



Do Anthropometrical Indices Correlate with Pulse Oximetry among Children Attending a Private Hospital in Enugu?

Josephat M. Chinawa¹, Bartholomew F. Chukwu¹, Awoere T. Chinawa²

¹Department of Paediatrics, College of Medicine, University of Nigeria Teaching Hospital, University of Nigeria,

²Department of Community Medicine, Enugu State University Teaching Hospital, Enugu State, Nigeria

Background: Pulse oximetry remains the most common investigation in pediatric cardiology as it acts as a window to unravel most abnormalities in cardiac functions and structure. **Objectives:** The objective of this study was to determine what is actually the normative pulse oximetry reading among children and to determine if anthropometry has any effect on pulse oximetry. **Methodology:** A cross-sectional prospective study in which pulse oximetry readings were ascertained among healthy children attending a private clinic in Enugu over a 3-year period. **Data Analysis:** Data were analyzed using Stata 10 software (STATA 10, College Station, Texas, USA: Stata [Corp]) Means and 95% confidence intervals were calculated for all the individuals. The level of statistical significance was considered $P < 0.05$. **Results:** A total of 349 individuals were recruited consecutively. The median value of oxygen saturation (SpO_2) was 98% (93%–99%). Females had a significantly higher SpO_2 than the males (Wilcoxon-Mann-Whitney test, $Z = 2.064$, $P = 0.04$). There was a positive correlation between the SpO_2 and age, weight, and height of the patients. Of these anthropometry, height is the most correlated with SpO_2 . On the other hand, there was a negative correlation between SpO_2 and heart rate of the subjects ($\rho = -0.1845$, $P = 0.0005$). There was no correlation between SpO_2 and patient's body mass index (BMI). **Conclusion:** The normal oximetry reading among children in this study is 98% with a positive correlation with age, weight, and height and a negative correlation with heart rate but no correlation with patient's BMI.

Key words: Pulse oximetry, anthropometry, children

INTRODUCTION

Oxygen saturation (SpO_2) is usually detected with arterial blood gas. Nonetheless, it can also be measured by pulse oximetry.¹ Pulse oximetry is normally used for checking SpO_2 and is very useful in rural communities or developing countries.² Normal pulse oximetry readings range from 95% to 100% at the sea level.² SpO_2 can be defined as the fraction of SpO_2 hemoglobin to that of total hemoglobin in the blood.³ Pulse oximetry is used in determining the percentage of oxygen bound to hemoglobin in the blood.³⁻¹¹ The pulse oximeter consists of a small device which sticks to the body such as a finger, earlobe, or foot and shows its readings through wireless. The device uses light-emitting diodes in conjunction with a light-sensitive sensor to measure the absorption of red and infrared light in the extremity.¹² The use of pulse oximetry

reduces the need for arterial blood gas analysis. While arterial blood gas remains the gold-standard for assessing ventilation and oxygenation, in those patients in whom blood gas analysis is indicated, arterialized capillary samples also have a valuable role in patient care.¹²

In Nigeria, the measurement of SpO_2 by means of pulse oximetry is routinely done both for children with hypoxia-related illness such as cyanotic congenital cardiac defects and pneumonias. However, much is not known on the actual normative values and cutoff points of SpO_2 in normal children as we rely on that given by western world. Again it is not clear if this pulse oximetry is affected by height, weight, or body mass index (BMI) or if there is any gender difference in the values obtained by the oximetry.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Chinawa JM, Chukwu BF, Chinawa AT. Do anthropometrical indices correlate with pulse oximetry among children attending a private hospital in Enugu? J Med Sci 2019;39:172-6.

Received: December 17, 2018; Revised: December 18, 2018;
Accepted: December 30, 2018

Corresponding Author: Dr. Josephat M. Chinawa, Department of Paediatrics, College of Medicine, University of Nigeria Teaching Hospital, University of Nigeria, PMB 01129, Enugu State, Nigeria. E-mail: maduabulchichinawa@yahoo.com

There is indeed paucity of data in the country on normative values of SpO₂ on Nigerian child. Whether SpO₂ really depends on anthropometry like peak expiratory flow rate still remains conjectural.

This work is thus aimed at determining normative values of SpO₂ by means of pulse oximetry among Nigerian children and to find out if height or BMI has any link with pulse oximetry.

METHODOLOGY

Study area

The study was carried out at a private children's hospital in Enugu, Southeast, Nigeria. It is a center that manages common pediatric illnesses mainly on an outpatient basis.

Study population

There are about 10,000 children registered at the private hospital with an average of nine new patients a month. The clinic runs every day and is manned by 1 consultant, a resident pediatrician, and a medical officer.

The individuals studied included 349 children aged from 6 months to 18 years who only attended outpatient clinic and who are on follow-up or who had no illness but accompany their siblings to the hospital with their parents. Patients excluded include those with congenital cardiac anomalies, pneumonia, or hypoxemia while those included are those who had no known illness and who gave consent.

Children who fulfilled the inclusion criteria were consecutively recruited into the study.

Ethical clearance for the study was obtained from the Research and Ethical Committee of the University of Nigeria Teaching Hospital.

Measurement of oxygen saturation

Here, the index finger of the subject is used. The correct measurement is detected if the oximeter displayed the subject's heart rate and SpO₂ and if the heart rate is compatible with age.³⁻⁵ We use normative values for heart rate and age to check for this. The oximeter pulse rate displayed on the screen was compared with the simultaneous measurement of the radial pulse obtained by palpation on the other hand to be sure that signals were coincident.³⁻⁵ If the sensor was not able to track the pulse during the measurement period due to excessive patient motion, no saturation reading was obtained, and a check sensor signal was displayed.⁶

The technique of pulse oximetry is by the use of spectrophotometric emission.^{13,14} The ratio of absorbance at these wavelengths is calculated and calibrated against direct measurements of arterial SpO₂.^{13,14} The waveform, which as seen on pulse oximeter help the clinician to eliminate all

artefacts [Figure 1]. SpO₂ was measured on two occasions, and the best is taken and documented. All readings were taken when the child is calm and awake. Weight and height were measured by standard measurements.

Data analysis

Data were analyzed using Stata 10 software (STATA 10, College Station, Texas, USA: StataCorp).

Means and 95% confidence intervals were calculated for all the individuals. The level of statistical significance is considered as $P < 0.05$.

RESULTS

A total of 349 individuals were recruited consecutively, comprising 50.14% males and 49.86% females. The data distribution was nonparametric. The median age was calculated as 3 years (range: 6 months–18 years). Individual's age and sex are as shown in Table 1 while the anthropometric parameters and heart rate are summarized in Table 2. The median value of SpO₂ was 98% (range: 93%–99%).

Females had a significantly higher SpO₂ than the males (Wilcoxon-Mann-Whitney test, $Z = 2.064$, $P = 0.04$). It was also significantly lower in children who are 5 years or less than those above 5 years of age (Mann-Whitney t -test, $Z = -3.368$, $P = 0.001$). Correlation between SpO₂ and the dependent variables is depicted in Table 2. There was a weak positive correlation between the SpO₂ and age, weight, and height of the patients. On the other hand, there was a weak negative correlation between SpO₂ and heart rate of the individuals ($\rho = -0.1845$, $P = 0.0005$). Table 3 There was no correlation between SpO₂ and patient's BMI. [Figures 1-3] are scatter plots showing the graphical correlation between the SpO₂ and dependent variables.

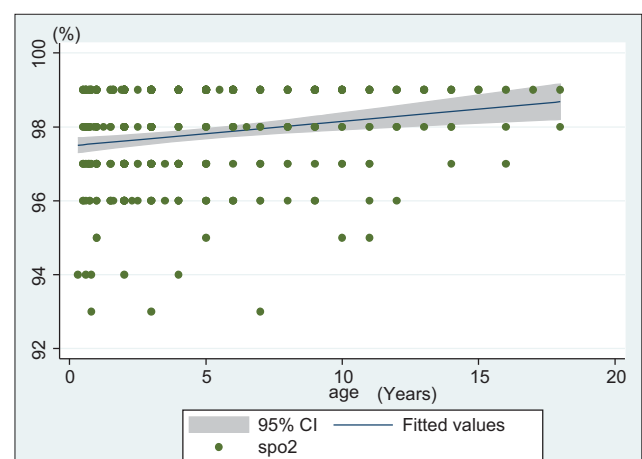


Figure 1: Scatter plot of oxygen saturation (%) against age of subjects in kg

Do anthropometrical indices correlate with pulse oximetry among children?

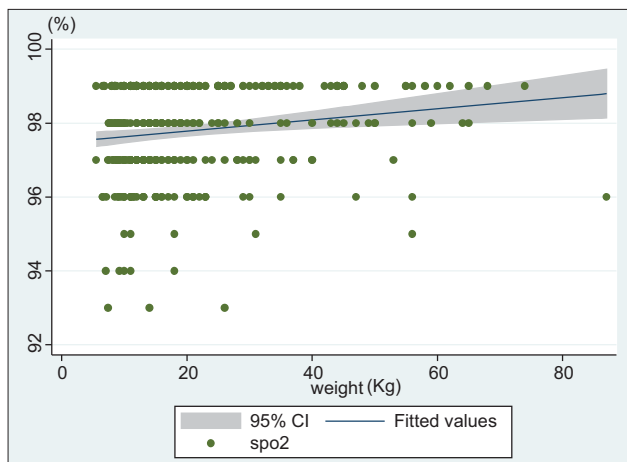


Figure 2: Scatter plot showing a positive correlation between oxygen percentage saturation and weight of patient with 95% confidence interval

Table 1: Age and sex of individuals

Variable	n (%)
Age (years)	
≤5 years	107 (30.9)
≥6 years	242 (59.3)
Sex	
Male	175 (50.14)
Female	174 (49.96)

Table 2: Anthropometric parameters and heart rate of individuals

Variable	n	Median	Minimum	Maximum
Age (years)	349	3	0.5	18
Weight (kg)	349	15	5.5	87
Height (m)	349	1.02	0.52	1.72
BMI (kg/m ²)	349	16.3	8.5	35.8
Heart rate (b/min)	349	115	72	168

BMI=Body mass index

DISCUSSION

This study revealed that the normal pulse oximetry reading among children in Enugu is 98%. This is indeed quite similar to that of Mau *et al.*¹⁵ who obtained a reading of 97% among Caucasians. Mau *et al.*¹⁵ noted in his study that though normal SpO₂ can occur with airway pulmonary or cardiovascular systems and respiratory infection, nevertheless, saturation <97% is associated with a higher risk of anomalies of cardiovascular systems and respiratory infection. This study, therefore, goes a long way to at least, in part, show a

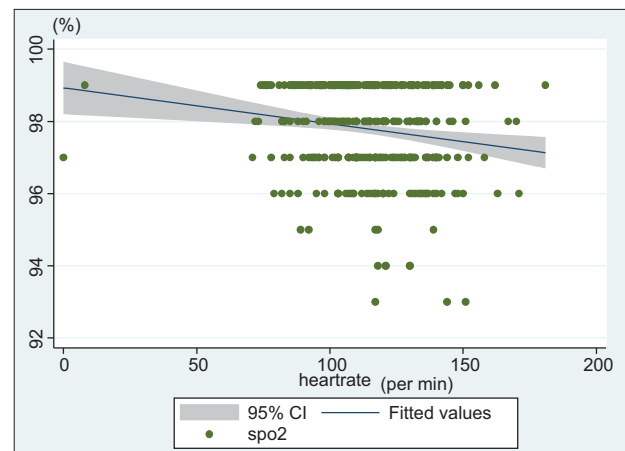


Figure 3: The scatter plot shows a negative correlation between the percentage oxygen saturation and subjects' heart rate at 95% confidence intervals

level wherein if it falls <2 standard deviations can be used as an acceptable point for hypoxemia and possibly give oxygen therapy if the need arises. One important thing to note here is that most studies where SpO₂ values were taken are mainly among the mixed population of children and adult, this study is thus unique in that it deals more on children.

Furthermore, Schult and Canelo-Aybar¹⁶ noted that SpO₂ in healthy children aged 5–16 years Residing in Huayllay, Peru at 4340 m was noted to be 85.7%, 14.2% lower than those at sea level. This suggests a decreasing trend of SaO₂ when altitude increased. We noted no correlation between SpO₂ and BMI in this present study. Although a study has shown that increased BMI is associated with increased SpO₂,¹⁷ They attributed this to the fact that young children have increased lean body mass when they are overweight since they become stronger to move their weight, the converse is true in adults. In a study by Jerrold *et al.*¹⁸, it was noted that above a BMI of about 30, there was an inverse relationship between BMI and SpO₂ in fingertip blood. This inverse relation in SpO₂ with higher BMI is even made worse when walking. These varying results of BMI and SpO₂ indicate that caution should be taken when using BMI as a predictor for SpO₂ in children.¹⁸ When we looked at the weight of our subjects and height in isolation, we noted that weight has a positive correlation with SpO₂. This same finding is also true for the height of our individuals. Height, however, remains the most dependent anthropometric variable with SpO₂ in terms of correlation.

We noticed a significant increase of SpO₂ with age. This is also corroborated in a study, where mean value for the SpO₂ of hemoglobin observed in children aged <1 month (92.6%) was statistically different from that in children between 13 and 18 months of age (93.7%).¹⁹

However, the proportion of fetal hemoglobin seen in younger infants may explain this. Again, the deviation to the

Table 3: Correlation between oxygen saturation and dependent variables

Variable	<i>n</i>	Spearman's rho	<i>P</i>
Age	349	0.21	0.0001
Weight	349	0.19	0.0004
Height	349	0.22	0.0001
BMI	349	0.02	0.6826
Heart rate	349	-0.18	0.0008

BMI=Body mass index

left of the fetal hemoglobin saturation curve usually produces higher SpO₂ readings for fetal hemoglobin when compared to adult hemoglobin.^{19,20} Moreover, there exists a natural selection to increase the frequency of alleles enhancing oxygen transfer, and this is strongest early in life and decreases in strength with age. This could explain the increase of SpO₂ at early childhood as seen in our study.²¹

We noted significant higher pulse oximetry readings among females when compared to their male counterparts. The significantly higher value could result from their smaller muscle mass, lower capillary density, and lower oxidative potential. Schult and Canelo-Aybar¹⁶ in his study in Bolivia noted that although there were no sex differences for SpO₂, the difference seems to develop in adulthood. Our findings are also different from that of Reuland *et al.*²² who noted no differences in gender values of SpO₂ among children aged 5–16 years.

There exists a converse relationship between pulse rate and SpO₂ in our study. This rise of pulse rate and fall in SpO₂ can be explained by the fact that a reduced cardiac output would cause an increased rate of oxygen consumption and decrease in stroke volume and increase heart rate.²³

Limitation

Pulse oximetry offers a noninvasive way of checking SpO₂ level. However, there are limitations with this measurement that could lead to erroneous results. Black, brown, or blue fingernail polish could falsely have decreased SpO₂ levels.

CONCLUSION

The normal oximetry reading among normal Igbo children is 98% with a positive correlation with age, weight, and height and a negative correlation with heart rate but no correlation with patient's BMI. Height, however, remains the most correlated anthropometric variable with SpO₂.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Abdu A, Gómez-Márquez J, Aldrich TK. The oxygen affinity of sickle hemoglobin. *Respir Physiol Neurobiol* 2008;161:92-4.
2. Young RC Jr., Rachal RE, Del Pilar Aguinaga M, Nelson BL, Kim BC, Winter WP, *et al.* Automated oxyhemoglobin dissociation curve construction to assess sickle cell anemia therapy. *J Natl Med Assoc* 2000;92:430-5.
3. Ellison B. Normal range of blood oxygen level. *Livestrong.com*. Assessed on 12/08/2018 obtainable from [https://en.wikipedia.org/wiki/Oxygen_saturation_\(medicine\)](https://en.wikipedia.org/wiki/Oxygen_saturation_(medicine)). [Last assessed on 2018 Aug 12].
4. Understanding Pulse Oximetry: SpO₂ Concepts". Philips Medical Systems. Available from http://www.incenter.medical.philips.com/doclib/enc/fetch/586262/586457/Understanding_Pulse_Oximetry.pdf?%3Fnodeid%3D586458%26vernum%3D2. [Last assessed on 2018 Aug 12].
5. Asada HH, Shaltis P, Reisner A, Rhee S, Hutchinson RC. Mobile monitoring with wearable photoplethysmographic biosensors. *IEEE Eng Med Biol Mag* 2003;22:28-40.
6. Collins JA, Rudenski A, Gibson J, Howard L, O'Driscoll R. Relating oxygen partial pressure, saturation and content: The haemoglobin-oxygen dissociation curve. *Breathe (Sheff)* 2015;11:194-201.
7. Antonini E. History and theory of the oxyhemoglobin dissociation curve. *Crit Care Med* 1979;7:360-7.
8. Severinghaus JW. Simple, accurate equations for human blood O₂ dissociation computations. *J Appl Physiol* 1979;46:599-602.
9. Breuer HW, Groeben H, Breuer J, Worth H. Oxygen saturation calculation procedures: A critical analysis of six equations for the determination of oxygen saturation. *Intensive Care Med* 1989;15:385-9.
10. Severinghaus JW. Blood gas calculator. *J Appl Physiol* 1966;21:1108-16.
11. Zavorsky GS, Cao J, Mayo NE, Gabbay R, Murias JM. Arterial versus capillary blood gases: A meta-analysis. *Respir Physiol Neurobiol* 2007;155:268-79.
12. Lozano JM, Duque OR, Buitrago T, Behaine S. Pulse oximetry reference values at high altitude. *Arch Dis Child* 1992;67:299-301.
13. Jubran A. Pulse oximetry. *Crit Care* 1999;3:11-7.
14. Wukitsch MW, Petterson MT, Tobler DR, Pologe JA. Pulse oximetry: Analysis of theory, technology, and practice. *J Clin Monit* 1988;4:290-301.

Do anthropometrical indices correlate with pulse oximetry among children?

15. Mau MK, Yamasato KS, Yamamoto LG. Normal oxygen saturation values in pediatric patients. *Hawaii Med J* 2005;64:42, 44-5.
16. Schult S, Canelo-Aybar C. Oxygen saturation in healthy children aged 5 to 16 years residing in Huayllay, Peru at 4340 m. *High Alt Med Biol* 2011;12:89-92.
17. Hakala K, Mustajoki P, Aittomäki J, Sovijärvi AR. Effect of weight loss and body position on pulmonary function and gas exchange abnormalities in morbid obesity. *Int J Obes Relat Metab Disord* 1995;19:343-6.
18. Jerrold P, Michael L, Iman AK, Stacy F, Andrew M. The Effect of BMI on oxygen saturation at rest and during mild walking. *J Appl Med Sci* 2015;2:2241-328.
19. Hay WW Jr. The uses, benefits, and limitations of pulse oximetry in neonatal medicine: Consensus on key issues. *J Perinatol* 1987;7:347-9.
20. Harris AP, Sendak MJ, Donham RT, Thomas M, Duncan D. Absorption characteristics of human fetal hemoglobin at wavelengths used in pulse oximetry. *J Clin Monit* 1988;4:175-7.
21. Cynthia MB. Oxygen saturation increases during childhood and decreases during adulthood among high altitude native Tibetans residing at 3800–4200 m. *High Alt Med Biol* 2000;1:25-32.
22. Reuland DS, Steinhoff MC, Gilman RH, Bara M, Olivares EG, Jabra A, *et al.* Prevalence and prediction of hypoxemia in children with respiratory infections in the Peruvian Andes. *J Pediatr* 1991; 119:900-6.
23. Reybrouck T, Fagard R. Gender differences in the oxygen transport system during maximal exercise in hypertensive subjects. *Chest* 1999;115:788-92.