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ORIGINALES

Perfusion index in a resuscitation with biological risk, as a measure of poor physiological tolerance

Índice de perfusión en una reanimación con riesgo biológico, como medida de mala tolerancia fisiológica

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ABSTRACT:

Introduction: Perform a cardiopulmonary resuscitation requires technical knowledge and minimal physical conditions. Perform this resuscitation a team of individual protection against biological risks level D placed increases the overexertion that encourage rescuers are subjected.
The objective of this study is to prove the existence of a pattern of poor physiological tolerance to the use of personal protective equipment level D, category 4-5-6B for action in incidents with biological risk objectified by measuring the perfusion index before and after a simulated resuscitation.
Material and methods: We have performed a quasiexperimental not controlled on 96 volunteers chosen through a random sampling, stratified by sex, level of education and professional category, medical and nursing students and professionals doctors and nurses.
A decision of the perfusion index before performing the resuscitation and other simulated after resuscitation.
Results: A 15% of the volunteers presented a perfusion index lower back to baseline, which translates into a situation of peripheral vasoconstriction after the completion of the physical exercise that involved the clinical case, when expected was a vasodilatation to Increase perfusion.
Conclusion: Extrapolating these data, we can conclude that, in the sample for the study, the volunteers who have less perfusion index at the end of that at the beginning do not tolerate well the effort involved in the case.

Key Words: Physiological tolerance; exposure to biological agents; personal protection; perfusion index.

RESUMEN:

Introducción: Realizar de una forma adecuada una reanimación cardiopulmonar precisa unos conocimientos técnicos y unas mínimas condiciones físicas. Realizar esta reanimación un equipo de protección individual frente a riesgos biológicos nivel D colocado aumenta el sobresfuerzo al que se ven sometidos los reanimadores.

El objetivo de este estudio es comprobar la existencia de un patrón de mala tolerancia fisiológica al uso de los equipos de protección nivel D, categoría 4-5-6B para la actuación en incidentes con riesgo biológico objetivado mediante la medición del índice de perfusión antes y después de una reanimación simulada.

Material y métodos: Se ha realizado u n estudio quasiexperimental no controlado sobre 96 voluntarios elegidos mediante un muestreo aleatorio estratificado por sexo, nivel de formación y categoría profesional, estudiantes de Medicina y Enfermería y profesionales Médicos y Enfermeros.

Se realizó una toma del índice de perfusión antes de realizar la reanimación y otra después de la reanimación simulada.

Resultados: Un 15% de los voluntarios presentaron un índice de perfusión posterior más bajo al basal, lo que se traduce en una situación de vasoconstricción periférica después de la realización del ejercicio físico que supuso el caso clínico, cuando lo esperable era una vasodilatación para aumentar la perfusión.

Conclusiones: Extrapolando estos datos, podemos concluir que, en la muestra de estudio que nos ocupa, los voluntarios que presentan menos índice de perfusión al finalizar que al comenzar no toleran bien el esfuerzo que supone el caso clínico.

Palabras clave:
Tolerancia fisiológica; exposición a agentes biológicos; protección personal; índice de perfusión.

INTRODUCTION

It is increasingly common, in recent times, to attend numerous incidents -both provoked, or fortuitous- that generate situations of collective emergency in which certain substances with nuclear, biological or chemical risk (HAZMAT) are immersed. Situations that require a highly specialized response; in short: situations that must be handled by the Pre-hospital Medical Emergency Services (PEMS) in an integral way[(1)], and that have become an ordinary part of the portfolio of services of emergency teams[(2)].

It is not surprising that, as the world changes and, with it, society - increasingly developed and industrialized -, emergency services must face situations that were not part of their intervention objectives in the past, situations such as the sanitary handling of accidents with dangerous goods or interventions in situations with HAZMAT risk [(3)].
To deal with these situations, the PEMS must change their way of thinking and acting: from a substitute and purely medical care, one must also go on to manage the situation in a coherent and rational way, that is, be able to carry out the so-called crisis management medicine, which integrates the strategies to solve a situation and the opportune assistance procedures.

The usual work of emergency teams is, in itself, difficult, changing and, in many cases, it takes place in complex contexts [(4)]. These situations justify that these professionals must have special attitudes and skills, both in training and training and in providing materials and resources, because their activity will be developed in multiple scenarios and will have very diverse needs [(5)].

Some of the events that occurred with mass victims, such as the recent attacks in Barcelona, London, Paris or Brussels, confront us with new situations with new unstable scenarios, where the SEMP must start working under new standards, in which they must prevail both own security and security of the environment [6].

Working with personal protective equipment (PPE) adapted to the risk involves the handling of new or little known materials, at best, although in many cases it is likely that professionals must use unknown equipment or for those who have not obtained the relevant training. Not only must the medical or surgical pathology of those affected be handled, but it is necessary to bear in mind other factors such as the containment of the incident, the decontamination or the massive handling of the injured and / or contaminated; all under a strict level of protection [7].

These operations are, therefore, especially sensitive, as they require a large amount of prior training, extra sanitary knowledge, training in the use of specific PPE for specific risks, and, in addition, differential management of patients affected by this type of situation: reverse triage, decontamination, use of antidotes, etc., facts that entail that the actions in this type of incident are essentially complex and require a greater degree of training, as events such as the crisis due to the Ebola virus disease have shown us [8].

Once the background has been exposed, and after a thorough bibliographic search, it has not been possible to find any study that relates the use of PPE in health workers and the effects that these teams cause in said professionals, answering questions such as: Is the reasonable time with which you should be with the equipment? Is everyone able to use these protection systems? How does the body behave when faced with the physical stress of working under these special conditions? To detect previously which workers are not suitable to work with these kits?

Some studies (Costello, 2015) try to explain the effects of the use of specific equipment against chemical agents and anti-fragmentation, and how the body behaves at the level of psychological stress, putting 12 volunteers to the test, and observing their behavior at the level of stress, temperature and weight [9]. Other studies [10-13] assess partial aspects, such as the use of protective masks, the use of suits, or the continuous relations of certain risks and their effects on workers' health.

However, for all the above mentioned, it is suggested that it could be very useful to study and describe, what effects the use of PPE causes against biological agents on health workers, and try to relate certain vital signs and / or measurements and their alterations with greater or lesser physiological predisposition to the use of said equipment, started in this study by the perfusion index (PI) assessment.

The general objective of this study is to describe the behavior of the PI, as well as its impact on physical stress to this parameter.

The specific objective is to verify the existence of a pattern of physiological poor tolerance to the use of protective equipment level D, category 4-5-6B for the action in incidents with biological risk objectified by measuring the PI before and after a simulated resucitation.

METHODOLOGY

Ethical aspects

The study was approved on April 6, 2016 by the Clinical Research Ethics Committee of the University Hospital Río Hortega of Valladolid (Spain) with registration code # 412016. All the volunteers had to read and sign the informed consent document, and the entire study was carried out with the highest safety standards, protecting the physical integrity and the confidentiality of the volunteers, complying with national and international regulations for the study of human beings, including the Helsinki Treaty.

Participants

An uncontrolled quasiexperimental study was carried out on 96 volunteers chosen by random sampling stratified by sex and professional category of an opportunity sample of 164 volunteers.

Medical professionals and nurses were selected from the Hospital Emergency Services and Prehospital Emergencies, between 22 and 65 years old and who voluntarily decided to participate.

All volunteers were subjected to a standard health examination, and any volunteer who presented at least one exclusion criterion was rejected (table 1).

Table 1: Exclusion criteria to participate in the study**.**

Electrocardiogram with alterations	Body mass index greater than 40
Capillary glycemia below 65 mg / dL	Functional impotence
Basal heart rate greater than 150 beats per minute	Anticoagulation
Baseline heart rate less than 35 beats per minute	Severe hearing loss
Systolic blood pressure greater than 160 mmHg	Severe visual impairment
Diastolic blood pressure greater than 95 mmHg	Acute phase skin diseases
Systolic blood pressure less than 80 mmHg	Systemic immunological diseases
Oxygen saturation less than 92%	Surgery greater than 30 days previous
Temperature greater than 38º C	Carrier DAI / Holter

Environmental conditions

All the simulated clinical cases were performed in the same laboratory, a diaphanous room of 20 m2, with controlled humidity, temperature and lighting (table 2). All the participants in the study had the same previous information and the same materials and devices of electromedicine to solve the same case.

Table: Description of the temperature and humidity data at the time of the test.

		Temperature	Humidity
Mean		33,66	51,16
SD		27,18	1,54
Minimum		29,10	48,90
Maximum		32,50	54,20
Percentiles	25	30,30	50,23
	Median	30,90	51,00
	75	31,50	52,58

Research protocol

Participants attended the laboratory for three hours, during which the entire protocol was performed. The present study has been carried out in a type or controlled situation, which consisted of the following phases.

Baseline vital signs and anthropometry

The volunteer was asked to sit on a chair, raise the sleeves and wait 5 minutes calmly, in order for the tests to be performed at rest. Subsequently, a serial sampling of vital signs was performed, including: heart rate, systolic and diastolic blood pressure, respiratory rate, tympanic temperature, total hemoglobin, perfusion index and oxygen saturation.

For the determination of systolic blood pressure, diastolic blood pressure and heart rate, the SCHILLER brand BP-200 plus meter was used. The temperature measurement was carried out with a thermometer tympanic brand BRAUN model ThermoScan PRO 6000 with ExacTemp technology. The values of total hemoglobin, oxygen saturation and perfusion index were obtained with a MASIMO model Pronto 7 multiparameter monitor, with software version b99e80000004ef796 (2.2.15), and revision version of sensor a83f90f0000c53f2.

Once the vital signs were taken, an anthropometric study was carried out in order to assess perimeters, height, weight, body fat, muscle mass, bone mass, body mass index and total water.

To carry out the carving of the volunteers, the mechanical tape measure SECA® model 206 was used and for the study of weight and bio impedance it was carried out with the TANITA® precision scale model BC-601.

Placement of the PPE

The volunteers were informed that they were going to be guided at all times in the putting and removal of the PPE, and that at no time would the correction of these techniques be evaluated, since it was only intended to assess the physiological response to the use of the equipment. .

The volunteers, guided by a specialist, had ten minutes to fully equip themselves, then proceeded to review this equipment. The implementation and withdrawal protocol was based on the recommendations of the ECDC [(14)].

Each volunteer had to observe himself in a mirror and check that he was properly equipped; Afterwards, the volunteers did two squats to check the ergometry and adjustments of the equipment, and then they were ready to start the case.

Simulated resuscitation

Each group of four volunteers made the same case, with the same temporal sequence of events, reminding them that the quality of the techniques used would not be evaluated, but emphasizing that they had to perform the techniques and procedures on the simulation dummy in the most correct way possible. The clinical case of simulated cardiac arrest was a ventricular fibrillation performed for 20 minutes.

Withdrawal from PPE

Once the case study was carried out, the PPE was supervised, following the recommendations of the ECDC [(14).]

Taking of vital signs later

After ten minutes of rest, a new series of vital signs was taken, identical to the basal intake.

Statistic analysis

To perform the statistical analysis, the qualitative variables are summarized with their frequency distribution, and the quantitative variables in their mean and standard deviation (SD). In all cases, the distribution of the variable was checked against the theoretical models; and, in case of asymmetry, the median and its interquartile range (RIC) were calculated.

The association between qualitative variables with the de2 test or Fisher's exact test was evaluated, in the case that more than 25% of those expected were less than 5.

The behavior of the quantitative variables was analyzed for each of the independent variables categorized by Student's t-test. The mean absolute effects and their 95% confidence intervals (95% CI) were estimated.

A logistic regression model was adjusted, in order to evaluate the association of those variables that predicted poor tolerance. This model allows to identify the relationship between a set of explanatory variables and the probability of control of the variables studied.

The calibration capacity of the model was evaluated with the Hosmer and Lemeshow test (p close to 1 denote high calibration) and the discrimination capacity was studied with the area under the curve of the probabilities predicted by the adjusted model (AUC).

In all hypothesis contrasts, the null hypothesis was rejected with a type I error or an alpha error of less than 0.05.

The software package used for the analysis was SPSS ver. 20.0.

RESULTS

Demographics

Out of a total of 96 volunteers without exclusion criteria, 40 were men (41.6%) and 56 women (58.3%), with an average age of 31.3 ± 10.8 years, of which 60% They are between 20 and 30 years old.

Of all the subjects who did not present exclusions, 49 were undergraduate students of medicine and nursing (51.1%) and 47 medical professionals and nurses of emergency services and emergencies (48.9%). In turn, of the undergraduate students, 24 were nursing students (48.9%) and 25 medical students (51.1%). Of the professionals, the distribution was 25 nurses (53.1%) and 22 physicians (46.8%), and in turn 26 professionals worked in hospital emergency services (55.3%) and 21 in prehospital emergency services. (44.6%).

Vital signs data

The mean values and standard deviation of the baseline and posterior parameters studied for HR, systolic and diastolic blood pressure, respiratory rate, temperature, total hemoglobin, perfusion index and oxygen saturation, for the total sample (n = 96) were presented in Table 3. The increase in PI afterwards is especially significant, with an average increase of 97.6% with respect to the baseline measurement (p <0.001).

Table 3: Distribution of vital signs before / after for the total sample

	Total sample (n = 96)				
	Before		**After**		
	Mean	SD	Mean	SD	P value
Heart rate	80,1	13,3	91,5	13,1	<0,001
Systolic blood pressure	129,5	14,2	125,1	15,1	0,001
Diastolic blood pressure	81,1	9,8	79,4	9,3	0,054
Breathing frequency	16,5	1,5	17,3	2,1	0,005
Temperature	36,6	0,5	37,2	0,4	<0,001
Hemoglobin	13,6	1,4	14,1	1,4	<0,001
Perfusion index	3,2	2,9	6,5	3,4	<0,001
Oxygen saturation	98,2	1,4	96,2	1,2	<0,001

In tables 4 and 5 we can observe the means and standard deviation of the parameters by sex and by subgroup of study (student or professional), before and after the simulated resuscitation with the protective equipment placed.

Table 4: Distribution of vital signs before / after by sex

	Male (N = 40) (Mean age 33,8 ± 11,8 years old)				
	Before		**After**		
	Mean	**SD**	**Mean**	**SD**	**P value**
Heart rate	78,8	15,1	93,4	13,5	<0,001
Systolic blood pressure	137,7	12,7	134,1	13,1	0,013
Diastolic blood pressure	85,1	9,9	82,6	9,5	0,05
Breathing frequency	16,3	1,8	17,2	2,3	0,061
Temperature	36,4	0,5	37,1	0,4	<0,001
Hemoglobin	14,7	1,2	15,3	0,9	<0,001
Perfusion index	4,37	3,2	7,8	3,5	<0,001
Oxygen saturation	97,3	1,3	95,6	0,9	<0,001
	Female (N = 56) (Mean age 29,5 ± 9,7 years old)				
	Before		**After**		
	Mean	**SD**	**Mean**	**SD**	**P value**
Heart rate	81,3	12,1	90,2	12,6	<0,001
Systolic blood pressure	123,7	12,3	118,7	12,9	0,003
Diastolic blood pressure	78,1	8,7	77,1	8,5	0,372
Breathing frequency	16,7	1,3	17,3	2,1	0,04
Temperature	36,7	0,4	37,2	0,4	<0,001
Hemoglobin	12,9	1,2	13,3	1,1	0,023
Perfusion index	2,5	2,3	5,7	3,2	<0,001
Oxygen saturation	98,8	1,1	96,7	1,2	<0,001

Table 5: Distribution of vital signs before / after by subgroups (students vs. professionals)

	Students (N = 49) (Mean age 22,8 ± 2,8 years old)				
	Before		**After**		
	Mean	**SD**	**Mean**	**SD**	**P value**
Heart rate	80,8	14,1	92,6	12,3	<0,001
Systolic blood pressure	129,3	15,2	125,1	15,1	0,027
Diastolic blood pressure	78,7	9,7	71,3	8,5	0,282
Breathing frequency	16,9	1,3	17,2	2,2	0,385
Temperature	36,8	0,4	37,3	0,3	<0,001
Hemoglobin	13,6	1,5	13,9	1,5	<0,055
Perfusion index	2,9	2,9	6,3	3,9	<0,001
Oxygen saturation	98,4	1,3	96,3	1,2	<0,001

	Workers (N = 47) (Mean age 40,1 ± 8,6 years old)				
	Before		After		
	Mean	SD	Mean	SD	P value
Heart rate	79,4	12,5	90,5	13,8	<0,001
Systolic blood pressure	129,7	13,3	125,3	15,1	0,019
Diastolic blood pressure	83,4	9,4	81,6	9,6	0,079
Breathing frequency	16,1	1,7	17,3	2,1	0,003
Temperature	36,4	0,5	37,1	0,4	<0,001
Hemoglobin	13,7	1,4	14,3	1,4	< 0,001
Perfusion index	3,6	2,8	6,6	3,1	<0,001
Oxygen saturation	98	1,5	96,1	1,2	<0,001

Bad tolerance pattern according to the PI

Figure 1 shows the means of the baseline PI and PI after the test in the study groups. The absolute increases of the mean PI were found to be significant in all the study groups (table 6), being undergraduate Nursing 3.3 (95% CI 1.1, 5.5), undergraduate in Medicine 3.8 (95% CI 2.7, 4.9), in nurses 3.8 (95% CI 2.2, 5.4) and 2.1 physicians (95% CI 1.0, 3.1) .

Figure 1: Mean PP values by study groups, before and after the test

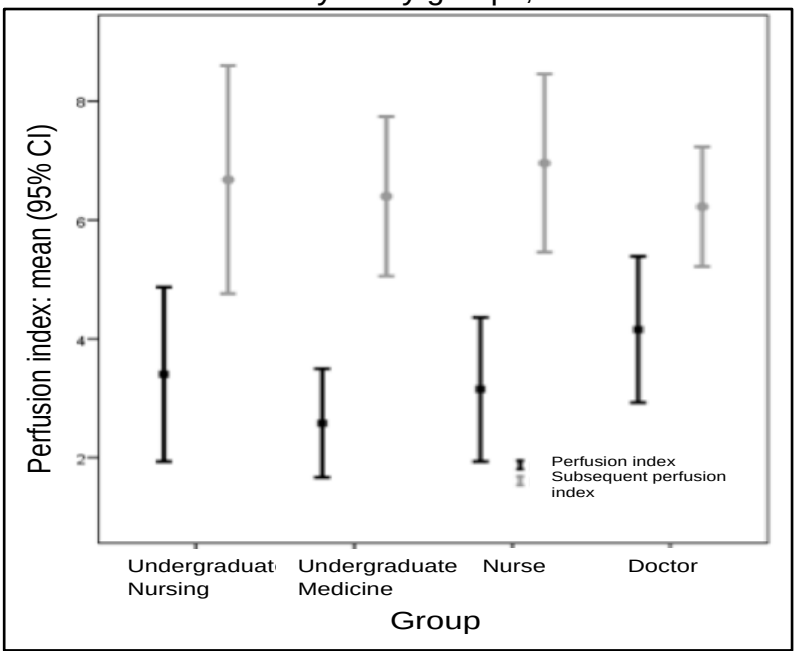


Table 6: Average variation of PI by study groups, before and after the test

Group	Perfusion index	Mean	SD	Average absolute effect	CI95%		P value
Undergraduate Nursing	Posterior	6,7	4,5	3,3	1,1	5,5	0,006
	Basal	3,4	3,5				
Undergraduate Medicine	Posterior	6,4	3,3	3,8	2,7	4,9	0,000
	Basal	2,6	2,2				
Nurse	Posterior	7,0	3,6	3,8	2,2	5,4	0,000

	Basal	3,1	2,9				
Doctor	Posterior	6,2	2,3	2,1	1,0	3,1	0,000
	Basal	4,2	2,8				

In order to evaluate the variables associated with the PI, both baseline and posterior, and their variation were correlated with the variables studied (tables 7 and 8).

The posterior PI correlated with size (r = 0.21, p = 0.04), with the neck perimeter (r = 0.24, p = 0.02), with muscle mass (r = 0, 24; p = 0.02), with the bone mass (r = 0.24, p = 0.02) and with the ideal weight (r = 0.21, p = 0.04).

The resting heart rate correlated inversely with the posterior PI (r = -0.26, p = 0.01) and its variation (r = -0.23, p = 0.01), as well as the frequency heart rate (r = -0.26; p = 0.01) and oxygen saturation (r = -0.27, p = 0.01).

Table 7: Correlations of the quantitative anthropometric parameters with PI, before and after the test, as well as its absolute variation

		Perfusion index	**Subsequent perfusion index**	**Perfusion index variation**
Size	r	0,20	0,21*	0,04
	p	0,05	0,04	0,68
Neck perimeter	r	0,25*	0,24*	0,03
	p	0,01	0,02	0,77
Weight	r	0,17	0,16	0,02
	p	0,09	0,12	0,87
Body fat	r	-0,15	-0,14	-0,01
	p	0,15	0,18	0,91
Muscle mass	r	0,24*	0,24*	0,04
	p	0,02	0,02	0,70
Bone mass	r	0,25*	0,24*	0,03
	p	0,02	0,02	0,74
BMI	r	0,12	0,09	-0,01
	p	0,25	0,39	0,93

*p<0,05 ** p<0,01

Table 8. Correlations of the quantitative physiological parameters with the PI, before and after the test, as well as its absolute variation

		Perfusion index	**Subsequent perfusion index**	**Perfusion index variation**
	p	0,89	0,01	0,02
Heart rate	r	0,01	-0,26*	-0,25*
Systolic blood pressure	p	0,91	0,01	0,02
Diastolic blood pressure	r	0,04	0,17	0,12
Breathing frequency	p	0,68	0,10	0,23

Temperature	r	-0,11	-0,13	-0,04
Hemoglobin	p	0,30	0,21	0,71
Perfusion index	r	0,11	-0,05	-0,13
	p	0,30	0,60	0,19
Heart rate	r	-0,16	0,00	0,12
Systolic blood pressure	p	0,11	0,99	0,23
Diastolic blood pressure	r	0,37**	,215*	-0,08
Breathing frequency	p	0,01	0,04	0,41
Temperature	r	-0,53**	-0,27**	0,16
	p	0,00	0,01	0,12

*p<0,05 ** p<0,01

A linear regression model was adjusted to explain the variables associated with the subsequent PI adjusted by the baseline PI data. The variables correlated with the posterior PI were included in the model, as well as those that were confused by the different distribution in the study groups.

No differences were found between groups or in subgroups.

DISCUSSION

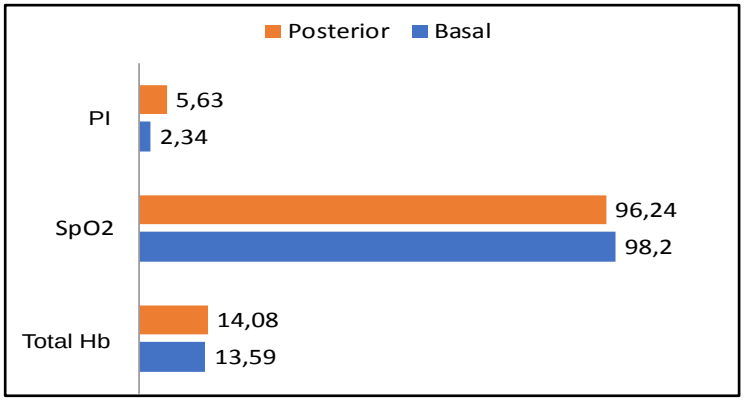
PI is an indirect, non-invasive and continuous measure that provides very useful information in different clinical contexts. This parameter refers to the relationship between pulsatile and non-pulsatile blood flow in peripheral tissues, so that a high PI means vasodilatation, and a low PI, vasoconstriction. The measurement of the PI is independent of other physiological variables such as FC, SpO2, oxygen consumption or temperature, a fact that makes the study of this parameter even more relevant.

The range of clinical situations in which PI has demonstrated its usefulness includes the monitoring of the effectiveness of epidural anesthesia, since an increase in PI after anesthesia administration indicates an increase in peripheral vasodilation, which normally occurs before the appearance of the anesthetic effect [(15)]. In critically ill neonates, it is contrasted that a low PI is an objective and precise measure of acute disease [(16)]. Similarly, this parameter is being used to estimate volume administration in patients with severe trauma, in states of sepsis [(17-19)], or in reimplantation surgeries and after cardiopulmonary bypass, for evaluation of peripheral perfusion.

There are not enough studies to support the use of PI in healthy people, but all the literature consulted [(20-22)] concludes that a high PI causes vasodilation and good perfusion, and a low PI causes vasoconstriction and poor perfusion. Extrapolating these data, we can conclude that, in the sample of study that occupies us, the volunteers who present less PI at the end than at the beginning do not tolerate well the effort that supposes the clinical case; In addition, a common pattern has been found in the behavior of total hemoglobin and oxygen saturation.

15% (14 of 96) of the volunteers presented a lower posterior PI than the previous one, which translates into a situation of peripheral vasoconstriction after the physical exercise that supposed the clinical case, when it was expected a vasodilation to increase perfusion (figure 2).

Figure 2: Pattern of behavior of PI, SpO2 and total Hb, baseline and final determinations



An expected effect of the increase in energy demands required as a consequence of physical exercise is the availability of all the available hemoglobin. The normal pattern indicates that, at the end of the clinical case, volunteers must present more total hemoglobin than at the beginning, a fact that matches the increase in PI and the slight decrease in oxygen saturation. Therefore, concluding the test with less total hemoglobin at the end than basal can indicate poor tolerance to exercise. 31.25% of the subjects (30 of 96) presented a poor physiological tolerance with respect to the inadequate use of hemoglobin.

Therefore, if we observe a posterior PI less than previous and less final hemoglobin than initial (data that is accompanied by more final than initial saturation) we can conclude that it is a totally inadequate pattern, that is, these subjects do not tolerate this type of simulation proposal (8 of 96).

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