ECUADORIAN JOURNAL OF PEDIATRICS
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ORIGINAL ARTICLE

Does fever influence oxygen saturation in children? A single-center observational study at 2800 masl

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Received: September 11; 2022
Accepted: November 27, 2022
Posted: December 15, 2022
Editor: Dr. Francisco Xavier Jijón Letort.

Bibliographic letterhead:

Espina M, Sarmiento M, Pereira H. Does fever influence oxygen saturation in children? A single-center observational study at 2800 masl. Ecuadorian Journal of Pediatrics 2022;23(3):183-191. DOI: https://doi.org/10.52011/174

e-ISSN: 2737-6494

Summary

Introduction: Up to 20% of patients who come to pediatric emergencies have a temperature rise, which has physiological effects on heart rate, respiratory rate, and blood pressure. The objective of this study was to measure the influence of temperature on oxygen saturation in children with fever living in Quito (2800 masl) treated in a second-level hospital.

Methods: The present observational-crossover study was carried out at the Pablo Arturo Suárez Hospital from July to December 2019. With a nonprobabilistic sample, children with fever were included; age, temperature, heart rate, respiratory rate, blood pressure, and oxygen saturation were recorded on admission and 1 hour after antipyretic treatment. Means are compared with Student's t test; the association is presented with Spearman's (R) correlation coefficient and odds ratio.

Results: A total of 196 patients were included. There was a decrease in saturation with increasing temperature in younger infants, older infants, and preschool children. This effect does not occur in school children or in preadolescents or adolescents. The cutoff point from which this event occurs is 38.35°C with an OR of 3.33 and an OR of 22 when hyperthermia occurs in the preschool stage. The decrease of -1.26 ± 0.03°C°C increases oxygen saturation by 1.28 ± 0.98%.

Conclusion: Temperature >38.4°C decreases oxygen saturation in preschool children and younger and older infants.

Keywords: MESH: Fever, Oxygen Level, Child, Hypoxia.

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Introduction

Taking vital signs into account is part of the routine evaluation of pediatric patients, even more so in pediatric emergencies where different triage scales take them into account to determine their care priority [1]. A total of 15-20% of patients who attend present a temperature rise at the time, and up to 40% have it as a reason for consultation regardless of their temperature at the time of arrival [2, 3].

The influence of temperature on heart rate, respiratory rate, and blood pressure, which rise during fever, is known [4]. However, information is scarce regarding its influence on oxygen saturation, which is considered the fifth vital sign. Therefore, the objective of this study was to measure the association between these variables.

Materials and methods

Study design

The present study is observational-crossover. The source is prospective.

Study area

The study was carried out in the pediatric emergency service of the Pablo Arturo Suárez Hospital in Quito - Ecuador, located at 2800 masl. The study period was from July 1, 2019, to December 31, 2019.

Universe and sample

The universe was made up of all patients registered in the institution. The sample size calculation was nonprobabilistic, census type, where all incident cases in the study period were included.

Participants

Cases of pediatric patients between 3 months and 15 years of age who were residents of Quito with fever at the time of admission to the institution were included. Incomplete records were excluded from the analysis. A crossover group was formed, the first on admission to the institution and the second group 1 hour after antipyretic treatment.

Variables

The variables were age, temperature, heart rate, respiratory rate, blood pressure, and oxygen saturation.

Procedures, techniques, and instruments.

Data were collected directly from a survey and measurements from patients in the emergency area. The temperature was measured with a Braun TermoScan-5 thermometer, saturation and heart rate were measured with Masimo Rad-8 equipment, and the respiratory rate was recorded through direct observation. The same parameters were rerecorded one hour after the intervention by the institution's medical staff to decrease body temperature. The vital signs were qualitatively classified according to the age group parameters determined by the AHA in the PALS [5, 6].

Avoidance of bias

To guarantee the reliability of the information, the researchers were trained in data collection. A double checklist was used to include the cases. The data were validated and cured by the principal investigator.

Statistical analysis

Once the information was compiled in an Excel spreadsheet, it was entered into a data matrix of the SPSS™ 2 4.0 software (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Descriptive statistics based on frequencies and percentages were used for the qualitative variables and the quantitative measures of central tendency. Averages were compared with Student's t test, and the association is presented with Spearman's correlation coefficient (R) and odds ratio to measure the association.

Results

The study included 196 patients.

General characteristics

The average age was 3.7 ±3.2 years. A total of 18.88% were younger infants, 23.98% were older infants, 27.04% were preschoolers, 23.98% were schoolchildren, and 6.12% were preadolescents and adolescents. Children under five years old accounted for 69.9% of the cases. A total of 54.59% were women (Table 1). Of the 196 children with fever, 7.14% (14) were diagnosed with respiratory distress from triage. Of the 14 children diagnosed with respiratory distress, 64.29% (9 children) were prescribed oxygen at that time.

Of 196 children with fever, 76.68% (148 children) received paracetamol, 23.32% (45 children) received ibuprofen, and 1.53% (3 children) received metamizole. Of the 196 children with fever, 25.00% (49) were given physical means to lower the fever.

Table 1 Age and sex of the study group.

Sociodemographic characteristics	Absolute frecuency (%)
age group	
Minor infant	37 (18.88%)
Plder infant	47 (23.98%)
Preschoolers	53 (27.04%)
Schoolchildren	47 (23.98%)
Preteens and teens	12 (6.12%)
Sex	
Male	89 (45.41%)
Female	107 (54.59%)

Vital signs at the start of care

The initial oxygen saturation was 90.65 ±3.48%. A total of 71.9% had average saturation values, and 28.1% were pathological. When compared by age, younger infants had the lowest saturation (saturation = 89.89%) compared to preadolescents (Sat = 93.25%) (P =0.02) (Table 2).

The average initial temperature was 38.62 ± 0.58°C.

The initial respiratory rate was 36 rpm, and by age group, the means were 49 rpm for younger infants, 40 rpm for older infants, 33 rpm for preschoolers, 28 rpm for school children, and 22 rpm for preadolescents and adolescents. Qualitatively, the respiratory rate for age was 55.2% high, 44.3% normal, and 0.5% low.

The heart rate was 148 ± 26 bpm; the age averages were 168 bpm in younger infants, 156 bpm in older infants, 147 bpm in preschoolers, 133 bpm in schoolchildren, and 113 bpm in preadolescents and adolescents. Thirty percent of patients had standard heart rates for age, 68.9% had high heart rates for age, and one adolescent case had bradycardia for age.

Vital signs at the end of care

The final oxygen saturation of care was 91.93 ± 2.5%, and the final temperature was 37.4 ± 0.61°C; for these parameters in this measure, no significant differences were observed by age group.

Respiratory frequency presented a mean of 32 rpm by age group; the means were 42 rpm for younger infants, 36 rpm for older infants, 30 rpm for preschoolers, 26 rpm for school children, and 20 rpm for preadolescents and adolescents. A total of 62.6% of the patients had respiratory rates considered normal for their age, 36.4% had high respiratory rates, and 1% had low respiratory rates.

The final heart rate was 130 bpm by age group; the values were 146 bpm in younger infants, 133 bpm in older infants, 132 bpm in preschoolers, 119 bpm in school, and 99 bpm in preadolescents and adolescents.

Cross Comparison (Start vs. End)

The comparisons between the age groups at the beginning versus the end of the treatment are presented in table 2. The temperature decreased in all groups to physiological ranges.

In the group of young infants, saturation increased at the end of treatment, and respiratory and heart rates decreased. There were no changes in blood pressure.

In the group of older infants, saturation increased, and there was a decrease in respiratory and heart rates without changes in blood pressure.

In the preschool group, oxygen saturation increased, respiratory and heart rates decreased, and systolic blood pressure decreased.

In the school group, there were no changes in oxygen saturation; heart rate and systolic blood pressure decreased.

In the group of adolescents, there were no changes in oxygen saturation; only heart rate decreased (Table 2).

Correlation between temperature and oxygen saturation

The correlation is presented by age and with all the data (Table 3). There is a statistically significant negative association between preschool and all groups.

Body temperature cutoff point associated with desaturation

The cutoff point from which desaturation occurs was 38.35°C (Figure 1).

Table 2. Comparison of vital signs in initial and final taking by age groups

Age group	Vital signs	Moment Initial Half of)	Moment Final Half of)	*P*
Minor infant n=37	Oxygen saturation 1/	89.9 ± 3.8	91.9 ± 1.9	0.002*
	temperature 1/	38.7 ± 0.62	37.4 ± 0.61	<0.0001*
	Respiratory rate 1/	49 ± 11	42 ± 9	<0.0001*
	heart rate 2/	168 ± 23	146 ± 21	<0.0001*
	TAS 1/	106 ± 10	95 ± 5	0.180
	TAD 1/	64 ± 6	52 ± 7	0.180
	SIZE 1/	77 ± 6	66 ± 5	0.180
Older infant n=47	Oxygen saturation 1/	90.1 ± 3.3	91.4 ± 2.9	<0.0001*
	temperature 1/	38.7 ± 0.59	37.5 ± 0.63	<0.0001*
	Respiratory rate 1/	40 ± 8	36 ± 7	<0.0001*
	heart rate 2/	156 ± 21	133 ± 20	<0.0001*
	TAS 1/	96 ± 7	105 ± 10	0.144
	TAD 1/	61 ± 11	68 ± 6	0.197
	SIZE 1/	72 ± 8	80 ± 7	0.197
Preschoolers n=53	Oxygen saturation 1/	90.7 ± 3.9	92.3 ± 2.7	<0.0001*
	temperature 1/	38.6 ± 0.6	37.2 ± 0.6	<0.0001*
	Respiratory rate 1/	33 ± 9	30 ± 7	0.001*
	heart rate 2/	147 ± 22	132 ± 19	<0.0001*
	TAS 1/	104 ± 15	95 ± 9	0.006*
	TAD 1/	63 ± 11	59 ± 12	0.875
	SIZE 1/	77 ± 12	72 ± 10	0.306
Schoolchildren n=47	Oxygen saturation 1/	91.1 ± 2.6	92.0 ± 2.3	0.080
	temperature 1/	38.5 ± 0.49	37.4 ± 0.61	<0.0001*
	Respiratory rate 1/	28 ± 7	26 ± 6	0.012*
	heart rate 2/	133 ± 22	119 ± 20	<0.0001*
	TAS 1/	101 ± 13	96 ± 9	0.039*
	TAD 1/	62 ± 9	58 ± 12	0.307
	SIZE 1/	75 ± 10	71 ± 10	0.034*
Preteens and teens n=12	Oxygen saturation 1/	93.3 ± 2.7	92.7 ± 2.2	0.551
	temperature 1/	38.6 ± 0.59	37.4 ± 0.58	0.002*
	Respiratory rate 1/	22 ± 4	20 ± 3	0.100
	heart rate 2/	113 ± 28	99 ± 23	0.038*
	TAS 1/	106 ± 13	104 ± 9	0.445
	TAD 1/	69 ±13	66 ±11	0.345
	SIZE 1/	82 ±12	78 ± 9	0.237

Note: SD=Standard Deviation; 1/based on the Wilcoxon signed -rank test ; 2/based on the t test of related samples *

Odds Ratio (OR)

The OR for children ≥38.4°C for the development of desaturation was 3.33 (95% CI 1.23-9.7) (*P* <0.001). For children with a temperature ≥38.4°C and preschool age, the OR=22.0 (95% CI 3.2-45.2) (*P* <0.0001).

Table 3. Correlation between temperature and oxygen saturation according to age group.

Age group	R.	*P*
Minor infant	-0.18	0.296
Older infant	-0.11	0.452
Preschoolers	-0.39	0.004*
Schoolchildren	-0.14	0.353
Preteens	-0.31	0.329
Total	-0.25	<0.0001*

R: Spearman correlation

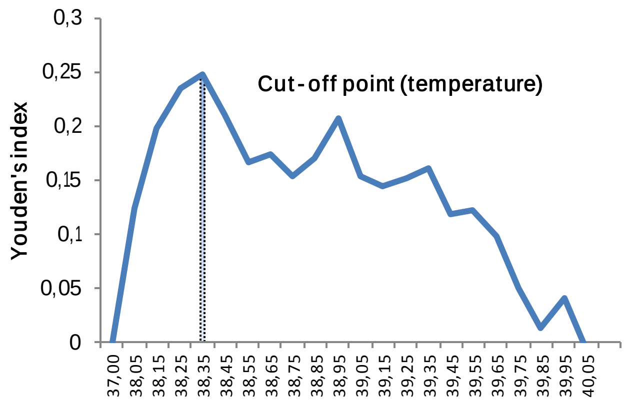

Figure 1. Temperature cutoff point for the presence of desaturation.

Discussion

The main result of this study is that there is a decrease in saturation due to the increase in temperature in younger infants, older infants, and preschool children. This effect does not occur in school children or in pre-adolescents or adolescents. The cutoff point from which this event occurs is 38.35°C with an OR of 3.33 and an OR of 22 when hyperthermia occurs in the pre-school stage. The change of decrease -1.26 ± 0.03°C increases oxygen saturation by 1.28 ± 0.98%; these findings were at 2800 masl.

In a study published by Goldberg et al. (2017) with children admitted with a temperature of 38.5°C, with a measurement period of 90 minutes at 800 masl, similar data were published as the present study in the decrease in oxygen saturation in febrile children concerning their basal saturation [7].

This study identifies a temperature cutoff point from which desaturation is more likely, 38.4°C, which differs from the theoretical prediction of 40°C posed by the Kelman equation [7, 8]. With the data obtained in this population, it was estimated that children with a temperature ≥38.4°C, in general, are 3.33 times more likely to present low levels of oxygen saturation than those who present fever with a lower temperature value, with the probability being up to 7 times higher in preschoolers.

There is no literature available that explains why the group of preschoolers is more affected than the others, being an intermediate group. The sample size, with a better attendance of children of these ages, has allowed a better study of this group. Therefore, if the sample were expanded, with more children of the younger age groups, that is, infants, it would allow finding a more significant relationship in them, in whom, despite finding variation, it was not statistically significant.

It is important to comment that in adults in a study, it was seen that the saturation variation is associated with age, showing typical values, but with lower means at older ages associated with the hypothesis of cardiopulmonary dysregulation [9]. Similar studies are reported in neonates to determine average values according to gestational age, but very few are reported in the pediatric population with inconclusive data [10–14].

There are different determinations of normal ranges for each age of the other vital signs, that is, respiratory and cardiac frequency and blood pressure. For this study, when carried out in the emergency service, the values described in the book of the provider of Pediatric Advanced Life Support (AHA, 2017) were used as a reference, despite the differences found with the classification proposed in the Canadian triage system that is used in the service, considering the most current revision of the first [15]. In addition, variables that are not controllable that generate variation in these vital signs, such as pain, fear, or dehydration that could be concomitant when approaching the emergency, should be taken into account [16].

The mean respiratory rate was initially high for age in the age groups except in younger infants, which was expected to decrease significantly in all children under ten years of age, being nonsignificant in preadolescents and adolescents, showing more significant variability of the respiratory rate in the face of temperature changes the younger the age. The difference between the initial and final means of the respiratory rate was 3.64 ± 2.19 rpm for an average temperature variation of 1.26 ± 0.03°C, with a more significant difference in the minors than in the preadolescents and teenagers. Considering the difference in temperature mentioned, by age group, in younger infants between the initial and final measurements, there was an average variation of 6.76±1.27 rpm; in older infants, it was 4.36±1.09 rpm, and in preschoolers, it was 2.82±2.14 rpm, which was lower. , almost half of that was reported by Gómez et al. (2013) in Bucaramanga (Colombia), who took a lapse of 90 minutes between the initial and final shot. In schoolchildren between 5 and

10 years old, the difference found in this study was 2.05 ± 0.03. The difference in patients older than ten years was not statistically significant.

The limitation found in the respiratory rate registry was that there are patients who, in the presence of fever, the possible sensation of pain, and the unknown environment of the emergency, become irritable. The quantification of their respiratory rate becomes complicated [5, 15, 16]. Recommendations to control fever prior to taking tachypnea should be considered a predictive sign of pneumonia or even sepsis [4, 17].

The mean heart rate in all the initial cases was high for age, standard in the final feeding of both younger and older infants. Nevertheless, the high mean persists in the remaining age groups, all with statistically significant variation. In the current medical literature, it is reported that the heart rate varies by approximately ten beats for each degree centigrade in the pediatric population in general. At the same time, the data obtained show a mean variation of 18.14 ± 3.43 bpm for a decrease of 1.26 ± 0.03°C. The findings described in these studies are not entirely comparable since the methodology used is different, and the determination of the variation of this vital sign for each degree of temperature was not studied. However, they allow us to affirm that this vital sign is susceptible to increased temperature in all pediatric ages. The decrease was more pronounced in the minors and decreased when reaching the older age group. Once again, the group of preschoolers was seen to be more affected without this peculiarity being reported in other studies [4, 16].

A relationship between desaturation and the diagnosis of respiratory distress was identified, but not all children with desaturation were classified as having respiratory distress. In addition, most of them had an improvement in this vital sign after overcoming the fever, and it was a minimum percentage that required oxygen support. This regulation reinforces the suggestion to control fever before considering low oxygen saturation as a sign of respiratory distress in children who come to the emergency room with a fever. Likewise, it should not be considered a definitive test for diagnosing lower respiratory infection since it has shown low sensitivity and specificity when used alone. It is practical when considered together with other signs of respiratory distress. However, it is mentioned that adequate saturation, precisely greater than 96%, presents a lower probability of presenting pneumonia [18, 19].

The most widely used antipyretic was paracetamol, followed by ibuprofen, recommended as the first line of antipyretics. There is a minority percentage corresponding to the use of metamizole that has controversies due to its adverse effects [20–22].

Recording nonpharmacological measures allowed us to analyze their use, particularly bathing in warm water for 20 minutes as a physical means to decrease the temperature. It was seen more frequently in children with higher temperatures, proving effective with antipyretics to reduce the temperature in one hour. However, its use is controversial; it is suggested that it leads to a rapid decrease but may predispose to a sudden increase due to superficial cooling with distal vasoconstriction that would signal the hypothalamus to raise the temperature again. Despite its proven effectiveness, there has yet to be a clear recommendation for its use [20, 23].

A limitation of the study is not having compiled the final diagnosis of the patients, which does not allow for the sensitivity of the diagnosis of lower respiratory infections through desaturation or due to the presence of tachypnea, as other study groups precisely analyzed the variations in vital signs according to temperature in groups of patients with severe pneumonia [19, 24]. The triage category assigned to each patient was also not recorded, without being able to identify if the triage tool is being used according to its guidelines if it is affected by the level of attendance and if other nosological entities that cause variation in vital signs are being recognized, such as dehydration or shock [4, 5, 15, 25].

Another limitation is the interference of the hemoglobin value, which is unknown in this population, making it heterogeneous among those with anemia or average values. Therefore, it is suggested that a saturation study be carried out in febrile patients with typical hemoglobin values for the demonstrated age [26, 27].

Conclusions

The data show a decrease in saturation with the increase in temperature in younger infants, older infants, and preschool children. This effect does not occur in school children or in preadolescents or adolescents. The cutoff point from which this event occurs is 38.35°C. The change of decrease -1.26 ± 0.03°C increases oxygen saturation by 1.28 ± 0.98%; these findings were at 2800 masl.

Abbreviations

masl: meters above sea level.

Supplementary information

No supplementary materials are declared.

Acknowledgments

Does not apply.

Author contributions

María Catalina Espina Rodas: Conceptualization, Data conservation, Acquisition of funds, Research, Resources, Software, Writing - original draft.
María Verónica Sarmiento Mejía: Conceptualization, Data conservation, Supervision, Acquisition of funds, Research, Resources, Writing: review and edition.
Hugo Pereira: Research, Resources, Software, Writing - original draft.
All authors read and approved the final version of the manuscript.

Financing

The authors financed the expenses incurred in the production of this research. Laboratory studies and administered drugs are part of the regular activity of the emergency service and are not an additional cost to the patients.

Availability of data and materials

The data sets generated and analyzed during the current study are not publicly available due to participant confidentiality but are available through the corresponding author upon reasonable scholarly request.

Statements

Ethics committee approval and consent to participate

It was not required for observational studies.

Publication Consent

This does not apply to studies that do not publish MRI/CT/Rx images or physical examination photographs.

Conflicts of interest

The authors declare they have no conflicts of interest.

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DOI: Digital Object Identifier PMID: PubMed Identifier SU: Short URL

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