Original Article

Comparison of Oxygen Saturation in Different Fingers of Hands Measured by Portable Pulse Oximeter in Healthy Adults

Oxygen Saturation Differences between Fingers

Adil Khan, Beena Khan and Aashir Jameel

ABSTRACT

Objective: To identify variation in oxygen saturation (SpO_2) measurements in different fingers of both hands and its clinical importance.

Study Design: Cross-sectional study

Place and Duration of Study: This study was conducted at the Department of Medicine, Fatima Hospital, Baqai Medical University, from 1st March 2023 to 31st March 2023.

Materials and Methods: 200 healthy medical students and healthcare professionals aged over 18 years were included in the study. It was made sure that study participants did not have any comorbid conditions like anemia or peripheral vascular compromise that may affect SpO_2 values. Oxygen saturation was recorded in all ten fingers in sitting position for at least five minutes.

Results: Highest SpO_2 was recorded in the right middle finger (98.71±1.21). The difference in SpO_2 values between all the fingers was significant. (Repeated ANOVA, F=5.035, p = 0.001). SpO_2 values of the right middle finger were significantly associated with the right ring and little finger and the left middle and little finger ($p<0.01$).

Conclusion: Some degree of difference exists in SpO_2 readings of different fingers, highest being recorded in the right middle finger. Information of this difference becomes clinically significant in states of poor perfusion.

Key Words: Oxygen saturation, Pulse oximetry, Portable pulse oximeter.

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INTRODUCTION

In different clinical situations, pulse oximetry or peripheral oxygen saturation testing is an important parameter to consider. Its reading and interpretation became more common and important in the COVID era, and it is sometimes referred to as the "fifth vital sign"[1]. During that period, oxygen saturation monitoring at home gained attention, and currently portable, inexpensive, and user-friendly pulse oximeters are available worldwide to monitor this important parameter at home. Pulse oximeters function on the principle that oxygenated and deoxygenated blood absorb different spectra of light. New pulse oximeters have light-emitting diodes that emit light in the red and near infrared region of spectrum as well as a photodiode that compares the absorption of red and infrared light by oxygenated and deoxygenated blood[2].

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Despite being simple to use and easily accessible, pulse oximetry readings are influenced by some factors that could result in artificially low or inaccurate values. Inaccurate pulse oximetry measurements can be caused by poor peripheral perfusion (as a result of low cardiac output, low body temperature, or significant anaemia), dyshaemoglobinemia (carboxy haemoglobin and methemoglobinemia), high ambient light, or patient motion. Pulse amplitude graph give some indication of peripheral perfusion status, but now new pulse oximeters also indicate perfusion index.[3],[4] Perfusion index (PI) measures the ratio between pulsatile blood flow and static, non-pulsatile blood flow in a selected peripheral tissue, used for pulse oximetry. The value of PI may range from 0.02% for a very faint pulse to 20% for a very strong pulse. A high PI generally indicates an optimal monitoring site for pulse oximetry.[5]

The finger that could provide the best or most accurate recording of oxygen saturation (SpO2), or, in other words, have the highest PI, is still up for debate in clinical practice[6]. In a prior study, Basarnoglu et al. found that the right middle finger has the highest SpO2 among healthy study subjects. Their study did not include PI[7]. Sepra et al. found that the right ring finger has the highest PI while the right thumb has the lowest among healthy healthcare workers. However, they did not ascertain the accuracy of the PI figures on the various fingers[8].

Considering the importance of pulse oximetry in clinical settings and the confusion regarding its measurement and interpretation, we conducted this study on young, healthy adults to find any differences in SpO2 values in different fingers.

MATERIALS AND METHODS

Design, Duration & Setting of Study: This research is cross-sectional and was conducted at the Medicine Department, Fatima Hospital, Baqai Medical University, Karachi, from 1st March 2023 to 31st March 2023. The study included healthy medical students and healthcare professionals over the age of 18 who agreed to volunteer. The study did not include those who are tobacco smokers, pregnant or having active menstrual bleeding, have radial or ulnar failure, hypotension, bradycardia, are clinically anaemic, have fingernail paint (nail polish) on them, have a history of hypertension, or diabetes. The Baqai Medical University, Karachi's ethics committee, approved the study idea (Letter No: BMU-EC/01-2023).

Sample Size: The G*Power 3.1.9.7(9) a free resource statistical software was used to determine the minimum sample size. At 5% of type error and 80% power, a total sample size of 200 was calculated.

Data Collection: Informed written consent was obtained from all participants before their inclusion in the study. Using a self-reporting questionnaire, information on variables like age, gender, and underlying medical conditions was collected. A professional staff member measured blood pressure, body temperature, weight, and height. A postgraduate trainee of the Medicine Department examined the pulse of participants and looked for general signs like anemia, cyanosis, and nails in order to exclude ineligible candidates. The same postgraduate trainee recorded oxygen saturation of participants. We used Certiza Germeny portable pulse oximeter, model number PO-907. After the participant had rested for at least five minutes, oxygen saturation was recorded while they were seated. The pulse oximeter was attached to the fingers one by one (abbreviations used for fingers are shown in Table 1) and for a duration of one minute so that we could have a stable reading.

Data Analysis: SPSS version 22 was employed for the data analysis. Proportions and frequencies were used to describe categorical variables like sex. Using the Shapiro-Wilk test, the normality of continuous variables was evaluated. Data that was normally distributed was shown as mean±standard deviation. The variance of SpO_2 among fingers was tested by repeated ANOVA. Post hoc Bonferroni test was applied to assess all multiple comparisons for significance. Statistics were judged significant at $P<0.05$.

RESULTS

1000 SpO_2 readings were obtained from 200 participants fulfilling the inclusion criteria. General information about participants is shown in Table 2.

Table No.1: Abbreviations for fingers

Right thumb	R1
Right Index finger	R2
Right middle finger	R3
Right ring finger	R4
Right little finger	R5
Left thumb	L1
Left index finger	L2
Left middle finger	L3
Left ring finger	L4
Left little finger	L5

Table No.2:General information of study population

Age(years)	33.05±10.31
Sex(male/female)	145/55
Height(m)	1.59±0.09
Weight (Kg)	67.19±11.25
BMI(kg/m^2)	26.36±4.22
Systolic blood pressure(mmHg)	117.83±11.24
Diastolic blood pressure (mmHg)	76.91±7.99
Heart rate (beats/minute)	80.07±10.58
Body temperature (℉)	97.98±0.29

Table No.3: Descriptive statistics of oxygen saturation in different fingers

Statistic	R1	R2	R3	R4	R5	L1	L2	L3	L4	L5
Mean	98.28	98.46	98.71	98.26	98.03	98.53	98.14	98.25	98.36	96.89
Standerd Deviation	1.07	1.18	1.21	1.19	1.28	1.19	1.08	1.31	1.10	1.15
Minimum	95	95	96	95	95	95	96	97	96	95
25^{th} Percentile	98	98	98	98	97	98	97	98	98	97
Median	99	98	98	98	98	99	98	98	98	98
75^{th} Percentile	99	99.75	100	99	99	99	99	99	99	99
Maximum	100	100	100	100	100	100	100	100	100	100

The average SpO2 values of each of the ten fingers were ranked in following order:
R3> L1> R2>L4>R1>R4>L3>L2>R5>L5 and descriptive statistics of these recordings are shown in Table 3.
SpO_2 values were compared between fingers using repeated ANOVA. A total of 45 comparisons were made. (F=5.035, p=0.001). The highest recorded SpO_2 was in R3 (98.71±1.21) and was significantly associated with R4, R5, L3, and L4. (Table 3). The interclass correlation coefficient of the measured SpO2 values was also significant. (ICC = 0.675, 95% CI 0.545–0.77, p = <0.001).

Table No.4: Multiple comparisons of repeated ANOVA by Bonferroni test

	R1	R2	R3	R4	R5	L1	L2	L3	L4
R1	--								
R2	NS	--							
R3	NS	NS	--						
R4	NS	NS	0.010	--					
R5	NS	NS	0.006	<0.001	--				
L1	NS	NS	NS	NS	NS	--			
L2	NS	NS	NS	NS	NS	NS	--		
L3	0.053	NS	<0.001	NS	<0.001	NS	NS	--	
L4	NS	NS	0.009	NS	<0.009	NS	NS	NS	--
L5	NS	NS	NS	NS	NS	NS	NS	NS	NS

DISCUSSION

Our study found that a difference exists in measured SpO_2 values in fingers. The highest SpO_2 was observed in the right middle finger, while the lowest SpO_2 was observed in the left little finger. Although it is statistically significant, the clinical significance of this difference needs to be discussed.
Clayton et al. suggested that the finger is the best site for pulse oximetry. Basaranoglu G et al. monitored the SpO_2 of 37 healthy volunteers who were not smokers and did not have cardiovascular compromise at the time of measurement. The highest SpO_2 was observed in the right middle finger among right-handed participants. Their study included only two left-handed participants, and these two had the highest SpO_2 in the left middle finger[7]. Swain MS et al. reported the highest perfusion index in the right middle finger. This may be due to the double blood supply to the middle finger by the ulnar and radial arteries[10]. Our study showed similar results, as the right middle finger had the highest SpO_2 (98.71±1.21) and was significantly associated with the left middle finger ($p < 0.001$).
A study by Mitzukoshi et al. showed that health care workers prefer the index finger for SpO_2 measurement. On the other hand, they found that the middle finger has the highest perfusion index, specially during a state of hypoperfusion. The sample size of this study was, however, small[11]. It may remain a debate as to why the index finger is preferred or commonly chosen for pulse oximetry. Its anatomical position is probably the reason.
Basaranoglu G et al. proposed that the dominant hand's middle finger has the highest and most accurate SpO_2 value[7]. In a study by Sur A et al.[12], the dominant middle finger showed the highest SpO2, followed by the dominant thumb. Both studies had a lower number of left-handed persons. Better recording in the dominant hand may be due to more physical and metabolic activity. Our study included all right-handed person. Importantly, there is less mean SpO_2 in the left middle finger. This emphasizes that apart from blood circulation, other factors like hand dominance also affect SpO_2 measurements.
The difference in SpO_2 readings among different fingers may not be considered significant by many clinicians. As in routine we see hospital protocols do not mention the preferred finger to be used for pulse oximetry. However, information about the difference in SpO_2 among fingers may be valuable in conditions with poor peripheral perfusion. In such cases, a finger with the highest perfusion index must be used, and previous studies and our study as well show that the middle finger may be preferred[13].
One limitation of our study was that we did not take hand dominance into account. A study by Sur A et al. found that hand dominance may also affect SpO_2 measurements. They found the highest SpO_2 in the dominant middle finger. Simillar results were observed by Basaranoglu G et al., but their sample size was very small, for left dominant individuals(7). Another limitation of our study and most of the other studies conducted on this topic is that arterial blood gas analysis is not done along with SpO_2 measurements. However, a study by Sirohya P et al showed that SpO_2 is a good representative of PaO_2 in COVID-19 patients[14]. Collins JA et al believed that pulse oximetry reduced the need for arterial blood gas analysis. They are in opinion that patients with acceptable SpO_2 do not need blood gas analysis[15].

CONCLUSION

In conclusion, the right middle finger can reliably and accurately give information about SpO_2. It becomes more important in a state of respiratory distress. Finger with the highest SpO_2 should be considered. SpO_2 values are good representative of PaO_2.

Author's Contribution:

Concept & Design of Study:	Adil Khan
Drafting:	Beena Khan, Aashir Jameel
Data Analysis:	Aashir Jameel
Revisiting Critically:	Adil Khan, Beena Khan
Final Approval of version:	Adil Khan

Conflict of Interest: The study has no conflict of interest to declare by any author.

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