Original Article

Effect of Glittered Nail Polish on Pulse Oximetry Measurements in Healthy Subjects

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Abstract

Background: Pulse oximeter is a simple and noninvasive standard device to monitor the saturation of peripheral oxygen (SpO_2) and heart rate. The nail polish of different colors may result in inaccurate oximetry reading and interpretation of oxygen saturation. This study aimed at determining the effect of different colors of glittered nail polish on SpO_2 in healthy students. **Materials and Methods:** This is a randomized clinical trial on 30 healthy students with SpO_2 ≥95% and without any complications on nail beds and environmental perfusion. SpO_2 was measured on 10 fingers of the participants after sitting and resting on a seat for 10 min in a room with normal temperature. Then they were asked to apply 10 colors of glittered nail polish randomly to their fingernails as all colors were used. After drying the two-layer nail polish, SpO_2 was measured again. **Results:** Of 10 glittered nail-polishes, dark green and purple did not change SpO_2 reading significantly. All other colors lowered SpO_2 significantly based on Wilcoxon test (red: $p = 0.003$; orange: $p = 0.002$; yellow: $p = 0.015$; pink: $p = 0.017$; dark blue: $p = 0.001$; violet: $p = 0.001$; brown: $p = 0.001$; black: $p = 0.001$). However, those changes were not clinically significant because SpO_2 differences before and after nail polish were in acceptable range (less than a 2% change). **Conclusions:** We conclude that different colors of glittered nail polishes do not result in a clinically significant change in pulse oximetry measurements in healthy subjects; therefore, it is not necessary to remove the glittered nail polish routinely in clinical, surgical, and emergency settings.

Keywords: *Diagnostic errors, healthy subjects, Iran, nails, oximetry*

Introduction

Pulse oximetry is a standard, convenient, noninvasive, and precise method for continuous monitoring of saturation of peripheral oxygen (SpO_2) and heart rate[1] with an extreme acceptability as it is used in all clinical conditions that cyanosis may occur including operating room, intensive care unit, post anesthesia care unit, emergency wards, ambulances, endoscopy rooms, sleep laboratory, heart catheterization units, labor and delivery rooms, and general units of hospitals. In addition, each patient who uses oxygen or mechanical ventilation needs pulse oximetry to monitor blood oxygen.[2,3] Privileges of pulse oximetry for assessing oxygenation of patients are safety, low expense, no need of specialist, short time results, and no need of blood sampling.[2,4]

Although pulse oximetry is simple, it may give incorrect and unreliable results (diagnostic errors) in some conditions such as oxygen saturation below 70%, nail polish, environment light (e.g., operation lamp, florescent lamp, fiber devices), movement of sensor, incompatibility of sensor with device, shock with decline in tissue perfusion, skin pigmentation, carboxy hemoglobin, methemoglobin, anemia, raised blood lipids, raised blood bilirubin, no calibration of device, and intravenously injected dye.[4,5] Since pulse oximeter probes are most commonly applied over the fingernails, it has been a concern that nail polish may hinder light transmission.[6] Some studies indicated clinically significant decline in oxygen saturation (5%–10%) due to nail polish,[7-9] whereas some of them have demonstrated the accuracy of pulse oximetry measurement even with black, blue, and purple nail polish.[6,10-13]

Clinical guideline for emergency and operation recommends routine removing of nail polish, but it is time-consuming and requires supplies and patient approval. Sometimes, patients may refuse to remove

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their nail polish which could result in a conflict between patients and healthcare staff. Moreover, the removal of nail polish is not possible sometimes due to urgent need for transmission of patient to operation room. If nail polish dose not effect on pulse oximetry measurement, it is not necessary to waste the time for obtaining consent and removing nail polish.[4,8]

Pulse oxometers work based on different absorption of red light by oxygenated and nonoxygenated hemoglobin. Therefore, every factor that absorbs or reflects or strengthens the light could affect the measurement of oximeters. Glittering particles in nail polish may affect the light absorption of hemoglobin. Despite increasing use of glittered nail polishes, to our knowledge, up to now, no study has been conducted on glittered nail polish on pulse oximetry measurements.[6] This study was designed to investigate the effect of different colors of glittered nail polishes on SpO_2 measurements.

Materials and Methods

This study is a clinical trial on 30 healthy students of nursing and midwifery faculty of Qom University of Medical Sciences that has been approved by Iranian Registration of Clinical Trial (IRCT 201206142560N7) in 2014. Inclusion criteria included age ≥18 years, being Iranian, no sensitivity to nail polish, no hypothermia (temperature <34°C), not pregnant, no lactation, no smoking, and being healthy. Healthy participants were identified as having SpO_2 ≥95% in normal temperature of room, having no complication on nail beds (e.g., mycosis, hematoma), having no cardiopulmonary and hematologic diseases, and no history of metabolic diseases such as hyperlipidemia and hyperbilirubinemia.

Data were gathered through simple sampling from available volunteers. Assuming that nail polish should lower SpO_2 more than 2% to be considered clinically significant, the sample volume was estimated to be 18 based on confidence level of 95% and adequate statistical power (80%). However, usually clinical trials are conducted on 30 participants in each intervention or control group. Hence, we entered 30 participants in to the study to strengthen the power of study. All participants continued their corporation and no one was excluded.

Ten widely used colors of glittered nail polish were used on 10 fingers including black, yellow, brown, red, orange, pink, violet, dark green, dark blue, and purple. The fingers were painted from left to right hand with two layers of nail polish. The interventions were conducted for all participants step by step as mentioned below:

(1) Each participant sat on a seat for 10 min in a room with ordinary light and temperature 25°C–27°C as his or her whole body was in rest and his or her hands lied on table motionlessly. (2) Body temperature was measured by oral thermometer for 3 min and blood pressure was measured by mercury manometer. (3) Pulse oximeter sensor probe was placed directly on the center of nail beds (top to bottom position) as light passed from nail bed downward. (4) After observing an effective signal (striking wave), heart rate and SpO_2 were recorded. (5) The participant was asked to color his or her nail beds by nail polishes as all 10 colors were applied arbitrarily for 10 finger nails. (6) After drying the first layer, each nail bed was colored by the same color for the second time. (7) All nail beds were assessed by the researcher for correct coloring and were modified if necessary. (8) The participant sat motionlessly on previous position for 10 min. (9) Again, heart rate and SpO_2 were measured and recorded in the same way. (10) The nail polishes were removed by the participants.

SpO_2 of all participants were measured using a pulse oximeter device (Abadis BC) made in Iran linked to a reusable finger sensor probe that was calibrated just before study. All nail polishes were made in Iran in Kenvis Company. This company offers a wide variety of colors, thus its nail polishes are used widely in Iran. All data were gathered by a single researcher.

Data were analyzed through SPSS statistical software package (IBM Corp., Released 2011; IBM SPSS Statistics for Windows, Version 20.0; Armonk, NY, USA), and $p < 0.05$ was considered significant. Descriptive statistics was applied to show distribution of demographic variables. The normality of the data was also examined through Kolmogorov–Smirnov test. Paired *t*-test or Wilcoxon test was used to compare the mean oxygen saturation before and after using nail polish (based on normality). A clinically significant difference was determined to be outside of the clinically acceptable range of allowed (±2%). Hence, the changes in SpO_2 are important (increasing or decreasing due to nail polish), for example, if SpO_2 lowers from 98% (before nail polish) to 95% (after nail polish), the difference (3%) is more than acceptable range of allowed, but if SpO_2 declines from 98% (before nail polish) to 96% (after nail polish) the difference (2%) is in acceptable range of allowed.

Ethical considerations

The study was approved by ethical committee of Qom University of Medical Sciences (code number: P/34/14920). In addition, all participants signed written informed consent forms. All checklists were anonymous.

Results

The mean (SD) age of the participants was 24.57 (6.73) years and their mean (SD) body mass index was 21.30 (3.40). The results of all demographic characteristics are summarized in Table 1.

Paired *t*-test showed no statistically significant difference between SpO_2 before and after coloring the nail beds with glittered dark green and purple nail; but Wilcoxon test

Table 1: Distribution of demographic characteristics of the participants

Characteristic	*n* (%)
Gender	
Male	7 (23.30)
Female	23 (76.70)
Age (years)	
18-22	16 (53.30)
23-27	8 (26.70)
28-32	6 (20.00)
Heart rate (beats/min)	
65-75	6 (20.00)
76-85	11 (36.70)
86-95	8 (26.70)
96-105	5 (16.70)
Body mass index (kg/m^2)	
<18.5	7 (23.30)
18.5-24.9	19 (63.30)
25-29.9	4 (13.30)
Body temperature (°C)	
36-36.5	6 (20.00)
36.60-37	24 (80.00)
Systolic blood pressure (mmHg)	
85-105	17 (56.70)
106-115	2 (6.70)
116-130	11 (36.70)
Diastolic blood pressure (mmHg)	
60-90	9 (30.00)
70-79	10 (33.30)
80-89	9 (30.30)
90-100	2 (6.70)
Respiratory rate (beats/min)	
14-16	9 (30.00)
17-19	4 (13.30)
20-22	17 (56.70)

showed statistically significant difference between SpO_2 before and after coloring the nail beds with rest of the nail polishes (red: $p = 0.003$; orange: $p = 0.002$; yellow: $p = 0.015$; pink: $p = 0.017$; dark blue: $p = 0.001$; violet: $p = 0.001$; brown: $p = 0.001$; black: $p = 0.001$). However, those differences were of no clinical significance because the difference in SpO_2 was less than a 2% change [Table 2].

Discussion

To the best of our knowledge, this is the first study conducted on the effect of glittered nail polish on pulse oximetry findings. Considering that there is no similar study to be compared with this study, we compare our findings with studies on simple nail polishes.

In this study, findings showed that glittered dark green and purple nail polishes did not result in statistically significant difference in SpO_2, whereas glittered red, orange, yellow, pink, dark blue, violet, and brown nail polishes resulted in statistically difference in SpO_2. However, that was not clinically significant because the differences of SpO_2 before and after using glittered nail polishes were less than 2% for all 10 colors.

In a similar study, we used simple nail polishes (without glittered particles) just with the same colors of the same company applied in this study and our report has been published before.[14] The best way to assess the effect of glittered particles on SpO_2 reading is comparison of these studies.

In a previous study with simple nail polish, the colors of orange, pink, and purple did not result in statistically significant difference in SpO_2, but red, black, yellow, dark blue, dark green, violet, and brown resulted in statistical difference in SpO_2.[14] In our two studies, no color was clinically effective on SpO_2, and therefore, glittered particles did not interfere with passing the light across the nail beds.

Consistent with our finding, three researches by Hinkelbein, Rodden, and Diccini (with simple nail polish) showed that some colors decreased the SpO_2 reading, but it was not clinically significant.[10,13,15] Rodden *et al*. conducted a similar research using two different pulse oximeter machines (Nellcor N20 and N595 pulse oximeters) on 27 healthy volunteers with $SpO_2 \geq 95\%$. SpO_2 was measured on all the 10 nails before and after using nail polish. The results showed a statistically significant decrease with brown and blue nail polish using both machines ($p < 0.05$), but this was not clinically significant (difference <1%). Using side-to-side configuration, the N595 oximeter had a statistically significant decrease in mean SpO_2 with red nail polish but again this was not clinically significant. They concluded that fingernail polish did not cause a clinically significant change in SpO_2 in healthy people.[13] Sharma *et al*., in 2015, in a study on 100 healthy females applied nine different colors (orange, red, purple, yellow, white, blue, green, beige, and black) to nine different fingers and left one finger empty as control. They reported that measurement of SpO_2 was not significantly different between the control finger and the other fingers colored with nine colors.[12] Also, Jakpor's study in 2011 revealed that five colors of nail polish (white, red, blue, pink, and wine) had a little or no significant effect on SpO_2 reading by pulse oximetry.[11] In another study conducted on patients with slight hypoxia, nine applied color did not change SpO_2 reading significantly.[6]

In contrast, in a study on 33 healthy females, one finger of the participants was left empty as control and the other fingers were dyed using 12 colors including red, blue, beige, purple, brown, white, pink, green, colorless polish, light blue, light green, and yellow. SpO_2 was measured applying three various pulse oximeter devices. Inconsistent with our findings, the researchers reported that the mean saturations obtained from blue, beige, purple, and white nail-polished fingers were significantly lower than those of control and the other colored fingers.[7]

Table 2. Comparison of mean saturation of peripheral oxygen measurments before and after coloring with 10 colors of glittered nail polish

Color	before/ after coloring	Mean SpO_2 reading (sd) or Mean of measurments of SpO_2(sd)	*t* (df*)	*p*
Dark green	Before	97.40 (0.81)	2.04 (29)	0.051
	After	96.97 (1.38)		
Purple	Before	97.37 (0.81)	0.68 (29)	0.501
	After	97.27 (0.88)		
Color	**before/ after coloring**	**Mean SpO_2 reading (sd) or Mean of measurments of SpO_2(sd)**	***Z***	***p***
Red	Before	97.70 (0.88)	−2.98	0.003
	After	97.07 (0.74)		
Orange	Before	97/60 (0.72)	−3.17	0.002
	After	97.03 (0.81)		
Yellow	Before	97.53 (0.78)	−2.42	0.015
	After	97.03 (0.77)		
Pink	Before	97.40 (0.72)	−2.38	0.017
	After	96.97 (1.13)		
Dark blue	Before	97.47 (0.94)	−3.86	0.001
	After	96.13 (1.20)		
Violet	Before	97.57 (0.68)	−3.33	0.001
	After	96.77 (0.97)		
Brown	Before	97.40 (0.89)	−3.72	0.001
	After	96.70 (0.75)		
Black	Before	97.47 (0.68)	−3.64	0.001
	After	96.60 (1.00)		

*df: Degree of freedom

In addition, Yönt *et al*., in 2014 in a research designed similar to this study, colored fingers of 40 healthy female students with 10 different colors of nail polish, namely, dark red, yellow, dark blue, green, purple, brown, white, metallic, black, and pink, of the same brand. SpO_2 readings were recorded before and after coloring the nails once oxygen saturation values on the screen became stable. Inconsistent with our findings, they suggested that all different colors except red caused a clinically significant change in pulse oximetry readings in healthy participants.[8]

Moreover, in another study by Desalou *et al*. in 2013, black and brown nail polish resulted in a significant decrease in SpO_2 reading with a Lifebox oximeter. They concluded that dark colored nail polish should be removed prior to SpO_2 determination to achieve accurate readings.[9]

The contradiction between the results of mentioned above researches and our results could be a result of applying two pulse oximeter devices simultaneously by them, using various pulse oximeter machines, different brands of nail polish, different participants (healthy/patients), different sample size, and different precision and accuracy of SpO_2 measuring. The limitation of this study is the participation of healthy volunteers with SpO_2 ≥95%; whereas the results are going to be used for patient population with cardiac or respiratory disease whose SpO_2 is lower than 95% (this can affect the findings of pulse oximetry).

This study has two strong points over previous studies. First, we investigated the effect of glittered nail polish on pulse oximetry measurements. Second, we assessed the effect of two-layer nail polish because most people apply two layers of nail polish.

Conclusion

We conclude that different colors of glittered nail polishes do not result in a clinically significant change in pulse oximetry readings in healthy volunteers; therefore, it is not necessary to remove the nail polish routinely in clinical, surgical, and emergency settings. In addition, in emergency situations, removing the nail polish may only waste valuable time, resources, and money. Further study is required to indicate the effect of glittered nail polish and different artificial nails in patients such as hospitalized patients in intensive care unit and so on.

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Conflicts of interest

Nothing to declare.

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