aim:** This study aims to assess the predictive value and correlation of this relationship in identifying children with mild symptoms of asthma exacerbation and defining their role in guiding early intervention decision-making. **Patients and Methods:** This was a retrospective review of the register of children with asthma seen at the respiratory clinic of a tertiary center in Nigeria from April 2014 to February 2020. Information on their biodata, medical history, clinical status, baseline SPO_2, and %predicted PEFR was retrieved and analyzed. **Results:** The mean values for participants with no symptoms and those with mild symptoms of asthma exacerbation were respectively: SpO_2 was 97 ± 1.6% and 96 ± 2.6% (MD: 1.2; 95% CI; 0.7–1.7, $P < 0.001$); %predicted PEFR: 77.8 ± 17.8 and 64.1 ± 23 (MD; 13.68; 95% CI; 7.3 to 20.0, $P < 0.001$). Among those with uncontrolled asthma who were having mild symptom exacerbation of their asthma, the correlation between SpO2 and %predicted PEFR was significantly moderate (r = 0.44, $P = 0.04$). Children with SpO_2 between the range of 92%–95% were significantly more likely to have mild symptoms of asthma exacerbation (OR: 2.52,95% CI: 1.22, 5.2, $P = 0.01$) compared to those with SpO2 >95%. **Conclusion:** Children with SpO2 of <95% are more likely to have an acute asthma exacerbation. While SpO_2 and PEFR have more role in identifying children without acute asthma exacerbation and a limited role in identifying children with mild symptoms of asthma due to their exacerbation due to their moderate to poor correlation.

Keywords: *Asthma, Nigeria, oxygen saturation, pediatrics, peak expiratory flow rate, predictive value*

Introduction

Asthma management guidelines require that lung function and oxygenation assessment be done for each asthma patient, and both these parameters cannot be substituted for the other.[1] Every patient should receive a written personalized asthma action plan based on the patient's personal best baseline peak expiratory flow rate (PEFR) recordings. The use of SpO_2 values further helps determine wheezing severity in children of all ages.[1,2] Studies have however shown a varying relationship between oxygen saturation (SpO_2) and PEFR in patients with asthma, and most of these studies have been done among children with moderate to severe asthma symptoms. However, there is limited data on the relationship between these two parameters in asthma patients in steady-state or those with mild symptoms of asthma exacerbation to assess their role in guiding the decision to activate a home asthma action plan before the symptoms escalate to warrant emergency hospital care. A study in Brazil showed a moderate correlation between SpO_2 and %PEFR in hospitalized patients with

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asthma although they recorded some discrepancies in 25% of their study population where some participants with high values of PEFR had SpO_2 less than 91% while some with low PEFR had normal oxygen saturation,[1] and this is an unexpected finding according to the GINA guideline.[3,4] The predictive value of these parameters if well studied may be useful in informing when best to commence clinical intervention without allowing for progression to more severe symptoms of acute exacerbation. This study is set out to assess the correlation between mean SpO_2 and %predicted PEFR among children with asthma who do not have acute symptom exacerbation and those having mild symptoms of asthma exacerbation and assess the predictive value of SpO_2 and %predicted PEFR in identifying children with mild symptoms of asthma exacerbation. This hopefully will define their role in guiding written protocols for initiating acute asthma management, especially for patients who have a poor perception of their symptoms.

Methods

This was a retrospective review of prospectively collected data from the asthma research register of the asthma outpatient clinic of Rivers State University Teaching Hospital, Nigeria, from April 25, 2014 to February 5, 2020. Before patients are registered, their consent is sorted for their data to be included in the register. Children with a diagnosis of asthma, based on GINA criteria,[3] were registered once on their first day of presenting to the clinic, and a serial number was allocated to each patient to avoid registering a patient more than once.

The respiratory clinic is a scheduled clinic that holds once every week, and a consultant pediatrician runs it and it usually sees asthma patients who had been referred to the clinic for diagnosis and follow-up of their asthma. Because the asthma clinic is a scheduled clinic for those with appointments, it usually sees those in steady-state (described as children with asthma who are not having an acute symptom exacerbation) or those who have mild symptoms of asthma exacerbation.

Classification of asthma symptom exacerbation was based on the third expert panel report of the National Asthma Education and Prevention Program (NAEPP)[5] using only the clinical symptoms section. Mild symptoms of asthma exacerbation are the absence of dyspnea at rest, ability to talk in sentences, no use of accessory muscles of respiration, and presence of end-expiratory wheeze.[5,6] Children with moderate to severe acute asthma symptom exacerbation usually go straight to the emergency department for urgent treatment and are not likely to be seen in the asthma clinic. The clinical status of the patients on the first day of registration having an acute exacerbation of asthma symptoms was also entered in the register.

Data of all children aged between 6 years and 16 years were retrieved from the register and their demographic indices were also retrieved. Children <6 years were excluded from the study. Their weight and height were measured using recommended standards and raw values were converted to Z-scores based on reference values from the National Health and nutrition survey,[7-11] and their baseline SpO_2 and PEFR were also measured at first presentation to the clinic.

Asthma control was assessed for those who had been taking medication for their asthma for at least 1 month before presenting to the clinic for their first scheduled consult and it was classified based on the childhood asthma control test (C-ACT). Children aged ≤11 years and the adult ACT for older children were classified into uncontrolled, partially controlled, or poorly controlled based on their ACT scores.[12,13] Patients whose caregivers could not give adequate information to enable classification of asthma severity or asthma control were unclassified for those parameters and excluded from the analysis that involved them.

Routinely, all patients who come for their first asthma consultation have their SpO_2 and PEFR measured, and the baseline values are entered into the register. The SpO_2 was measured using a standard pulse oximeter (Choice med, model: Oxy watch C20).[14] The sensor was adapted to the patient's preferred thumb with no lesions or nail polish while ensuring that the waveform is uniform.[15] The patients were coached individually as part of their clinic consult after their history and clinical examination has been done. They were coached individually on how to correctly use the peak flow meter,[16] using the Mini Wright Peak Flow Meter (Respironics health scan inc. model 52224,87), the best of three repeated standing PEFR values were recorded and the reading was further expressed as a percentage of the predicted value for age (%predicted PEFR).[17] Hygiene and safety are ensured by discarding every mouthpiece after each patient's use and cleaning the machine with a disinfecting solution. Internal validation and quality assurance of the peak flow meter were done weekly by comparing obtained readings with a new peak flow meter, and the acceptable limit of agreement was set at −60.12 l/min and 40.26 l/min for the new and old meters.[18] The severity of their asthma was classified into intermittent, mild persistent, moderate persistent, and severe persistent according to NAEPP guidelines.[5] Ethical approval was obtained for the study from the Rivers State University Teaching Hospital's research ethics committee.

Data analyses

The minimum sample size was 19, with a correlation coefficient (r = 0.61) for SpO_2 and %predicted PEFR, assuming an alpha error of 0.05 and a beta error of 0.20.[1] Data were transferred to a Microsoft Excel spreadsheet® and analyzed using IBM SPSS statistics version 23. Categorical variables were expressed as frequencies and percentage proportions, while continuous variables were expressed in means, medians, and standard deviation. The mean differences (MD) of variables among those with no symptoms and those with mild symptoms of asthma exacerbation were calculated. Comparison of means was done using analysis of variance and independent sample t-test. The receiver operating characteristics curve (ROC) analysis was done to determine the predictive cut-off values of different coordinates of SpO_2, and %predicted PEFR in identifying those with mild symptoms of asthma exacerbation. Among participants with mild symptoms of asthma exacerbation, selected cut-offs close to the mean value for their SpO_2 and %predicted PEFR were analyzed to obtain their predictive value. Correlation of the pulse oximetry values and %predicted PEFR was assessed using Pearson correlation and linear regression, while multivariable logistic regression was performed to ascertain the predictive value of SpO_2 and %predicted PEFR to help identify patients who may have mild symptoms of asthma exacerbation. The model was internally validated using The goodness of fit and Nagelkerke R2 variance test. The level of significance was set at a value of 0.05.

Result

Three hundred and seven asthma patients were registered during the study period out of which 118 patients aged <6 years were excluded while 189 participants who met inclusion criteria were analyzed. There were 113 (59.8%) males with a male to female ratio of 1.5:1. As shown in Table 1, the mean age of all participants was 9 ± 2.6 years; the majority had normal weight for age 149 (78.8%) while 34 (18%) were overweight. The height for age of most of the children, 131 (69.9%), was between 2 and −2 Z-score. Of all study participants, 128 (67.7%) had been diagnosed with asthma for less than three years. The majority had intermittent asthma, 65 (34.5%) and uncontrolled asthma, 86 (45.5%), although 68 (36.0%) could not give adequate information for their level of control to be accessed. Among the study participants, 60 (31.7%) children had acute asthma exacerbation at the time they were registered [Table 1].

The SpO_2 values ranged from 82% to 99%. The mean SpO_2 for participants with no asthma symptoms was 97% ± 1.6 compared to 96 ± 2.6, in those with mild symptoms of asthma exacerbation, P = 0.001 [Table 2]. The mean %predicted PEFR among participants with no acute symptom exacerbation was 77.8 ± 17.8% while it was 64.1 ± 23% in those with mild symptoms of asthma exacerbation (MD: 13.68; 95% CI 7.3 to 20.0, P < 0.001), the difference in %predicted PEFR was significantly (P = 0.002) contributed by those aged 6 to 12 years [Table 2].

Children with SpO_2 between the range of 92% and 95% were significantly more likely to have mild symptoms of asthma exacerbation (OR: 2.52, 95% CI: 1.22, 5.2, P = 0.01) while those with SpO_2 >95% were less likely to be having an acute exacerbation (OR: 0.25,95% CI: 0.13, 0.54, P = 0.000008), see Table 3.

Table 1: Characteristics of the study population

Variables	Frequency N=189 n (%)
Age (years)	
6 to <12	140 (74.1)
12 to 16	49 (25.9)
Sex	
Male	113 (59.8)
Female	76 (40.2)
Weight for age Z-score	
>2 (Overweight)	34 (18.0)
2 to−2 (Normal weight)	149 (78.8)
< −2 (Underweight)	6 (3.2)
Height for age Z-score	
>2	48 (25.2)
2 to−2	131 (69.9)
<−2	10 (5.2)
Duration of asthma disease (years)	
≤3	128 (67.7)
>3 to 6	31 (16.4)
>6 to 9	21 (11.1)
>9	9 (4.8)
Asthma Severity	
Intermittent	65 (34.5)
Mild persistent	28 (14.8)
Moderate persistent	45 (23.8)
Severe persistent	22 (11.6)
Unclassified	29 (15.3)
Asthma control status	
Not controlled	86 (45.5)
Controlled	35 (18.5)
Unclassified	68 (36.0)
Distribution of SpO_2 (%)	
<92	6 (3.2)
92-95	39 (20.6)
>95	144 (76.2)
Clinical status	
Stable asthma (no symptoms)	129 (68.3)
Mild symptoms of asthma exacerbation	60 (31.7)

Relationship between SpO_2 and PEFR among study participants

There was a positive but poor correlation between the oxygen saturation and %predicted PEFR (r = 0.15, 95% CI: 0.004 to 0.31, *P* = 0.04). The correlation was worse among those with no symptoms (r = 0.0001, 95% CI: - 0.192, −0.19, *P* = 0.92) when compared to those with mild symptoms of asthma exacerbation (r = 0.215, 95% CI: −0.07 to 0.44, *P* = 0.92) [Figure 1a–c].

There was a poor positive correlation (r = 0.21, *P*: 0.015) between SpO_2 and %predicted PEFR among those with normal weight for age Z-score. Those who were overweight had a negative correlation, and the correlation was moderate among those with mild symptoms of asthma exacerbation (r = −0.55, *P* = 0.15) and very weak among those who did not have acute asthma symptoms (r = −0.14, *P* = 0.54). Among those with uncontrolled asthma who were having mild symptom exacerbation of their asthma, the correlation between SpO_2 and %predicted PEFR was significantly moderate (r = 0.44, *P* = 0.04) [Table 4].

Predicting acute asthma exacerbation

The ROC coordinates of the SpO_2 levels showed a sensitivity of 62.4% with a specificity of 13% when using a cutoff of 96%, which was approximate to the mean SpO_2 of children with mild symptoms of asthma exacerbation as shown in Table 3. Using the approximated mean %predicted PEFR of 64.5% for those with mild symptoms as cutoff, the ROC coordinates of the %predicted PEFR showed a

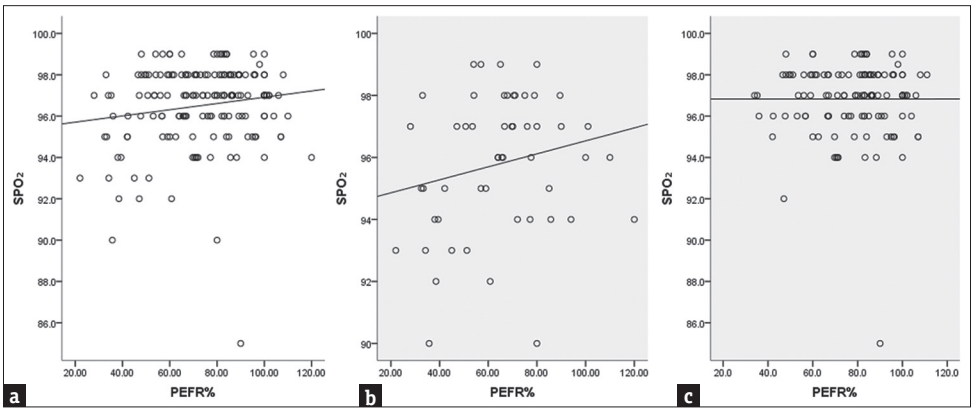

Figure 1: (a-c) Correlation between SpO_2 and %predicted PEFR (a) Correlation of pulse oximetry and % predicted PEFR for all study participants (b) Correlation of pulse oximetry and % predicted PEFR among children with mild symptoms of asthma exacerbation (c) Correlation of pulse oximetry (SpO2) and % predicted PEFR among children with stable asthma

Table 2: Mean SpO_2 and PEFR values in study participants with asthma

Variables	All participants (*n*=189) Mean±SD	No acute asthma symptoms (*n*=129) Mean±SD	Mild symptoms of asthma exacerbation (*n*=60) Mean±SD	MD	95% CI of MD	*P*
SpO_2 (%)	96.7±2.03	97.1±1.6	95.9±2.6	1.2	0.7 to 1.7	0.001
PEFR l/min: All	236.3±169	253.5±194	197. 26±76	56.2	3.27 to 109.2	0.03
6 to <12 years	227.7±194.0	247.4±223.3	178.6±65.5	68.79	−5.3 to 142.8	0.06
12 to 16 years	271.8±78.5	287.4±72	243.4±83.8	44.07	−2.3 to 90.4	0.062
%Predicted PEFR: All	73.6±20.53	77.8±17.8	64.13±23	13.68	7.37 to 20.0	0.001
6 to 12 years	76.5±20.36	80.5±66.5	66.4±23.8	14.06	6.5 to 21.54	0.002
12 to 16 years	65.9±19.14	69.7±17.2	59.0±21.0	10.7	−1.50 to 22.9	0.083

MD=mean difference

Table 3: Oxygen saturation levels associated with mild symptoms of asthma exacerbation

SpO_2 range	Mild symptoms of Asthma exacerbation *n*=60	Stable asthma *n*=129	Total *n*=189	Odds ratio (OR)	95% confidence interval		*P*
					Lower	Upper	
SpO_2: <92%	4 (66.7)	2 (33.3)	6	4.5	0.8	25.4	0.08
SpO_2: >92%	56 (30.6)	127 (70.5)	183				
SpO_2: 92-95%	19 (48.7)	20 (51.3)	39	2.52	1.22	5.2	0.01*
SpO_2: <92 and >95%	41 (27.3)	109 (72.6)	150				
SpO_2: <95%	35 (24.3)	10975.7)	144	0.25	0.13	0.54	0.00008*
SpO_2: >95%	25 (55.6)	20 (44.4)	45				

* = Significant *P* values <0.05

Table 4: Correlation between SpO_2 and PEFR among children with asthma and different nutritional status

Variable	Clinical status	Variable	Mean±SD	Pearson correlation=*r*	*P*
Normal Weight		% PEFR	73.0±21.0	0.21	0.01*
(2 to−2 Z-score)		SpO_2	96.5±1.7		
	Stable	% PEFR	77.0±18.3	0.06	0.54
		SpO_2	96.8±1.4		
	Mild exacerbation†	% PEFR	62.5±23.2	0.15	0.35
		SpO_2	95.7±1.4		
Overweight		% PEFR	78.9±16.8	−0.20	0.31
(>2 Z-Score)		SpO_2	96.6±2.5		
	Stable	% PEFR	79.6±16.4	−0.14	0.54
		SpO_2	96.3±2.8		
	Mild exacerbation†	% PEFR	76.9±18.8	−0.55	0.15
		SpO_2	97.2±1.1		
Controlled Asthma		% PEFR	77.7±19.4	0.34	0.48
		SpO_2	96.5±1.7		
	Stable	% PEFR	82.6±16.1	0.05	0.82
		SpO_2	96.9±1.3		
	Mild exacerbation†	% PEFR	66.9±22.5	0.09	0.80
		SpO_2	96.1±1.8		
Uncontrolled Asthma		% PEFR	71.4±20.9	0.24	0.04*
		SpO_2	96.8±1.5		
	Stable	% PEFR	73.5±17.9	0.02	0.83
		SpO_2	97.0±1.3		
	Mild exacerbation†	% PEFR	66.5±26.9	0.44	0.04*
		SpO_2	96.2±1.8		

†= Mild symptom of asthma exacerbation, WAZscore=weight for age Z-score, * = Significant p values <0.05

Table 5: Multivariate logistic regression for predicting acute asthma exacerbation using SpO_2 and %predicted PEFR

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I.for EXP (B)	
							Lower	Upper
SPO_2	−.218	0.091	5.693	1	0.017	0.804	0.673	0.962
% PEFR	−.034	0.009	13.009	1	0.000	0.967	0.949	0.985
Constant	22.524	8.760	6.612	1	0.010	6054994458.374		

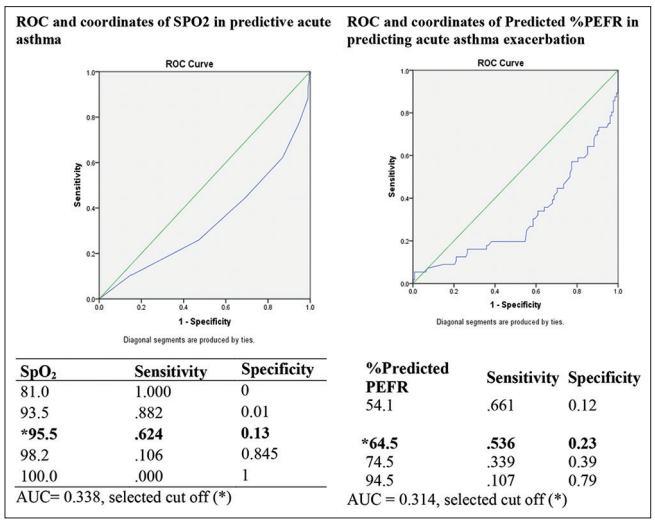

Figure 2: ROC and coordinates of SpO_2 and %PEFR in Predicting acute asthma

sensitivity rate of 53.6% and specificity of 23% in identifying those with mild symptoms of asthma exacerbation. see Figure 2.

SpO_2 and %predicted PEFR were put into a multivariable logistic regression model to determine their predictive value in identifying participants who had mild symptoms of asthma exacerbation. The model was statistically significant, X^2 (2) = 24.01, $P < 0.0001$, explained 18.8% (Nagelkerke R^2), and overall, it correctly predicted 74.6% of the patient's acute asthma symptom status by correctly predicting 93.3% of those with no acute asthma symptoms and 30% of those with acute asthma symptoms. Both SpO_2 and %predicted PEFR were significant predictors of having symptoms of mild acute asthma exacerbation [Table 5].

Discussion

This study evaluated the correlation between mean SpO_2 and %predicted PEFR among children with asthma who were having mild symptoms of asthma exacerbation and those not having symptom of exacerbations. It assessed the predictive value of SpO_2 and %predicted PEFR in identifying children with mild symptoms of asthma exacerbation.

While a majority of our patients came for their scheduled clinic appointment not having acute symptoms, one-third came to their scheduled clinic appointment having mild symptoms of asthma exacerbation. This is worrisome as the onset of exacerbation of asthma symptoms should trigger the use of rescue medication to abort symptoms and if symptoms are not abating or progressing despite intervention, they should go to the emergency department. Having scheduled asthma visits is part of a chronic care model design aimed at achieving a proactive treatment schedule in disease management[19] as opposed to reactionary treatment seen in urgent care. This group of people who presented in a scheduled outpatient clinic setting with mild symptoms of asthma exacerbation could have a poor perception of their symptoms such that neither they were aware that they needed to activate their home treatment plan nor were they aware that they needed any form of urgent health care.

The mean SpO_2 was significantly higher in children with no asthma symptoms, although the error margin of a pulse oximeter is ±2% to 4% between 70% and 99% of oxygen saturation.[20] This implies that an MD of 1.2% among those with mild symptoms of asthma exacerbation and steady-state may have limited clinical value despite it being statistically significant.

We observed that the stand-alone value of SpO_2 in predicting and distinguishing between those in steady state and acute asthma was neither sensitive nor sufficiently specific. It was difficult to identify the ideal cutoff for SpO_2 levels below which the likelihood of having mild symptoms of asthma exacerbation could be predicted. This is because SpO_2 of 96% which is close to the mean levels seen in patients with mild symptoms of asthma exacerbation was able to identify only 62.4% of those with mild symptoms of an asthma exacerbation while it was able to exclude only 13% of those not having mild symptoms of asthma exacerbation. Lower SpO_2 levels of 94% with improved sensitivity could only be seen in 3.1% of our study population with a specificity of 1%. It could therefore be inferred that SpO_2 has more value in identifying those with acute asthma especially if it is severe, while it has limited value in excluding those with mild symptoms of asthma exacerbation. The fact that during an asthmatic attack deterioration in symptoms can occur rapidly and desaturation can occur in a nonlinear oxygen dissociation curve[21] could explain why we could not get a precise cutoff for mild exacerbation, but we were able to identify a range (92%–95%) at which the odds of having mild symptoms of asthma exacerbation were twice more likely to happen.

Overall, the correlation of 0.15 and 0.21 between SpO_2 and %predicted PEFR were seen among children with stable and mild symptoms of asthma exacerbation in our study, although this is similar to 0.18 recorded by Yamamoto *et al*.;[2] it is much poorer than 0.41 to 0.61[1] reported among hospitalized children with asthma. The correlation of 0.44 found among those with uncontrolled asthma having mild symptom exacerbation in our study is similar to what has been reported among hospitalized patients with asthma.[1] The similarity between our patient cohort and that used by Yamamoto *et al*.[2] is that the majority of their patients had mild symptoms of asthma exacerbation that did not require hospitalization which is similar to the level of asthma exacerbation severity in our study cohort. Respiratory failure usually occurs late in acute exacerbation of asthma[20] and children hospitalized for asthma exacerbation are more likely to have moderate to severe asthma exacerbation which could explain why they had a higher correlation between SpO_2 and %predicted PEFR. Given this, patients in steady-state and those with mild symptoms of asthma exacerbation, using home SpO_2 or PEFR monitoring in isolation to decide when they can initiate a home treatment plan for their asthma may result in late treatment of asthma symptoms. But in a hospital setting where children admitted for their asthma symptoms are more likely to have severe to moderate acute asthma symptoms, both SpO_2 and PEFR could have a place because of the higher correlation documented in these settings.[1]

There was a negative correlation between SpO_2 and %predicted PEFR among overweight children with asthma, contrary to a positive correlation seen in those with normal weight. Obesity increases the work of breathing by stiffening respiratory muscles, causes breathlessness, and increases oxygen consumption.[22] Although our finding of a negative correlation is surprising, a possible explanation could be that obesity causes a decrease in FEV_1,[23] and obese people are more likely to be breathless with minimal effort causing them to hyperventilate which would increase their baseline SpO_2.

Using the mean %predicted PEFR of those with mild symptoms of asthma exacerbation as a cutoff for

predicting those with mild symptom exacerbation was not very sensitive in identifying this group of patients with a sensitivity rate of 53.6%, it also had poor specificity in identifying those with mild symptoms of asthma exacerbation. The use of formula derived PEFR as a reference value to compare asthma symptom severity has various limitations as these reference values cannot be reasonably applied to other populations outside where they were derived due to racial and geographical differences in PEFR; for example, black adults have a PEFR that is 10%–13% lower than their European counterparts due to lower thoracic to leg ratio[24-26] so it is not surprising that the overall %predicted PEFR recorded in our study was low as our reference was from a European population.[17] Although ethnic bias could account for the overall low %predicted PEFR in our cohort, it cannot account for the poor discriminatory power of PEFR measurements in identifying patients with mild symptoms of asthma exacerbation. The low sensitivity may also be related to the effort-dependent nature of the peak flow measurement procedure itself, such that a low PEFR, when compared to a reference population, may not necessarily be pathologic for the individual as that could be the person's personal best. The guidelines for asthma management advocate for using personal best PEFR in asthma management as one's personal best eliminates all other external confounding factors that could impact the interpretation of a PEFR reading. The challenge is the interpretation of PEFR for first-time presenters without prior records of baseline values. An individualized asthma action should always include monitoring PEFR to have baseline values while in the management of acute asthma, serial measurements during treatment can give valuable information in response to intervention. Our findings were also in consonance with the work by Robeiro de Andrade and colleagues,[1] who found no strong correlation and concluded that the two parameters were important but independent measures assessing different anatomical aspects of the respiratory system. Another study[27] showed strong positive correlations between SpO_2 and %predicted PEFR. Patients in this study[27] were recruited from the emergency unit, a place where moderate to severe asthma is more likely to be attended to. This further suggests that PEFR is more likely to correlate better with SpO_2 in patients with more severe symptoms of asthma exacerbation than in those with no or mild symptoms. Our observation of those with mild symptoms of asthma exacerbation does support that there is a positive correlation between SpO_2 and PEFR in asthma patients with more severe symptoms of asthma exacerbation. In other words, the correlation between the two parameters may have a limited role in identifying children with mild symptoms of asthma exacerbation but does have a role in assessing the severity of an acute exacerbation. This means that a simultaneous decrease in both parameters is a pointer to severe symptoms of asthma exacerbation even when the clinical symptoms are not yet overt.

The predictive model was good in predicting those with no acute symptom exacerbation with a specificity of 93.3%; however, it performed poorly in identifying those having acute symptom flare with a sensitivity of 30% which means that SpO2 and PEFR could miss up to 70% of patients having mild acute asthma exacerbation if patients with poor symptom perception depended solely on them to know when they are having acute symptom flare up.

Conclusions

Children with SpO_2 <95% are more likely to be having acute symptom exacerbation of their asthma while the correlation between SpO_2 and %predicted PEFR is moderately positive in mild asthma exacerbation in those whose asthma symptoms were previously uncontrolled. SpO_2 and %predicted PEFR can identify those not having acute asthma exacerbation but have a limited role in identifying children with mild symptoms of asthma exacerbation. Measurement of these values in isolation can delay the initiation of the home treatment plan in asthma management.

Limitations of the study

This study design used only SpO_2 and %predicted PEFR in identifying children with mild symptoms of asthma exacerbation. A spirometer test would have given a more robust measure of lung function.

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Conflicts of interest

There are no conflicts of interest.

References

1. Andrade CR, Duarte MC, Camargos P. Correlations between pulse oximetry and peak expiratory flow in acute asthma. Braz J Med Biol Res 2007;40:485-90.
2. Yamamoto LG, Wiebe RA, Anaya C, Chang RK, Chang MA, Terada AM, *et al*. Pulse oximetry and peak flow as indicators of wheezing severity in children and improvement following bronchodilator treatments. Am J Emerg Med 192;10:519-24.
3. Global Initiative for Asthma (GINA). Global strategy for Asthma management and prevention (2020 Update). 2020. Available

from: https://ginasthma.org/wp-content/uploads/2020/06/GINA-2020-report_20_06_04-1-wms.pdf. [Last accessed 2020 Jul 07].

4. Mourad S, Elganady A, Mohamed E, Elgammal A. Assessment of the effect of implementation of global initiatives for asthma (GINA) guidelines in the outcome of asthma exacerbation in the emergency department. Egypt J Chest Dis Tuberc 2012;61:257–73.
5. Bethesda (MD): National Heart, Lung, and Blood Institute (US). National Asthma Education and Prevention Program, Third Expert Panel on the Diagnosis and Management of Asthma. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. Aug, 2007. Available from: http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf. [Last accessed on 2021 Jun 16].
6. Camargo CA Jr, Rachelefsky G, Schatz M. Managing asthma exacerbations in the emergency department: summary of the National Asthma Education and Prevention Program Expert Panel Report 3 guidelines for the management of asthma exacerbations. J Emerg Med. 2009;37(2 Suppl):S6-17. doi: 10.1016/j.jemermed.2009.06.105. PMID: 19683665.
7. World health Organization. WHO STEPS Surveillance Manual Part 3: Training & Practical Guides 3-4-15 Section 4: Guide to Physical Measurements (Step 2). 2017. Available from: https://www.who.int/ncds/surveillance/steps/Section%204%20Step%202%20Physical%20Measurements.pdf Last. [Last accessed on 2020 Dec 15].
8. Medscape. CDC Height for Age Percentiles for Boys (2 - 20 years). 2020. Available from: https://reference.medscape.com/calculator/653/cdc-height-for-age-percentiles-for-boys-2-20-years. [Last accessed on 2021 Jun 21].
9. Medscape. CDC Height for Age Percentiles for Girls (2 - 20 years). 2020. Available from: https://reference.medscape.com/calculator/655/cdc-height-for-age-percentiles-for-girls-2-20-years#about-references. [Last accessed on 2021 Jun 21].
10. Medscape. CDC Weight for Age Percentiles for Boys (2-20 years) Calculate Z-score and percentile. 2020. Available from: https://reference.medscape.com/calculator/658/cdc-weight-for-age-percentiles-for-boys-2-20-years. [Last accessed on 2020 Jul 07].
11. Medscape. CDC Weight for Age Percentiles for Girls (2-20 years) Calculate Z-score and percentile. 2020. Available from:https://reference.medscape.com/calculator/659/cdc-weight-for-age-percentiles-for-girls-2-20-years. [Last accessed on 2021 Jun 21].
12. Liu AH, Zeiger R, Sorkness C, Mahr T, Ostrom N, Burgess S, *et al*. Development and cross-sectional validation of the Childhood Asthma Control Test. J Allergy Clin Immunol 2007;119:817-25.
13. Nathan RA, Sorkness CA, Kosinski M, Schatz M, Li JT, Marcus P, *et al*. Development of the asthma control test: A survey for assessing asthma control. J Allergy Clin Immunol 2004;113:59-65.
14. Schrading WA, McCafferty B, Grove J, Page DB. Portable, consumer-grade pulse oximeters are accurate for home and medical use: Implications for use in the COVID-19 pandemic and other resource-limited environments. Ann Emerg Med 2020;1:1450-58.
15. World Health Organization. WHO Pulse Oximetry Training Manual. 2011. Available from: https://www.who.int/patientsafety/safesurgery/pulse_oximetry/who_ps_pulse_oxymetry_training_manual_en.pdf?ua=1. [Last accessed 2021 Mar 13].
16. Mrindha Md. Amin MDR, Kabir AL. Peak expiratory flow rate (PEFR)-A simple ventilatory lung function test. JSSMC 2012;3. doi: 10.3329/jssmc.v3i2.12078.
17. Carson JW, Hoey H, Taylor MR. Growth and other factors affecting peak expiratory flow rate. Arch Dis Child 1989;64:96-102.
18. Nazir Z, Razaq S, Mir S, Anwar M, Al Mawlawi G, Sajad M, *et al*. Revisiting the accuracy of peak flow meters: A double-blind study using formal methods of agreement. Respir Med 2005;99:592-5.
19. Backer V, Bornemann M, Knudsen D, Ommen H. Scheduled asthma management in general practice generally improve asthma control in those who attend. Respir Med 2012;106:635-41.
20. Welsh EJ, Carr R. Pulse oximeters to self monitor oxygen saturation levels as part of a personalised asthma action plan for people with asthma. Cochrane Database Syst Rev 2015:CD011584. doi: 10.1002/14651858.CD011584.pub2.
21. Welsh EJ, Carr R. Pulse oximeters to self monitor oxygen saturation levels as part of a personalised asthma action plan for people with asthma. Cochrane Database Syst Rev 2015:CD011584. doi: 10.1002/14651858.CD011584.pub2.
22. Hossain D, Khanum S, Choudhury Alikawser C. Relationship of obesity and peak expiratory flow rate (Pefr) amongst 8-15 years old school children. Bangladesh J Child Health 2015;39:77-81.
23. Santos Moreira GM, Ribeiro AM, de Melo Carvalho PM, de Carvalho Mira PA, Guedes Freitas IM. Relationship between peak expiratory flow and impaired functional capacity in obese individuals. Fisioter. Mov. 2021;34:1-9. DOI: 10.1590/fm.2021.34105.
24. Lu Souef PN. Paediatric prediction equations for PEF (growth, ageing, gender, race and health). Eur Respir J 1997;10(Suppl 24):75s-9s.
25. Salisu AI, Adelaiye AB, Babashani M, Adelaiye AB, Babashani M. Predicted peak expiratroy flow in human and the clinical implications of differences across related formulae: A proposed guideline standard reference for Asthma. Bajopas J Pure Appl Sci 2008;1:16-9.
26. Njoku CH, Anah CO. Reference values for peak expiratory flow rate in adults of African descent. Trop Doct 2004;4:135-40.
27. Bishop J, Nolan T. Pulse oximetry in acute asthma. Arch Dis Child 1991;66:724-5.