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ORIGINAL ARTICLE

Evaluation of oxygen saturation values in different body positions in healthy individuals

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Aims and objectives. The research was conducted to evaluate oxygen saturation values measured in healthy individuals in different body positions.

Background. Changes in position affect ventilation-perfusion rates, oxygen transport and lung volume in normal lungs. There have been few studies and not enough information about which positioning of a healthy individual can increase oxygenation.

Design. A descriptive study.

Methods. A sample of 103 healthy individuals with no chronic disease, anaemia or pain was included in the research. Individuals were positioned in five different positions: sitting upright, supine position, prone position, lying on the left side and lying on the right side. Oxygen saturation and pulse rates were then measured and recorded after the individuals held each position for ten minutes.

Results. It was found that the average oxygen saturation value when measured while sitting in an upright position in a chair was significantly higher than that measured when the individual was lying on the right or left side of the body. Oxygen saturation values measured in the five different body positions were significantly higher in women, in individuals below the age of 35, in those with Body Mass Indexes of below 25 kg/m^2, and in nonsmokers.

Conclusion. All of the oxygen saturation values measured in the five different body positions were in the normal range. Although oxygen saturation values were within the normal range in the five different body positions, *post hoc* analysis showed that the best oxygenation was in the 'sitting upright' position while the lowest oxygenation was in the supine position.

Relevance to clinical practice. Based on the results of this research, it can be concluded that the differences among oxygen saturation values according to the different body positions were statistically significant.

What does this paper contribute to the wider global clinical community?

- Positioning patients or changing their body positions with the objectives of improving an individual's oxygenation and contributing to his/her recovery is one of the independent initiatives taken on by nurses.
- While there are many studies on patients in this context, there is still uncertainty about which position promotes oxygenation in healthy individuals. This study showed that body positions have a significant effect statistically on oxygenation in healthy subjects.

Key words: body positions, healthy individuals, oxygenation, pulse oximetry

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Introduction and background

Changing a patient's position for reducing pressure, increasing patient comfort and helping to facilitate pulmonary secretions (Marklew 2006) is one of the independent initiatives carried out by nurses and these initiatives contribute to protecting the patient's health and ensuring recovery (Eveleyn & Yeaw 1996, Kusano *et al.* 2000, Yıldırım & Yavuz 2009). Body position and body position changes have an effect on the optimal transport of blood and oxygen. Placing the patient in the right position at the right time improves gas exchange and contributes to recovery (Vollman 2004). Patients who are not positioned correctly face the risk of harmful or even fatal consequences due to a disruption of the ventilation/perfusion ratio and a lowered cardiac flow rate (Yıldırım & Yavuz 2009). A particular body position, the time a body remains in a particular position, or changes in body position may have an adverse effect on oxygen transport, especially in the very young or elderly, obese individuals or the severely ill (Dean 1985). For this reason, to avoid the adverse effects in oxygen transport in the neuromuscular, musculoskeletal systems and skin that positioning or changing the body position may cause, body positions and body position changes that improve oxygen transport and oxygenation should always be considered (Jones & Dean 2004).

It is known that body positions can increase ventilation-perfusion ratios (Neagley & Zwillich 1985, Marklew 2006). In a normal standing individual, blood flow and alveolar ventilation in the upper parts of the lungs is significantly lower than in the lower parts. Blood flow, however, is very much reduced compared to ventilation. The imbalance between the ventilation and perfusion in the upper and lowest areas of the lungs causes a slight reduction in the efficiency of the lungs in terms of the exchange of oxygen and carbon dioxide (Guyton & Hall 1996).

Some physiological changes such as changes in cerebral blood volume and blood pressure occur during postural changes in healthy people (Demura *et al.* 2008). It is believed that gas exchange and cardiovascular system kinetics are affected when the body position is changed during spontaneous breathing (Naitoh *et al.* 2014). The position of the body and changes in body position determine the degree of gravity acting on the cardiovascular and cardiopulmonary systems as well as on optimal blood circulation and oxygen transport (Dean 1985, Jones & Dean 2004). Gravity affects oxygen transport in many indirect ways. It affects lung volume and lung capacity as well as respiratory mechanisms. It is asserted that compared to recumbent positions, the position of sitting upright increases lung volume and capacity (Jones & Dean 2004).

There are few studies related to oxygenation in different body positions in healthy individuals. Wong *et al.* (2014) produced magnetic resonance imaging of systemic and pulmonary blood flow at rest in two different positions in 24 healthy adults. They concluded that pulmonary arterial blood flow did not differ between the prone and the supine position, but there was a decrease in blood flow to the left lower pulmonary vein in supine position (Wong *et al.* 2014). In a study by Naitoh *et al.* (2014) to examine pulmonary function in different recumbent positions, 20 healthy non-obese young people (age, 28·0 ± 1·4 years) were positioned in sitting, prone and six other recumbent position, and it was found that pulmonary function decreased in all recumbent positions after five minutes. In a quasi-experimental study with 32 healthy subjects that examined the effect of body position on oxygen consumption, arterial saturation did not change across body positions (Jones & Dean 2004).

It is not known if different body positions change oxygen saturation and pulse rates in healthy adults and which position can increase oxygenation. This research was conducted with this objective to evaluate oxygen saturation values and oxygenation, as measured in healthy individuals in different body positions.

Methods

Study design, participants and procedure

This was a descriptive study carried out over the period April 2014–October 2014. The sample consisted of second-year students (n = 235) enrolled in the Ege University Faculty of Nursing in the academic year 2013–2014 and of personnel (n = 201) working in the same facility. Cohen has suggested in the literature that in similar studies where enough data cannot be accessed to make an estimate regarding minimum sample size (means and standard deviation), conventional defined values for effect size can be employed. In the comparison of oxygen saturation measured in five different positions in the same individuals, an estimate of effect size as d = 0·40 yielded a 95% confidence interval and an 80% power, indicating a minimum sample size of 99 subjects (Portney & Watkins 1993). The sampling for the research was drawn using a simple random sample from students and faculty at Ege University Faculty of Nursing, using a table of random numbers set up in proportion to the number of students and personnel. A total of 103 individuals who had no chronic disease, anaemia or pain were recruited into the study. The recommended oxygen saturation reference value is 94–98% for adults (Smith *et al.* 2012). This range of values was considered in the study.

Data collection

The researcher collected demographic information and characteristics of health behaviour using a data collection questionnaire that was drawn up in the light of the literature. The individuals were measured for oxygen saturation and pulse rate and then placed in five different positions: sitting upright in a chair with feet on the ground, supine, prone, lying on the right side and lying on the left side respectively. In the supine, prone and lateral positions, a pillow was placed under the head of the subject. Oxygen saturation and pulse rates were measured with a pulse oximeter at each positions after a wait of 10 minutes. The measurements were carried out in the Ege University Faculty of Nursing Skills Laboratory. To avoid any unwanted effect on the measurements, any nail polish that the subjects may have been wearing was removed. In addition, considering the possibility that a full stomach may make a change in lung capacity and affect measurement results, measurements were taken before lunchtime. All of the pulse oximeter measurements were performed with Onyx Vantage Model 9590 pulse oximeter (Nonin, Maryland, USA).

Data analysis

Data analysis was performed with the IBM SPSS-version 22.0 statistical package (Chicago, IL, USA). The descriptive characteristics were expressed as numbers and percentages in the categorical variables and as means, standard deviation and medians. The repeated measures ANOVA and *post hoc* analysis techniques were used in the comparison of the oxygen saturation and pulse rate mean values in the different body positions. The Kolmogorov–Smirnov test was employed to test the normality of the distribution of data. As the data did not display Normal distribution, the Mann–Whitney *U* test was employed in the comparison of the oxygen saturation values in the dual-category variables related to demography and health. The paired samples *t* test was used in the *post hoc* analysis, and because 10 different comparisons were made for the five different body positions, the significance level was recalculated ($0{\cdot}05/10 = 0{\cdot}005$) and accepted as $p < 0{\cdot}005$. Significance for the other analyses was $p < 0{\cdot}05$.

Ethical considerations

The approval of the Ege University Faculty of Nursing Scientific Board of Ethics was obtained to enable the implementation of the research. The written consent of the individuals agreeing to participate in the study was also obtained.

Results

The mean age of the study participants was $33{\cdot}0 \pm 13{\cdot}4$ (median: 27) years; 66% were males. The mean BMI of the participants was $24{\cdot}4 \pm 4{\cdot}4$ kg/m^2; 25·2% reported engaging in regular exercise, 33% said that they smoked and 32% reported drinking alcoholic drinks (Table 1).

There was a statistically significant difference in the oxygen saturation values measured while the individuals were in different positions (Table 2). Although oxygen saturation values were within the normal range in the five different body positions, *post hoc* analysis showed that the mean value of oxygen saturation measured in the sitting upright position was found to be significantly higher than the mean values of oxygen saturation measured in a supine position or when lying on the right or left side ($p < 0{\cdot}005$). The mean oxygen saturation value measured in a prone position was found to be significantly higher than the value measured in a supine position ($p < 0{\cdot}005$).

Table 1 Distribution of the sample in terms of demographics and health behaviour ($n = 103$)

Characteristics	*n*	%
Gender		
Male	68	66·0
Female	35	34·0
Age (years)		
<35	61	59·2
≥35	42	40·8
BMI (kg/m^2)		
<25 *	58	56·3
≥25 †	45	43·7
Physical activity status		
Yes	26	25·2
No	77	74·8
Smoking status		
Yes	34	33·0
No/give up	69	67·0
Alcohol intake status		
Yes	33	32·0
No	70	68·0

*BMI < 18·5 kg/m^2: seven participants.
†BMI > 30 kg/m^2: 12 participants.

Table 2 Comparison of oxygen saturation and pulse rate mean values in different body positions ($n = 103$)

Body positions	Oxygen saturation (%) Mean ± SD	Pulse rate Mean ± SD
Sit upright	97·48 ± 1·42	74·77 ± 10·94
Prone	97·23 ± 1·62	72·97 ± 10·89
Right lateral	97·00 ± 1·90	70·27 ± 11·05
Left lateral	96·99 ± 1·96	70·32 ± 10·99
Supine	96·76 ± 1·98	68·63 ± 10·09
F (*p**)	5·106 ($p < 0·001$)	25·331 ($p < 0·001$)

*Repeated measures ANOVA.

There was a statistically significant difference in the pulse measurements when the individuals were in different positions (Table 2). In the *post hoc* analysis, the mean pulse value measured in an upright sitting position was found to be significantly higher than the mean pulse measurements in a supine position or when lying on the right or left side ($p < 0·005$). The mean pulse measurement in a supine position was significantly lower than when measured in a prone position ($p < 0·005$). The mean pulse measurement in a prone position was significantly higher than when measured when lying on the right or left side ($p < 0·005$).

The effects of demographic and health-related variables on the oxygen saturation values measured in different body positions are shown in Table 3. It was found that the mean values of oxygen saturation measured in five different body positions were significantly higher in women compared to men ($p < 0·001$). Similarly, mean values of oxygen saturation measured in five different body positions were significantly higher in individuals below the age of 35 years compared to those 35 years of age and older ($p < 0·001$).

Oxygen saturation mean values measured in the five different body positions in individuals with a BMI of below 25 kg/m^2, were significantly higher than in individuals with a BMI of 25 kg/m^2 or more ($p < 0·001$). Oxygen saturation mean values measured in the five different body positions in individuals who reported that they were nonsmokers or had quit smoking were significantly higher than those mea-

Table 3 Comparison of oxygen saturation values according to demographic characteristics and health behaviour

Characteristics	Oxygen saturation values: Sit upright Mean ± SD*	Supine Mean ± SD*	Prone Mean ± SD*	Right side Mean ± SD*	Left side Mean ± SD*
Gender					
Male	96·6 ± 1·7	95·5 ± 2·1	96·2 ± 1·8	95·9 ± 2·0	95·8 ± 2·3
Female	97·9 ± 0·9	97·4 ± 1·6	97·8 ± 1·3	97·5 ± 1·6	97·6 ± 1·5
p†	**<0·001**	**<0·001**	**<0·001**	**<0·001**	**<0·001**
Age					
<35	97·9 ± 1·1	97·8 ± 1·3	98·0 ± 1·1	97·8 ± 1·4	97·9 ± 1·2
≥35	96·9 ± 1·6	95·3 ± 1·9	96·1 ± 1·5	95·9 ± 2·0	95·7 ± 2·2
p†	**<0·001**	**<0·001**	**<0·001**	**<0·001**	**<0·001**
BMI					
<25	97·8 ± 1·4	97·5 ± 1·5	97·9 ± 1·4	97·7 ± 1·5	97·7 ± 1·7
≥25	97·0 ± 1·3	95·8 ± 2·1	96·3 ± 1·5	96·1 ± 1·9	96·1 ± 1·9
p†	**<0·001**	**<0·001**	**<0·001**	**<0·001**	**<0·001**
Physical activity status					
Yes	97·6 ± 1·2	97·0 ± 1·4	97·4 ± 1·4	97·2 ± 1·7	97·3 ± 1·8
No	97·4 ± 1·5	96·7 ± 2·1	97·2 ± 1·7	96·9 ± 1·9	96·9 ± 2·0
p†	0·673	0·739	0·457	0·523	0·371
Smoking status					
Yes	96·9 ± 1·8	95·9 ± 2·2	96·3 ± 1·9	96·3 ± 2·2	96·0 ± 2·4
No/give up	97·8 ± 1·1	97·2 ± 1·7	97·7 ± 1·3	97·4 ± 1·6	97·5 ± 1·5
p†	**0·006**	**0·001**	**0·001**	**0·018**	**0·002**
Alcohol intake status					
Yes	97·6 ± 1·6	96·9 ± 1·6	97·4 ± 1·4	97·5 ± 1·3	97·2 ± 1·7
No	97·4 ± 1·3	96·7 ± 2·1	97·1 ± 1·7	96·8 ± 2·1	96·9 ± 2·1
p†	0·258	0·815	0·451	0·161	0·548

*Standard Deviation.
†Mann–Whitney *U* test.
The bold values are $p < 0·05$.

sured in smokers ($p < 0{\cdot}05$). No impact on oxygen saturation values was found in the different body positions in terms of physical activity status or alcohol drinking habits ($p > 0{\cdot}05$) (Table 3).

Discussion

It was found in this research, conducted to evaluate oxygen saturation levels and oxygenation in different body positions in healthy individuals that all oxygen saturation values were in the normal range at five different body positions.

Although all oxygen saturation values measured in five different body positions were within the normal range, the best oxygen saturation value was obtained when the individual was sitting on a chair in upright position. Literature showed that the most convenient position for respiration is the upright sitting position (Vollman 2004, Naitoh *et al.* 2014).

In a study conducted in healthy individuals, it was reported that no significant statistical difference had been recorded in oxygen saturation values and that these values were within the normal range in two different body positions (supine and Fowler's) (Smith *et al.* 2010). In other research, 32 nonsmoking individuals in five different body positions (sitting upright on a chair, supine, head-down supine flat 30° angle, lying on right and left sides) were studied in terms of the hemodynamic and metabolic impact of a change of position. When pulse rate, blood pressure and oxygen consumption while lying down were compared, the sitting position caused the greatest effect while the left lateral position displayed the least effect. Oxygen saturation values did not change with changes in position (Jones & Dean 2004). In the study by Hardie *et al.* (2002) with a group of healthy seniors (average age 75·2), the effect of two different positions (sitting and supine) on changes in arterial blood gases was observed and as in the present study, it was found that arterial oxygen tension was better in a sitting position.

The mean oxygen saturation value measured in a prone position is significantly higher that the value measured in a supine position. There are few studies conducted in this context with healthy individuals. In a study carried out by Jones & Dean with healthy individuals, no difference was found between oxygen saturation values in different positions (Jones & Dean 2004). Studies conducted with individuals with pulmonary disease have shown, as in this study, oxygenation is better in a prone position (Breiburg *et al.* 2000, Meade 2002, Lin *et al.* 2005, Das *et al.* 2011, Wright & Flynn 2011, Masuda *et al.* 2014).

In this study, it was seen that the pattern of pulse rates according to body positions resembled the oxygen saturation pattern. Pulse rates measured when individuals are seated in a chair in an upright position were found to be significantly higher than in all the other body positions, with the exception of the prone position. Pulse rates measured in the supine position, however, are significantly lower than in the prone position. In a study with healthy individuals, consistent with this study, pulse rates were highest in the sitting position (Jones & Dean 2004).

According to the results of this study, mean oxygen saturation values measured in the five different body positions were significantly higher, in women, individuals under the age of 35, persons with Body Mass Indexes of below 25 kg/m^2 and nonsmokers. These results supported the literature (Jones & Dean 2004, DeLaune & Ladner 2011).

Conclusion and relevance for clinical practice

This study demonstrates that body positions did not affect oxygen saturation in healthy individuals. The results of the research show that oxygen saturation values measured in five different body positions are within the normal range. Although oxygen saturation values were within the normal range in the five different body positions, *post hoc* analysis showed that the best oxygenation was in the 'sitting upright' position and the lowest oxygenation was in the supine position. In the light of the results of this research, it can be stated that the differences between oxygen saturation values according to different body positions were statistically but not clinically significant.

Limitations of the study

This research was conducted with healthy individuals, ages 18–65, with no known disease or anaemia. The study results cannot be generalised to encompass children, the older people or individuals suffering from illness. The presence of anaemia was recorded on the basis of the individuals' own statements. The fact that haemoglobin values were not investigated is another limitation to the study. Other limitations were that oxygen saturation values were measured only with a pulse oximeter and body temperatures were not measured.

Studies on this matter have predominantly dealt with individuals with illness and there has been limited research conducted on healthy individuals. It is suggested that more studies with larger samples that include children and older individuals as well as individuals with anaemia will be useful in exploring this area.

Contributions

Author contributions BC and LK were responsible for the study conception and design, and the BC, LK, UYG and AZ were responsible for the drafting of the manuscript. BC and UYG performed the data collection and BC, UYG and LK performed the data analysis. LK, UYG, BC and AZ made critical revisions to the paper. BC, LK and UYG supervised the study.

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Conflict of interest

The authors have not disclosed any potential conflicts of interest.

References

Breiburg AN, Aitken L, Reaby L, Clancy RL & Pierce JD (2000) Efficacy and safety of prone positioning for patients with acute respiratory distress syndrome. *Journal of Advanced Nursing* **32**, 922–929.

Das H, Shaikh S & Kella N (2011) Effect of prone versus supine position on oxygen saturation in patients with respiratory distress in neonates. *Pakistan Journal of Medical Sciences* **27**, 1098–1101.

Dean E (1985) Effect of body position on pulmonary function. *Physical Therapy* **65**, 613–618.

DeLaune SC & Ladner PK (2011) *Responding to Basic Physiological Needs, Fundamentals of Nursing Standards & Practice Fourth Edition*. Delmar, Cengage Learning, Canada, p. 865.

Demura S, Yamaji S, Kitabashi T, Yamada T & Uchiyama M (2008) Effects of room temperature and body position change on cerebral blood volume and center-of-foot pressure in healthy young adults. *Journal of Physiological Anthropology* **27**, 63–70.

Eveleyn MJ & Yeaw RN (1996) The effect of body positioning upon maximal oxygenation of patients with unilateral lung pathology. *Journal of Advanced Nursing* **23**, 55–61.

Guyton AC & Hall JE (1996) Physical Principles of Gas Exchange; Diffusion of Oxygen and Carbondioxide, Chapter 39, In *Textbook of Medical Physiology*, 9th edn (Cavusoglu H, ed.). Nobel Medicine Bookstores, Yüce Publication, Istanbul, pp. 510.

Hardie JA, Mørkve O & Ellingsen I (2002) Effect of body position on arterial oxygen tension in the elderly. *Respiration* **69**, 123–128.

Jones AYM & Dean E (2004) Body position change and its effect on hemodynamic and metabolic status. *Heart and Lung* **33**, 281–290.

Kusano E, Yorifuji S, Okuno M, Nakanishi F, Imaoka H, Matsuo Y, Abe K & Hayakawa K (2000) Skin hemodynamics during change from supine to lateral position. *Journal of Neuroscience Nursing* **32**, 164–168.

Lin FC, Chen YC, Chang HI & Chang SC (2005) Effect of body position on gas exchange in patients with idiopathic pulmonary alveolar proteinosis: no benefit of prone positioning. *Chest* **127**, 1058–1064.

Marklew A (2006) Body positioning and its effects on oxygenation – a literature review. *Nursing in Critical Care* **11**, 16–22.

Masuda Y, Tatsumi H, Imaizumi H, Gotoh K, Yoshida S, Chihara S, Takahashi K & Yamakage M (2014) Effect of prone positioning on cannula function and impaired oxygenation during extracorporeal circulation. *The International Journal of Artificial Organs* **17**, 106–109.

Meade M (2002) Prone positioning for acute respiratory failure improved short term oxygenation but not survival. *Evidence-Based Nursing* **5**, 52.

Naitoh S, Tomita K, Sakai K, Yamasaki A, Kawasaki Y & Shimizu E (2014) The effect of body position on pulmonary function, chest wall motion, and discomfort in young healthy participants. *Journal of Manipulative & Physiological Therapeutics* **37**, 719–725.

Neagley SR & Zwillich CW (1985) The effect of positional changes on oxygenation in patients with pleural effusions. *Chest* **88**, 714–717.

Portney LG & Watkins MP (1993) *Foundations of Clinical Research. Applications to Practice*. Appleton & Lange, Norwalk, CT, pp. 651–667.

Smith SJ, Harten JM, Jack E, Carter R & Kinsella J (2010) Pre-oxygenation in healthy volunteers: a comparison of the supine and 45 seated positions. *Anaesthesia* **65**, 980–983.

Smith GB, Prytherch DR, Watson D, Forde V, Windsor A, Schmidt PE, Featherstone PI, Higgins B & Meredith P (2012) SpO2 values in acute medical admissions breathing air – implications for the British Thoracic Society guideline for emergency oxygen use in adult patients. *Resuscitation* **83**, 1201–1205.

Vollman KM (2004) The right position at the right time: mobility makes a difference. *Intensive and Critical Care Nursing* **20**, 179–182.

Wong DT, Lee KJ, Yoo SJ, Tomlinson G & Grosse-Wortmann L (2014) Changes in systemic and pulmonary blood flow distribution in normal adult volunteers in response to posture and exercise: a phase contrast magnetic resonance imaging study. *The Journal of Physiological Sciences* **64**, 105–112.

Wright AD & Flynn M (2011) Using the prone position for ventilated patients with respiratory failure: a review. *Nursing in Critical Care* **16**, 19–27.

Yıldırım GÖ & Yavuz M (2009) The hemodynamic and physiologic effects of supine positions given to the patients in intensive care units. *Maltepe University Journal of Nursing Science and Art* **2**, 94–99.