

Effect of High-Altitude on Motorcycle Riders

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Abstract

*Observational study characterized by analyzing data prospectively collected and developed by a researcher at the Institute of Cardiology Aloysio de Castro-RJ. Prospective observational analysis of a group of five motorcycle riders (*HD/84-13.3) exposed to a maximum altitude of 4133m returning in 14 hours to sea level. Starting off with concepts in the literature about the effects of Altitude on the organism, and taking into consideration that there are changes in cardiorespiratory physiology that can generate clinical symptoms, the identification of those changes and the correlation with the analysis of body temperature, oxygen saturation, respiratory rate, heart rate and blood pressure analyzed every 1000 meters in the moments of ascent and descent can together add clinical evidence to the studies already carried out and favor prevention and acclimatization procedures.*

Keywords: High Altitude, Altitude illness, Coronary Artery Disease, Obesity.

INTRODUCTION

The exposure of individuals to places with high altitude can individually initiate the risk of a variety of physiological changes and their complications related to low oxygen concentration, resulting in some changes in the vital signs leading to symptoms known as Altitude illness.

These signs and symptoms are described in individuals who make fast ascents above 2500 meters in periods of three to four days, reaching up to 5000 meters with a prevalence of up to 15% of severe symptoms, such as acute noncardiogenic pulmonary edema and symptomatic cerebral edema [ref], these complications are rarely reported at altitudes of 2500m[1].

Luks and Swenson. (2007), reported significant clinical changes in direct ascents to altitudes of 1400 meters, however, it is known that the highest prevalence is at much higher altitudes, depending on the speed of ascent and the length of stay that can be considered only as acclimatization, time in which it is proposed to remain at an altitude allowing the compensations in the organic reactions to adapt the organism progress

during higher points like altitudes above 2500 meters. Starting at 2000 meters, initial symptoms have been reported, for example: headache, nausea and asthenia with a consequent increase in heart and respiratory rate, especially when reaching the mark of 3000 meters. In some studies with altitudes above 4500m, the changes were very evident in the pulmonary dynamics with a significant reduction of gases to the arterial level indirectly demonstrated by oximetric saturation presenting variations of 78 +/- 7%. [2]

Given the fact that fast ascents are the main risk factor for the development of symptoms, we can consider that the only important step for the prevention of symptoms consists in proceeding with slow ascents to the intended elevation. The effects of daily changes at the intended altitude may vary slightly from one individual to the other, however, the general recommendation is that once you make ascents above 2500m, your ascent to night rest should increase only 300 to 600m per day. The Alpinists also include a day of rest where they sleep at the same altitude so that on a second night, they can try to gain up to 1000m in elevation or continue without any excess in the basic

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change of level at the intended altitude. [3]

In the present observational study, there was a fast ascent to reach 4131m followed by a brief descent to level zero, or sea level, with stops having to be taken every 1000m on the ascent and descent, which took an average duration of 25 minutes each to go through clinical examination, vital signs checklist and the transcription of collected data.

METHODOLOGY

Observational analysis carried out in September 2014, analyzing every 1000 meters of ascent until reaching 4131m in the city of JUJUY in the Chilean Andes, as well as every 1000 meters on the descent to level zero (considered sea level), the clinical symptoms that might appear with the already known rarefied air (Altitude Illness) and the variations in axillary temperature, heart rate, respiratory rate, blood pressure and pulse oximetry collected from five volunteer motorcycle riders.

Due to the reduced number of evaluated volunteers, the literature findings were considered in order to consolidate the results in the performed collection methodology considering that the volunteers had to interrupt their ascents and descents every 1000 meters for the proper evaluations.

The five volunteers were evaluated, and each stage of the analysis called Moment was represented by the letter M, with the climb up to 4000 meters, 5 moments. M1 before departure at sea level, M2 at 1000 meters, M3 at 2000m, M4 at 3000m, reaching the highest Moment M5 at 4000m.

The moments related to the descent have the same description: M6, M7, M8 and M9 being the stop point at sea level with total interruption of the route.

In the present observational study, there was a fast ascent to reach 4131m followed by a brief descent to level zero, or sea level, with stops having to be taken every 1000m on the ascent and descent, which took an average duration of 25 minutes each to go through clinical examination, vital signs checklist and the transcription of collected data.

The axillary temperature was measured at all the Moments with the G-TECH Water Proof digital

thermometer for 6 to 12 seconds; oximetry was measured by the UT-10 device with precision of 2% for heart rate between 30 and 250bpm, and 2% for oxygen saturation between 70% and 100%, the blood pressure was directly measured by the researcher with a Tyco device model Durashock DS44, the stethoscope used was the Master Lytman Cardiology.

The evaluation of clinical symptoms was collected on an individual form with objective questions individually answered.

The descriptive analysis presented the observed data in tables, expressed by the measures of central tendency and dispersion suitable for numerical data and by the frequency and percentage for categorical data.

The longitudinal analysis of the parameters was evaluated by the analysis of variance (ANOVA) for repeated measures and by the multiple comparison test of Sidak adjusted for five moments.

The normality of data distribution was assessed by the Shapiro-Wilk test and graphical analysis of the histograms. The criterion for determining significance was of 5%. The statistical analysis was processed using the SPSS software version 26.

The study was approved by the IECAC-RJ ethics research committee. Participants have signed an informed consent form and were followed up for 6 months after the tour.

The equipment used in the evaluations and graphic materials were acquired by the author and kept with him.

RESULTS

General sample profile

Table 1 presents the general profile of the motorcyclists who were evaluated on the route, all of them were strictly followed and it provides a description of the clinical variables in the full sample. The data were expressed by the Average, Standard Deviation, minimum and maximum for numerical data and by the frequency (n) and percentage (%) for categorical data.

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Table1. General Sample Profile

Variable		
Weight (Kg)		
Average ± SD (min-max)	92,6 ± 10,7 (83-100)	
Age (Years)		
Average ± SD (min-max)	51,0 ± 6,2 (44-59)	
SAH n (%)	N	%
Yes	3	60
No	2	40
DM n (%)		
Yes	0	0
No	5	100
CODP n (%)		
Yes	0	0
No	5	5
Smoking n (%)		
Yes	2	40
No	3	60
Medication n (%)		
Yes	4	80
No	1	20
Sedentary n (%)		
Yes	2	40
No	3	60

Due to the very small number of individuals evaluated, it was proposed to analyze the evolution of the parameters in two stages of 5 moments: the first corresponding to the ascent from sea level to the intended elevation and the second corresponding to the descent (from the intended elevation to sea level).

Tables 2.1 and 2.2 provide the Average ± Standard Deviation of the temperature parameters, SBP, DBP,

HR, Oxim and RR in the five moments of ascent (0m, 1000m, 2000m, 3000, and 4000m) and descent (4000m,3000m,2000m,1000m and 0m), respectively, and the corresponding descriptive level (p-value) of ANOVA for repeated values. The adjusted Sidak multiple comparison test was applied to identify which moments differed significantly from each other at the level of 5%.

Table2.1. Longitudinal analysis of ascent parameters

Variable	M5 average ± SD	M6 average ± SD	M7 average ± SD	M8 average ±SD	M9 average ± SD	p value	significant differences
Temperature	36,6 ± 0,5	36,0 ± 0,0	36,4 ± 0,5	36,2 ± 0,4	36,4 ± 0,5	0,43	
SBP	135,8 ± 21,6	124 ± 17,1	124 ± 18,5	120 ± 17	117,0 ± 14,8	0,008	M5 ≠ (M8 and M9)
DBP	83,6 ± 6,7	81 ± 5,5	79,4 ± 10,2	74 ± 7,4	74,6 ± 7,6	< 0,001	(M5 and M6) ≠ (M8 and M9)
HR	119,2 ± 14,4	96,4 ± 11,0	88,4 ± 11,5	83,4 ± 10,3	80,8 ± 12,4	0,001	M5 ≠ (M7 and M8 and M9)
Oxim	81,2 ± 5,0	89,2 ± 1,9	96,2 ± 0,8	96,8 ± 0,8	96,8 ± 0,8	< 0,001	(M5 and M6) ≠ (M7 and M8 and M9)
RR	27,0 ± 1,2	18,6 ± 1,1	14,8 ± 2,8	14,0 ± 1,6	14,8 ± 1,8	< 0,001	M5 ≠ (M6 and M7 and M8 and M9)

M1 0m, M2: 1000m, M3:2000m, M4: 3000m, M5: 4000m (top): data were collected by mean and standard deviation and compared by ANOVA for repeated measures.

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Table 2.2. Longitudinal analysis of descent parameters.

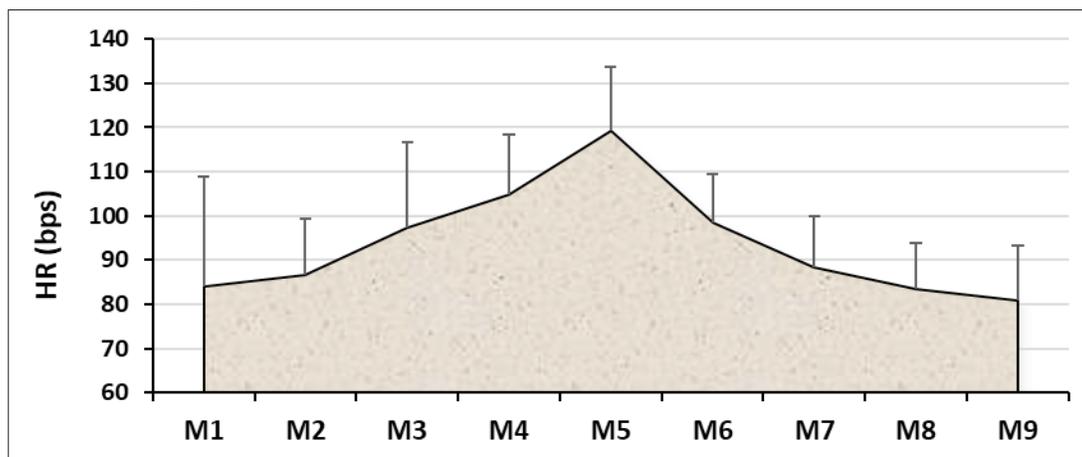
Variable	M1 average ± SD	M2 average ± SD	M3 average ± SD	M4 average ± SD	M5 average ± SD	p value	significant differences
Temperature	36,2 ± 0,4	36,4 ± 0,5	36,8 ± 0,4	36,4 ± 0,5	36,6 ± 0,5	0,48	
SBP	117 ± 6,7	116 ± 15,6	119 ± 20,7	128 ± 16,8	135,8 ± 21,6	0,008	M2 ≠ M5
DBP	82 ± 6,7	69 ± 5,5	73 ± 10,4	81,4 ± 3,1	83,6 ± 6,7	< 0,001	M2 ≠ (M1 and M4 and M5)
HR	84 ± 24,9	86,6 ± 12,7	97,2 ± 19,5	104,8 ± 13,5	119,2 ± 14,4	0,001	(M1 and M2) ≠ M5
Oxim	98,2 ± 0,4	96,8 ± 1,1	94,6 ± 1,5	89,2 ± 1,5	81,2 ± 5,0	< 0,001	(M1 and M2 and M3) x M5; (M1 and M4)
RR	19,6 ± 0,9	17,6 ± 1,1	15 ± 2,9	22,6 ± 1,9	27,0 ± 1,2	< 0,001	(M1 and M2 and M3) x M5; (M1 and M4)

M1 0m, M2: 1000m, M3:2000m, M4: 3000m, M5: 4000m (top): data were collected by mean and standard deviation and compared by ANOVA for repeated measures.

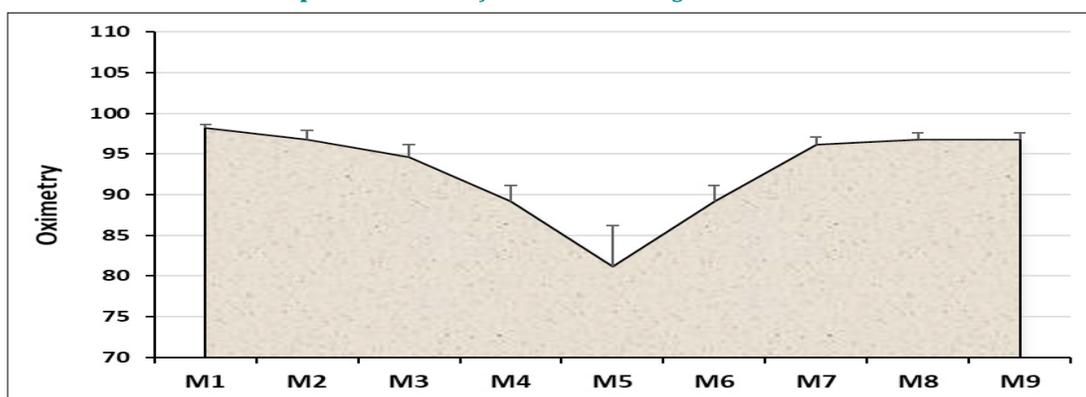
It was observed, according to ANOVA for repeated measures, that there is significant variation ($p < 0.05$) in all the parameters of ascents and descents, except for the temperature ($p = 0.48$ and $p = 0.43$) along the time. According to Sidak's multiple comparison test adjusted at the 5% level, a significant variation was identified between the pairs of moments highlighted

in the "Significant Differences" column.

Graphs 1, 2 and 3 illustrate the evolution of three out of the six clinical parameters evaluated on the ascents and descents, whose variations were expressed by the average plus a standard deviation according to the moment evaluated.

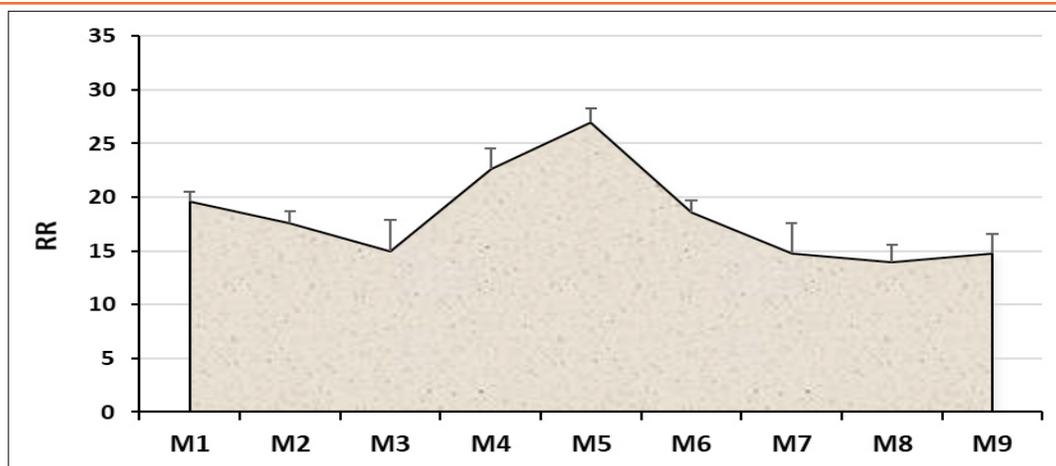


Graph 1. Elevation of heart rate during the Moments.



Graph 2. Drop in oximetry during the Moments.

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Graph3. Elevation of respiratory rate during the Moments.

Analysis of the manifestation of clinical symptoms verified at each Moment determined by the evaluation at the stops at the altitudes on the table; there we can see that at the level of 3000 meters, three motorcycle Riders felt at least one symptom due to reduced oxygen on the ascent, and at 4000 meters, all of them had

symptoms. Three of them reported two symptoms, one of them reported three symptoms and another one reported 4 symptoms due to the altitude. At the time of descent to 3000 meters, everyone reported at least one symptom and below that altitude they had no more symptoms.

Table2.3. Frequency of the number of symptoms at the Moments.

Number of Symptoms	ASCENT				4000m	DESCENT			
	0m	1000m	2000m	3000m		3000m	2000m	1000m	0m
none	5	5	5	2	0	0	5	5	5
1				2		5			
2				1	2				
3					2				
4					1				
5									

Symptoms: 1-Mild headache, 2-nausea, 3-palpitation with small efforts, 4-breathing difficulties and fleeting dizziness.

DISCUSSION

Despite the small sample in this clinical analysis of the effects of altitude on the organism with the evaluation of direct variables, such as oximetry, heart rate, respiratory rate, body temperature and blood pressure, it was proposed to analyze these effects in fast passage considering the Moments of data collection (M) every 1000 meters with a permanence time of never less than 30 minutes, each participant had their individuality preserved in the evaluations and this route was performed in 14 hours from level zero on the ascent to the level zero at the end of the descent.

It is significant to report that this route is widely used by motorcycle riders, and that the signs and symptoms collected in this sample might have caused them difficulties in driving these vehicles, which even

at low speed can weigh between 350 and 450 kilos, not considering the driver.

In this small group, the symptoms started on the ascent at approximately 3000 meters reaching more than half of the group mainly with headache, when reaching the moment M5, at 4000 meters, everyone started to suffer the effects of altitude. Three people started having breathing difficulty, one of them had nausea and the other one felt dizzy along the way, besides the nausea. On the descent, the symptoms were headache at 3000 meters and no clinical symptoms were reported until reaching 2000 meters.

Peter and Robert [1], in 2001, described in a review article that non-conditioned individuals can present 22% of the symptoms between 1850 and 2750 meters, 42% when they reach 3000m and 50% when they exceed 4000 meters. In general, the symptoms

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appear from 6 to 10 hours, but in some cases, they appear before 60 minutes and headache is the most frequent symptom.

In our group, the age ranged from 44 to 59 years old. The youngest had undergone CABG (Coronary Artery Bypass Graft) 4 years ago, was overweight and had been using acetylsalicylic acid and atorvastatin. The oldest was also overweight and he was hypertensive. Two others were obese and hypertensive, and one of them was just obese. Those who were overweight practiced regular aerobic exercises, however, all patients with arterial hypertension continuously used ARBs (renin-angiotensin receptor blockers) and their blood pressure levels were controlled by their doctors. In this group, two people were smokers and both of them were obese.

When analyzing the youngest in the group who was submitted to CABG 4 years ago, we found out that his symptoms at 4000 meters were headache and breathing difficulties, with fast improvement on the descent. When we compare the little that exists in literature, we can find that Schmidt et al. 2006, analyzed seven patients who were revascularized and made their ascents of 3454 meters, but the level of evidence of risk was very low (I-C), not considering symptomatic revascularized patients before 6 months or who suffered complications [4,5,6].

In our evaluation, we found out that both systolic and diastolic blood pressure had slight but statistically significant variations both on the ascent and descent, which can be analyzed in tables 2.1 and 2.2. We must consider that all hypertensive patients were using ARBs and all of them were obese. Keyes et al. found out that 60 hypertensive patients who had their levels checked at 2860, 3400 and 4300 meters did not show significant variations. These were around 15% at 4300 meters where our observation is related [6]. The HighCare Andes study demonstrated in patients who left sea level to an altitude of 3259 meters that night periods were followed by elevated blood pressure levels. And the HighCare Himalaya study found out that healthy individuals when subjected to altitudes above 5540 meters have elevated both systolic and diastolic hypertension. [7]

Yang B et al [8]. comparatively studied 120 obese patients with a control group exposed to 3658 meters every 12 and 24 hours, verifying not only the higher prevalence of clinical symptoms but also a drop in

arterial saturation by direct evaluation. In another study, a group of obese patients were compared with a control group exposed to a simulation equivalent to more than 3500 meters and it was found that the prevalent symptom was 89% headache, associated with oximetry levels around 75%, well below the control group.

The three obese in the group were those who had the highest level of desaturation on the oximeter, heart rate and respiratory rate and a greater number of symptoms related to low oxygen rates that were well evident at 4000 meters. Two of them were smokers, but we could not identify due to the small sample if it were a factor that worsened the development of symptoms or not. In 2016, Vinnikov D et al. [9] carried out a systematic review where 29 studies might be eligible to assess the impact of smoking on symptoms of altitude and concluded that there is not enough statistical evidence to associate smoking as a factor of precipitation or worsening of symptoms prevalent at altitudes.

Sanches et al. (2007), published an article evaluating 302 individuals whom submitted to altitudes above 2500 meters, divided into smokers, nonsmokers and ex-smokers, he concluded that smokers in conditions of lack of acclimatization presented a reduced risk to develop Altitude Illness, however, he highlights that this does not indicate that these individuals can adventure themselves into altitudes due to the greater potential for chronic complications of smoking on the lungs [10].

In our group, both smokers were also obese and had, as previously described, a greater number of symptoms and saturations below the other participants, mainly above 3000 meters.

CONCLUSION

Despite the small sample, we have not found in the medical literature any evaluation with follow-up of this sport (motorcycle) performed in the transposition of altitudes in mountain ranges for decades; It is worth mentioning that obesity compared to other risk factors was the one that showed, as well as in the literature, the greatest worsening of symptoms and clinical signs during the low oxygenation at altitudes.

ACKNOWLEDGMENT

*For the voluntary participation of motorcycle riders (84-13.3) based in Rio de Janeiro; Brazil.

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Citation: Gerez Fernandes Martins, Italo Cesar de Sousa Ribamar. *Effect of High-Altitude on Motorcycle Riders. Archives of Cardiology and Cardiovascular Diseases. 2021; 4(2): 01-07. DOI: <https://doi.org/10.22259/2638-4744.0402001>*

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