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Quantitative descriptive study of oxygen saturation in women living at altitudes greater than 2800 M.A.S.L. Huancavelica Peru

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ABSTRACT

The objective of the research work was to determine the oxygen saturation (SpO2) in women of childbearing age who live at altitudes greater than 2800 meters above sea l evel (m.a.s.l) Huancavelica 2021. The study was observational, prospective, cross-sectional, in 151 healthy women of childbearing age, from 18 to 49 years old, the SpO2 was evaluated, through a pulse oximeter, to all women who attended the consultation between July and August of the year 2021, women without cardiopulmonary pathology were considered within the study group and those who accepted take part. Results: the average of the SpO2, of those who live between 2819 - 3499 m.a.s.l. is 93.72% and between 3500 - 4200 m.a.s.l., it is 90.85%; the minimum SpO2 was 85% and 83% respectively, the maximum SpO2 was 99% in both altitude floors. According to age, 92.91% were between 18 and 19 years old, 93.09% between 20 and 34 years old, and 91.74% between 35 and 49 years old. The average SpO2 of the pregnant women was 92.29% and in the non-pregnant women 92.67%, the minimum SpO2 was 88% and 83% respectively, while the maximum value was the same in both groups 99%. Conclusion: the inhabitants show lower saturations at higher altitudes, and it is observed to decrease after 35 years old, no difference is found between pregnant and non-pregnant women.

Keywords: Oxygen saturation, Women, Pregnant women, High altitudes, Meters above sea level.

INTRODUCTION

The physiology of the human being changes at great heights, which is why the need arises to better understand the normal parameters of those who inhabit the different altitude levels of our diverse Peru. Measuring oxygen saturation is vital during the pandemic. However, altitude variation complicates interpretation. A study evaluated oxygen saturation in women living above 2,800 meters, considering age and pregnancy. The oxygenation system depends on intrinsic aspects of the organism and the availability of oxygen in the environment that can be captured in the inspired air,

which depends on the barometric pressure, in which the higher the pressure, the greater the availability of oxygen as given to sea level and at higher altitudes there is a decrease in barometric pressure, therefore oxygen uptake becomes more difficult, a situation that creates an adaptation system in living beings that live at more than 2500 meters above sea level [1].

The inhabitants who live at high altitudes have biophysical characteristics that help counteract hypoxia caused by the decrease in barometric pressure, and the low temperatures and dryness of the environment, in this case, above 3000 m.a.s.l., some signs of hypoxia can already be observed, when a person who lives at sea level ascends [2].

These adaptations that manifest at more than 2,500 m.a.s.l. are: increased concentration of hemoglobin in blood, elevation of hematocrit and a decrease in oxygen saturation in percutaneous arterial blood [3]. On the other hand, prolonged hypoxia gradually increases systemic pressure, especially diastolic blood pressure and mean arterial pressure, compared with equivalent measurements lower [3].As for women, it has been reported that menarche takes longer to appear and menopause is earlier compared to those who live at sea level [4][5], in women of reproductive age the levels of estradiol, progesterone and serum prolactin are lower with height, and during perimenopause follicle-stimulating hormone is higher with height [6], [7]. The populations of the highlands of Peru are found mostly at altitudes greater than 2,500 meters above sea level, and represent 28% of the territory and are home to 38% of the population [1]. Huancavelica is one of the departments located in the southern highlands of Peru and can be found at altitudes from 1950 to 4500 meters above sea level [8],[9].

Environments with varying altitudes can affect oxygen saturation levels, leading to potential misdiagnoses. Accurate baseline data is necessary for reliable interpretations and better healthcare. This research can benefit health professionals working in similar conditions and help with better diagnoses and future investigations. We make the findings obtained available to the scientific community and health personnel, so that we can continue the search for knowledge and improve the clinical evaluation of patients who live in high altitudes such as the Andes Mountain range.

Literature Review

Levental, et al.[10]in the research "Sex-linked difference in blood oxygen saturation" 2018. The study compared SpO2 levels in young adult men and women and analyzed SpO2 data in newborns at different altitudes. The results showed that healthy young adult women had higher SpO2 levels than men, with no significant gender difference found in newborns. The difference in SpO2 between men and women remained significant after correcting for BMI, BSA, and age. They found that in young adult men the mean SpO2 was 97.1% ± 1.2% versus 98.6% ± 1.0% in women ($p < 0.001$); they also found that the difference remained significant ($p = 0.002$) after correction for BMI, BSA and age. Study compares SpO2 (1.5%) levels in healthy young adult men and women, finding a significant difference in favor of women.

Ceylan, et al[11]in an article "Evaluation of oxygen saturation values in different body positions in healthy individuals" research developed to evaluate the oxygen saturation values measured in healthy individuals in different body positions. Descriptive study, in 103 healthy individuals, the effects of different body positions on oxygen saturation were evaluated. Measurements were taken in sitting, supine, prone, left lateral, and right lateral positions after 10 minutes of exposure. Results showed that the highest saturation was recorded in the sitting position in an upright chair, while the lowest was in the supine position. Women and those under 35 years old with a BMI below 25kg/m and who did not smoke had higher saturations. It was concluded that the best position for oxygenation is sitting upright, while the worst position is supine.

Bustamante, et al [12]in a thesis to opt for the professional title, "Estudio preliminar para determinar valores referenciales de saturación de oxígeno medidos por oximetría de pulso en personas mayores de 18 años, sin patología cardiorrespiratoria, residentes en la ciudad de Quito (altitud 2850 metros sobre el nivel del mar", whose objective was: To determine the values of oxygen saturation in people over 18 years old, without cardiorespiratory pathology, through pulse oximetry to establish, in 387 people, reaching the following results: value of average saturation 94.3% with a variability of 2.5%, minimum saturation 84% and maximum 99%.

Trompetero, et al [1], in an article, "Comportamiento de la concentración de hemoglobina, el hematocrito y la saturación de oxígeno en una población universitaria en Colombia a diferentes alturas", whose objective was to analyze the behavior of Hb, Hto and SaO2 at different intermediate altitudes (970 m.a.s.l., 1,520 m.a.s.l., 1,728 m.a.s.l., 1,923 m.a.s.l., 2,180 m.a.s.l. and 2,600 m.a.s.l.). Methods: to values increased while SO2 decreased with altitude. Men had higher Hb and Hto values than women, while women had higher SO2. At 970 m.a.s.l., women had an average saturation of 96.4, which decreased to 94.4% at 2,600 m.a.s.l. The study included clinically healthy participants who were not physically active and reported consuming iron-rich foods. Blood samples were collected from the antecubital vein and earlobe and analyzed using a radiometer. A non-parametric statistical analysis was performed.

Tinoco et al. [13], in an article entitled "Gasometría arterial en diferentes niveles de altitud en residentes adultos sanos en el Perú" whose objective was to present the values of arterial blood gases, SatO2, pO2/fiO2, in two cities of Peru Huánuco (1818 m.a.s.l.) and Cerro de Pasco (4380 m.a.s.l.). In a sample identified for convenience, the following results were found in Huánuco and Cerro de Pasco, the oxygen saturation was found to be 96.24 (0.87) and 87.02 (2.31). Concluding that the values of arterial blood gas analysis at altitude in healthy adult residents are different from those considered normal for residents at sea level. At higher altitudes, the changes are more marked.

Conceptual basis

In this section, we will discuss the basic concepts, which are quantified in this study, and some others related to the clinical measurement of oxygen saturation.

Oxygen and function

Oxygen is a chemical element, with atomic number 8, it is found in two dioxygen atoms (O_2). Its main organic function is to participate in metabolism, optimizes energy production (ATP), in all stages of food oxidation, to capture energy, oxygen is present [14].

The respiratory system supplies oxygen to cells and removes carbon dioxide through four events: ventilation, gas diffusion, transport, and regulation. [15]. It means that for adequate oxygenation it is necessary that these three events occur optimally.

Oxygen partial pressure

The partial pressure of oxygen is given by the affinity capacity that oxygen molecules have, and varies according to the place where it is quantified, the pulmonary capillaries can have a pressure of 104 mmHg, when it reaches the atrium left, it may be at 98%, because it combines with blood that has irrigated the lung tissues, which has not had contact with the alveoli, and thus descends into the tissue capillaries, where if there is an O_2 requirement, therefore, it goes dissociate and will be consumed in different oxidative reactions necessary for the body and produce CO_2, which will be transported from the tissue capillaries to the alveoli [15].

Hypoxemia

It is the decrease in the partial pressure of oxygen in arterial blood, it may be due to an inadequate uptake of oxygen, which would be mediated by pathologies at the level of the respiratory system or alterations in transport, the environmental factor in this case plays an important role, at more than 3000 m.a.s.l., the cause is the decrease in barometric pressure (BP) [16]. Increased pulmonary ventilation removes large amounts of carbon dioxide by reducing the pressure of carbon dioxide (PCO2) and increasing the pH of body fluids, both of which inhibit the respiratory center as opposed to stimulating hypoxia, however, after three to five days, this inhibition disappears, allowing the respiratory center to respond energetically to the stimuli of the chemoreceptors caused by hypoxia [17].

In this sense, the ascent to a peak of 3500 m.a.s.l. produces detectable adaptive changes such as hyperventilation, respiratory alkalosis, pulmonary hypertension, drop in cardiac output and increased secretion of erythropoietin which, in turn, will produce the described polyglobulin [4]. However, due to the hypobaric and hypoxic environment, there is a decrease in oxygen saturation in percutaneous arterial blood, as well as a gradual increase in systemic pressure, especially diastolic blood pressure and mean arterial pressure [5].

Suspected hypoxemia

a. Altitude ≤ 2200 meters SpO2 < 92%
b. Altitude 2600 to 3000 meters SpO2 < 90%

Significant hypoxemia

When SaO2 is less than 86%. In this case, the ideal is to take arterial gases and if it is not possible to start with oxygen therapy.

Chronic hypoxemia, is considered as follows

a. Altitudes ≤ 2200 meters SpO2 < 88%
b. Altitudes 2600 to 3000 meters SpO2 < 86%.

Patients at risk of hypoxemia

Sedation, patients over 80 years of age, pneumonia, Atelectasis. Aspiration, upper airway obstruction, inadequate intubation, residual anesthesia, potent opioids for pain management and major tranquilizers, obesity, heart failure, lack of protective airway reflexes, pulmonary edema, pulmonary embolism, sepsis, fluid overload, thoracic and upper abdomen surgery, surgical time greater than two hours, tobacco index greater than 8, neuromuscular diseases, liver disease, kidney disease.

Oxygen saturation values

The saturation values that have been found at the national level is the one reported by Dr. Pablo Grajeda – Epidemiologist, who recognizes that it may have limitations, however, in the face of the health emergency that we have been going through. found useful.

Table 1: oxygen saturation state according to height based to sea level, cusco – peru

Saturation state	0 m.a.s.l.	1000 m.a.s.l	3000 m.a.s.l	3400 m.a.s.l.	3600 m.a.s.l.	3900 m.a.s.l.
Normal	93-100	92-99	88-96	87-95	84-93	83-92
Mild hypoxia	89-92	88-91	84-87	83-86	80-83	79-82
Moderate hypoxia	85-88	84-87	80-83	79-82	76-79	75-78
Severe hypoxia	<85	<83	<79	<78	<75	<74

Source: Dr. Pablo Grajeda – Epidemiologist from Diresa Cusco – Peru, extracted from: cuscopost.com/salud/si-esta-tratando-covid-19-en-casa-debe-estar-alerta-a-estos-valores-de-saturacion-de-oxigeno/

Pulse oximetry

Pulse oximetry is a method that helps us to continuously and transcutaneous control the oxygen saturation in the hemoglobin of arterial blood.

To better understand the mechanism of action it is necessary to know two basic principles

The first principle is that oxyhemoglobin (O2 Hb) and deoxyhemoglobin (H Hb) differentially absorb red and near-infrared (IR) light; this difference in absorption of red and infrared light is fortuitous, while Blue, green, yellow, and far IR light are significantly absorbed by non-vascular tissues and water. O2Hb absorbs more IR light and less red light, giving it a bright red color, while H Hb absorbs red light and less IR light, making it appear less red, concluding, the pulse oximeter uses the relative amount of red and IR light absorbed to determine the proportion of Hb bound to oxygen.

The second principle is based on the ability of pulse oximetry to detect SpO2 from arterial blood only, this is achieved thanks to the fluctuation of red and IR light with the cardiac cycle, since blood volume increases with systoleand decreases with diastole. While the volume of blood in the veins, capillaries, and the volumes of skin, fat, bone, among others, remain constant, creating relatively stable currents in these areas, avoiding pulsatility: these processes can be better understood by examining the Beer-Lambert law [18].

Clinical use of pulse oximetry

Currently it is the fifth vital sign, however, it is mandatory in the following disorders: acute and chronic respiratory, in patients with oxygen therapy, it helps us in determining the fraction of inspired oxygen, (FIO2) [18].

Factors affecting measurement through pulse oximeter

Blood perfusion is essential, this is affected when blood pressure is below normal values, in case of blood loss in this case acute hemorrhages, shock pictures, hypothermia, obstructive problems of blood vessels, can also be affected by external electromagnetic interference from CT scanners, electrocautery and cell phones [19]. Alterations of Hemoglobin Carboxyhemoglobin, methemoglobin, has a light absorption spectrum like oxyhemoglobin, therefore, it can falsely increase SpO2. It should not be used to assess SaO2 in these cases. Care must be taken when dealing with patients with CO poisoning. Skin color, icteric skin does not interfere with saturation measurement, when SaO2 is less than 90%, very dark skin can overestimate SpO2" by 2%, nail polish, when dark (coffee, wine, black, blue) decreases the saturation, therefore, before taking the enamel must be removed. Digital clubbing is a clinical sign that affects the fingers and is characterized by deformity in the nails with bulging in watch glass. In these cases, there may be a bad record, up to 8% of false decrease could be shown. Anemia interferes with the measurement if it is below 5 gr/dl. Ambient light, at the time of measurement avoid intense light on the sensor [19].

Pulse oximetry at altitude

The mean SpO2 at sea level is 97-99%, with lower limits of 94%. SpO2 is related to arterial oxygen tension (PaO2), that is, small changes in SpO2 reflect large changes in PaO2; therefore, oxygen should be used in patients with SpO2 less than 90% and not less than 94% [19], [20].

Respiratory Physiology

To guarantee the good uptake of oxygen from the inspired air, a difference has been seen at the level of the alveolar and capillary system, at height the diffusion capacity at the level of the alveolar membrane is increased, this is due to the increase in the size of the membranes, thick capillaries, and dilated alveoli. Likewise, the amount of blood in the pulmonary vessels is much greater compared to the inhabitants at sea level, this greater amount of liquids causes the thorax to be dilated, which results in an increase in the vital capacity and the residual volume in high-rise dwellers. Despite the adaptations, high-altitude dwellers respond less to hypoxia, so they always have decreased ventilation at higher altitudes compared to people living at sea level. On the other hand, additional hypoxia, due to pathological conditions, generates minimal stimuli in the ventilatory impulse in the people who live there; this response would be genetic or acquired at an early age as a response from the environment [21].

In addition to the above, cold would be a contributor to hypoxia at high altitudes, due to its bronchoconstriction effect, decreased secretion and low mucociliary clearance, and hypertrophy of the muscular fascicles of the airways [22].

Oxygen saturation

It is the proportion of hemoglobin in arterial blood loaded with oxygen, which reflects the transport of gas from the lungs to the cells of the different organs and tissues, it is quantified in proportion (%). In this case, the quantification will be performed through a pulse oximeter

MATERIALS AND METHODS

The type of research was observational, descriptive, prospective, since the information was collected in the month of August, it is cross-sectional because the data was taken in a single moment [23][24]. As is typical of this level, we refer only to observing how the event unfolded, in this case the behavior of the fetal heartbeat of pregnant women diagnosed with COVID-19.

Temporal and spatial scope

The research was developed in the districts of Mariscal Cáceres, and Castrovirreyna, of the Department of Huancavelica, populations that are between 2800 to 4800 meters above sea level, their main source of subsistence is agriculture and livestock, trout farming and mining. The women who participated in the study live between 2,819 and 4,174 meters above sea level.

The research type is observational, prospective cross-sectional and descriptive. This research has a descriptive level [24]. Since the oxygen saturation was observed in its natural state, within the established conditions, and in the geographic area identified by altitude.

Operationalization of Variable

Oxygen saturation in women living at altitudes greater than 2800 meters above sea level.

The design responds to a descriptive design.

Design scheme: M-O.

Where:

- M = constituted by women who live at more than 2800 meters above sea level, healthy.
- O= Oxygen saturation.

Population, sample and sampling

Population

It was made up of healthy women between 18 and 49 years old from the districts of Mariscal Cáceres 317, Castrovirreyna 619, according to the nominal register of the year 2021, of the health establishments of both districts.

Table 1: oxygen saturation in women living between 2800-3499 m.a.s.l. and 3500-4200 m.a.s.l., huancavelica, peru, 2021

Conceptual definition	Operational definition	Dimensions	Indicators	Item	Type of variable
It is the amount of oxygen bound to hemoglobin carried by arterial blood (SpO2).	It is the result of the quantification of oxygen saturation through pulse oximetry in women of childbearing age at more than 3600 meters above sea level.	Environmental characteristics	Altitude (m.a.s.l.)	Altitude in reference to the sea	Discrete
			Time absenteeism from the place	How many days have you been on the coast or in the jungle in the last year?	Discrete
			Occupation	Housewife, independent pastor, public employee others: …	Discrete numeric
		Conditions of the woman	Age	Age in years at the time of taking.	Discrete numeric
			Physiological condition	Is pregnant Not pregnant	Categorical nominal
		Saturation Of oxygen	Vital functions	Temperature Oxygen saturation (spo2) Blood pressure (mmhg) Heart rate	Discrete

The sample consisted of 151 healthy women, who attended the health facility between June and July 2021. Sampling was for convenience, every woman between 18 and 49 years of age who agreed to participate was taken as a sample and the medical evaluation did not report or was diagnosed with pulmonary, cardiovascular, and other pathologies that could alter health, and a clinical history was reviewed to confirm that the sample does not suffer from diseases such as severe anemia, hypertension, heart problems, liver, kidney and lung disease.

Instrument and technique for data collection

A portable digitalis equipment brand Medical System International Corp. Model Sp02 5001 was used, on the index finger of the right hand. Technical observation sheet is Pulse oximetry, based on the emission of light of different wavelengths transmitted through the skin and measured by a photodetector, which shows the hemoglobin bound to oxygen as a radiant red color [19].

The following technique was used to take the oxygen saturation:

Calibration

It is suggested that non-disposable sensors be calibrated or validated every 1 to 2 years.

Disinfection

Must be cleaned and disinfected between patients according to the manufacturer's recommendations. The contact area can be cleaned with a damp cloth or alcohol.

Wash or disinfect your hands, the evaluator must repeat this process between patients.

Site of use

Check perfusion and temperature of the place where it is placed, skin must be dry. In adults, usually on a finger.

Sensor placement

Place the light emitting photodiode (red light) towards the nail bed and the receiving photodiode (not emitting light) on the opposite side

The finger sensors take a while to stabilize the measurement, it must be ensured that the pulse wave is adequate in intensity and rhythm, keep the finger without movement.

8.If you do not get a pulse wave of good intensity and rhythm, or stable measurements, change the sensor site [19].

Taking procedures

The patient enters the routine facility is controlled in triage, all vital functions: temperature, blood pressure, heart rate, SpO2, heart rate and saturation are done with the PUSH brand pulse oximeter. The requested data is recorded in the observation instrument.

Go to medical attention for evaluation. After that, an exhaustive review of the clinical history is made, and the observation sheet is completed. And the admission of her to the study or not is decided. If admitted to the study, after evaluating the indicated criteria, the record is coded and proceeded to save, otherwise it must be discarded.

RESULTS AND DISCUSSION

The quantitative results of the measures taken through the intervention are shown below

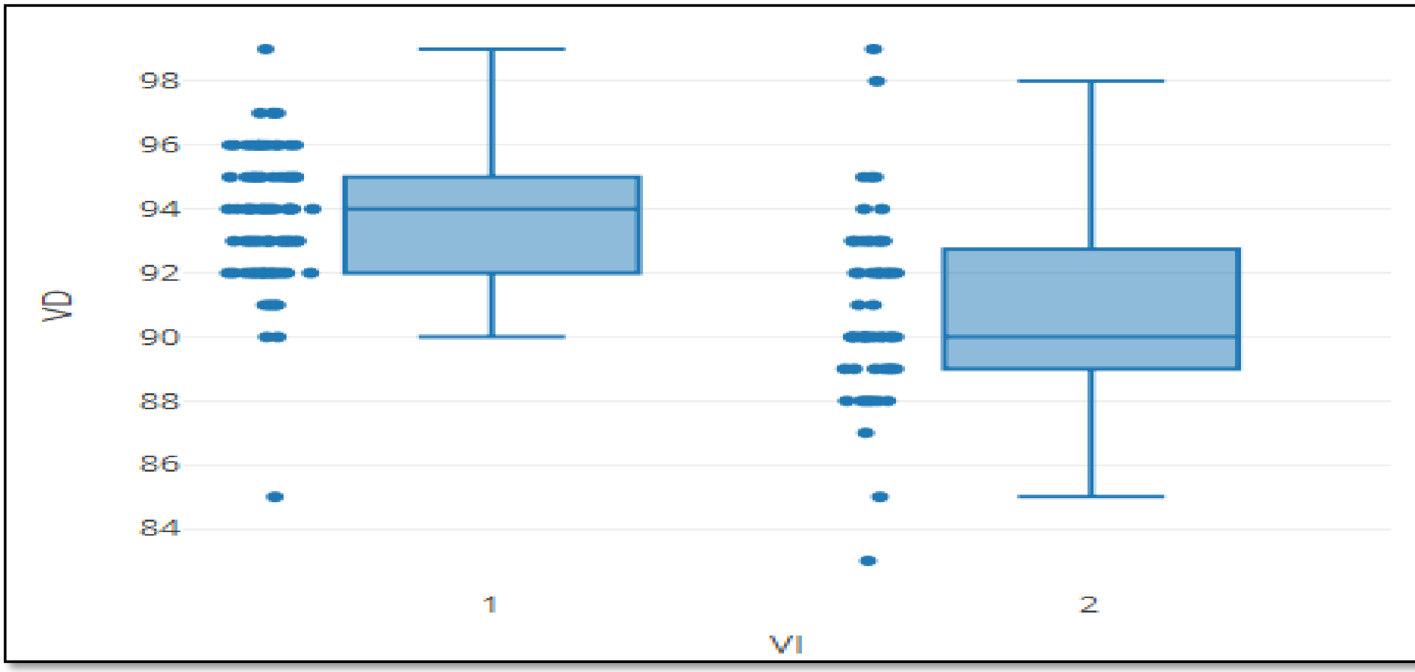
Table 3: oxygen saturation in women living between 2800 - 3499 m.a.s.l. and 3500 to 4200 m.a.s.l huancavelica, 2021

Measures	SpO2 at 2800 - 3499 m.a.s.l.	SpO2 at 3500 - 4200 m.a.s.l.
Minimum	85	83
Maximum	99	99
Mean	93.72	90.85
Standard error	0.21	0.36

In Table 3, we can see that the average oxygen saturation (SpO2), of those who live between 2819 - 3499 m.a.s.l. is 93.72% and in inhabitants between 3500 - 4200 m.a.s.l., it reaches 90.85%. On the other hand, the minimum SpO2 was 85% between 2,819 - 3,499 m.a.s.l. and 83% between 3,500 - 4,200 m.a.s.l., while the maximum saturation found was 99% in both altitude levels.

Figure 1 clearly shows the average of each of the altitudes, being lower at 3,500 to 4,200 m.a.s.l., as well as the lowest saturation. On the other hand, the majority of those who live between 2,800 and 3,499 meters above sea level, presented a saturation of 92 to 96%, while those who live between 3,500 and 4,200 meters above sea level between 88 and 93%.

Figure 1: Oxygen saturation in women living between 2,800 – 3,499 m.a.s.l. and 3,500 to 4,200 m.a.s.l. Huancavelica, 2021.



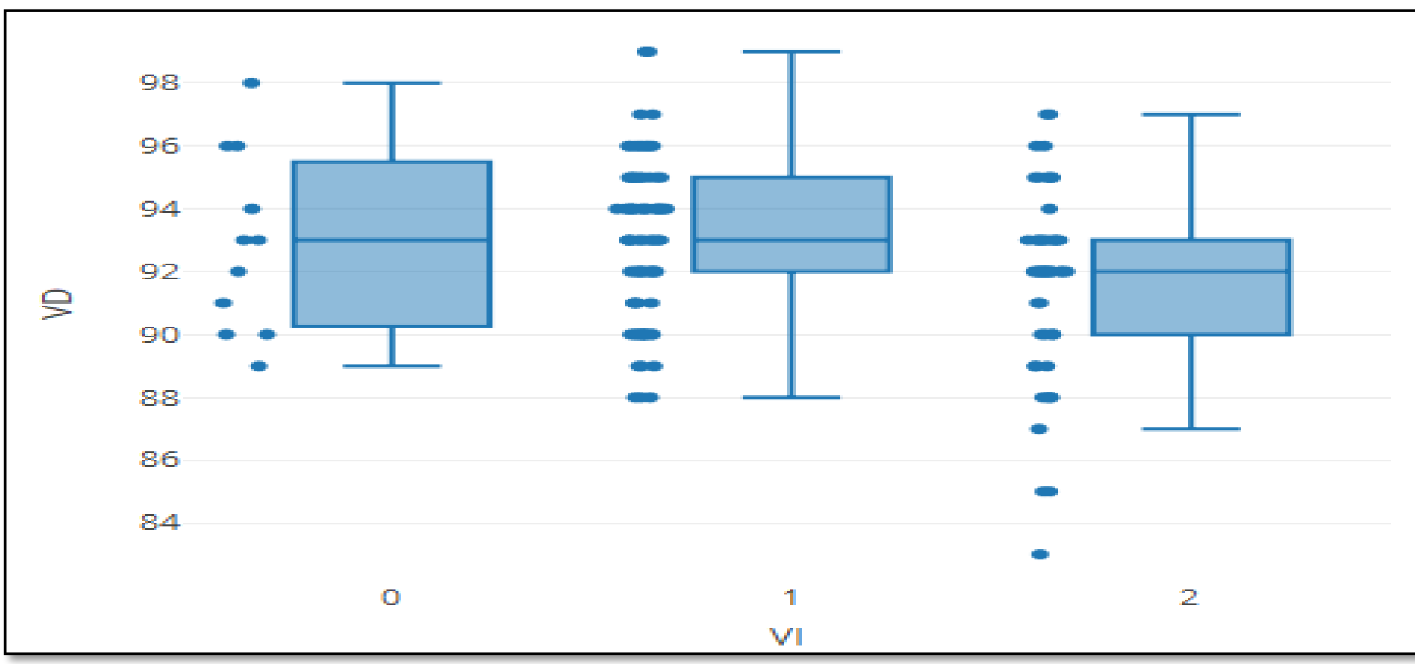
Legend: 1: 2819 – 3499 2: 3500 – 4200.

Table 4: oxygen saturation in women by age groups, huancavelica, 2021

Measures	SpO2 in women aged 18 to 19 years old	SpO2 in women aged 20 to 34 years old	SpO2 in women aged 35 to 49 years old
Minimum	89	88	83
Maximum	98	99	97
Mean	92.91	93.09	91.74
Standard error	0.87	0.26	0.4

Table 4 shows the means of SpO2 in adolescents at 92.91%, between the ages of 20 to 34 years old the average was 93.09% and from 35 to 49 years old it is recorded at 91.74%, this age range presented a minimum SpO2 of 83%, a slight decrease in the minimum value found was observed, showing lower at older ages.

Figure 2: O2 saturation in women by age group Huancavelica, 2021



Legend: 0= women between 18 and 19 years old, 1= women between 20 and 34 years old, 2= women between 35 and 49 years old

In figure 2, we can see that the saturation between 18 to 19 years old and among women between 20 to 34 years old was similar, while in those between 35 and 49 years old, a slight decrease is observed. Likewise, we can appreciate that there were more women between 20 and 34 years old.

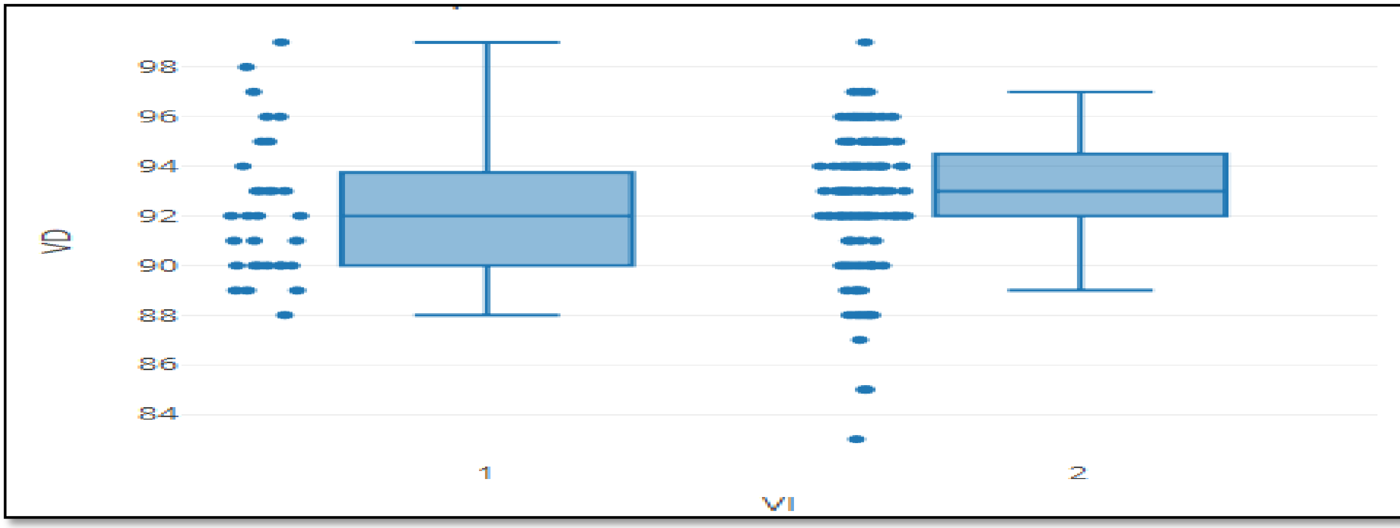
Table 5: oxygen saturation among pregnant and non-pregnant women of referable age, huancavelica, 2021

Measures	**SpO_2in pregnant women**	**SpO_2in Non-pregnant women**
Minimum	88	83
Maximum	99	99
Mean	92.29	92.67
Standard error	0.51	0.24

Measures	**SpO_2in pregnant women**	**SpO_2in Non-pregnant women**
Minimum	88	83

Table 5 shows the oxygen saturation in pregnant and non-pregnant women, showing a similar mean in both pregnant cases 92.29% and 92.67% in non-pregnant women, the minimum SpO2 reached was 88% in pregnant women and 83% in non-pregnant women, while the maximum value was the same in both groups, reaching 99%.

Figure 3: Oxygen saturation between pregnant and non-pregnant women Huancavelica, 2021



Legend: 1 = pregnant women and 2= non-pregnant women

In Figure 3, we can see that the largest number of women were non-pregnant, and the average saturation is similar in both groups.

The measurement of oxygen saturation has become one more vital sign to control as part of the consultation process of any indoles, to which the consultations made by women of childbearing age in the obstetrics and gynecology services of the different health establishments are not related to this. On the other hand, the values in the different altitudinal floors are still not clear.

In addition, within obstetric care, the measurement of oxygen saturation should be a sign to monitor in pregnancy complications that affect the uptake, transport of O2, as well as the elimination of CO2, these cases are: hypovolemic and septic shock, hypertensive disorders, cardiac, pulmonary and metabolic pathologies [25].It must be taken into account that SpO2 differs between men and women [1], [10]. That is why the research work was done in women.

The average oxygen saturation between 2819 - 3499 m.a.s.l. was 93.72% and from 3500 - 4200 m.a.s.l. it was 90.85%, observing a decrease at higher altitudes, the minimum saturation was 85% and 83%, respectively, the maximum saturation in both altitudes were displayed at 99%. Bustamante [12]in Quito (2,850 m.a.s.l.), finds the saturation at 94% similar to that identified between 2,819 – 3,499 m.a.s.l.. Likewise, in Castrovirreyna (3600 – 4010 m.a.s.l.) Escobar [23]found the average SpO2 in this population group at 91.7%, at more than 3600 m.a.s.l.. On the other hand, Tinoco, et al [13], reports that in Huánuco (1818 m.a.s.l.) the saturation was 96.24% and in Pasco (4380 m.a.s.l.) it was recorded on average at 87.02%, it is evident that at higher altitudes there is a clear decreased O2 saturation. This decrease is possibly due to the fact that the human being, despite adaptations to altitude, does not respond to hypoxic conditions at altitude as at sea level [21].

This scenario is probably due to the decrease in barometric pressure at higher altitudes, causing the inspired PO2 to decrease, leading the individual to a hypoxic condition, to this is added the climatic factor and the temperature so low that it causes changes at the level of the respiratory system, which causes the O2 saturation to decrease at higher altitudes [22], [26]. Therefore, we can say that the oxygen saturation in both altitudinal floors studied is below the normal values referenced at sea level, which range from 95 to 100%.

The average of the O2 saturation, in the three age groups, is above 90%, however, in the age of 35 to 49 years old (91.74%) it is shown decreased by 1.35% in relation to the age of 20 at 34 years old (93.09%). Likewise, the lowest saturation of the entire study was recorded in the group of 35 to 49 years old (83%). On the other hand, Trompetero et al [1], at an altitude of 2600 m.a.s.l., found 94.4% saturation between men and women aged 18 to 30 years old. The slight difference at the different ages is since the age range in which we worked is between late adolescents, young people, and adults, in addition the study is in a normal population.

Oxygen saturation between pregnant and non-pregnant women was quite similar, 92.29% and 92.67%, respectively, with the minimum saturation being 88% in pregnant women and 83% in non-pregnant women, a situation that draws attention and warrants further study in this regard.

From what was reviewed, we can deduce that the oxygen saturation in women decreases at higher altitudes, showing above 90%, having a minimum saturation of 83% and a maximum of 99%, also at older age a slight decrease is noted. And no variation was found between pregnant and non-pregnant women.

CONCLUSION

Oxygen saturation in women decreases at higher altitudes, showing the average at 2800 - 3499 m.a.s.l. in 93.72%, descending to 90.85% between 3500 - 4200 m.a.s.l., the minimum saturation was 83% and the maximum 99%. At older ages, a slight decrease in saturation is noted, from 93.09% between 20 to 34 years old to 91.74% between 35 to 49 years old, while pregnant and non-pregnant women showed a similar saturation.

In future research, we propose measuring oxygen saturation to assess the oxygenation of individuals after the pandemic's health crisis ends. This measurement has proven to be particularly useful in primary healthcare facilities. Additionally, for women residing above 2,800 m.a.s.l., a saturation level of 90% or higher can be considered normal. It is recommended to measure oxygen saturation above 2,500 m.a.s.l. in all obstetric patients due to the risk of fetal hypoxia.

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