

## PHYSIOLOGY OF BLOOD PRESSURE REGULATION

# Effect of Altitude on Blood Pressure

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## ABSTRACT

The effect of higher altitude over the blood pressure (BP) is not exactly known, and it appears to vary both between and within individuals. The effects of lower temperature, light, increased physical stress, and duration of living at higher altitude also play a significant role. Most of the studies showed that higher altitude correlated with rising BP. This change in BP is due to many factors, the important one being the effect of hypoxia causing activation of sympathetic nervous system. Activation of sympathetic nervous system causes an increase in cardiac output, heart rate, and peripheral vasoconstriction, which lead to increase in BP. The incidence of BP in high latitudes is controversial; some research shows greater rates while others show lesser rates of hypertension in these individuals. It may be due to the effects of multiple other confounding factors like genetic, ecological, and lifestyle variables. Hence, increasing popularity of high-altitude travel needs further research to evaluate this problem. Furthermore, the implications of altitude-induced hypertension for cardiovascular risk and end-organ damage require more clarification.

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## INTRODUCTION

Studies evaluating the effects of high altitude on arterial BP are not enough. There is a contradiction about the effect of higher altitude on arterial BP. The results of various research generally support the positive relationship between arterial BP and higher altitude.<sup>1-5</sup> Individual predisposition is very important, as the effect of higher altitude appears to vary both between and within individuals.<sup>6</sup> Even there are differences in susceptibility among races.<sup>2</sup> Duration of living at higher altitude also plays a significant role. Persons who have acclimatized over weeks show less effect of higher altitude on BP. Studies have shown that altitude-induced BP elevations can persist for months.<sup>1</sup> The effects of lower temperature,

light, and increased physical stress also play an important role in survival in more difficult environments.

Most of the studies showed that higher altitude correlated with rising BP.<sup>2,5</sup> Susceptible individuals undergoing short-term ascents above 2,500 m showed an acute effect on BP. This change in BP is due to many factors, the important one being the effect of hypoxia causing activation of sympathetic nervous system. Activation of sympathetic nervous system causes increase in cardiac output, heart rate, and peripheral vasoconstriction. These facts have many implications for patients suffering from disease conditions that can lead to hypoxia. Hence, appropriate measures should be taken in these patients whenever they are going to higher altitudes. Some studies demonstrate an increase in BPs,<sup>7-9</sup> and others describe a decrease in BP<sup>10</sup> in nonhypertensive individuals acutely exposed to hypoxia, while some other studies report no change in BP.<sup>11,12</sup> Similarly, in the hypertensive patient, various studies report elevations in BP upon acute exposure to higher altitudes,<sup>13-16</sup> yet others report no significant change.<sup>9,11,17</sup>

A recent study demonstrated that among residents of Tibet, there is a significant correlation between the higher altitude and incidence of raised BP. It was found that prevalence of hypertension increased by 2% for every 100 m increase in altitude.<sup>18</sup> In another study, Italian researchers found that during ascend at higher altitude BP steadily increases. They also found that medicines are not very effective for treatment of high BP once a certain height is reached. Forty-seven individuals traveled to the base camp of Mount Everest at an altitude of approximately 5400 m. All participants checked BP round-the-clock during their ascent. The volunteers were also randomized to take either a placebo or 80 mg of telmisartan. Telmisartan is an angiotensin receptor blocker. Angiotensin receptor blocker blocks angiotensin II, which causes constriction of blood vessels. The study also showed that at an altitude of 5400 m an increase in BP by 14/10 mm Hg is caused.<sup>19</sup> This study also showed that although telmisartan significantly reduced BP up to 3400 m but no effect was seen at 5400 m.<sup>19</sup> The findings impact on people who ascend at high altitude and also in those living at sea level.

Some people may also be prone to consistent elevations in BP while living at high altitudes. On the contrary, in the higher land, the prevalence of hypertension is more mixed.<sup>4,5</sup> Some research show greater rates while others show lesser rates of hypertension in these individuals. It

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may be due to the effects of multiple other confounding factors like genetic, ecological, and lifestyle variables. The literature to support the occurrence of hypertension at altitude is variable. At higher altitude, the prevalence of severe hypertension is not exactly known. The exact incidence and severity of the hypertensive response to high altitude are still not precisely evaluated.<sup>20-22</sup> Furthermore, the implications of altitude-induced hypertension for cardiovascular risk and end-organ damage require more clarification. Health care workers should be aware of these relationships. Hypertension guidelines<sup>23,24</sup> should be addressing the importance of the higher altitude on BP during hypertension treatment. To ascend to a higher altitude, BP monitoring is necessary for each individual.

Hence, increasing popularity of high altitude travel and high prevalence of hypertension need further research to evaluate this problem. Research should focus on identifying various factors for increase in BP at high altitude and also see whether hypoxia at sea level can predict the altitude hypertensive response in an individual. Persistence of altitude-induced high BP on return to sea level should also be evaluated. It should imply for future hypertensive risk at sea level. Finally, clinical trials needed to determine the most appropriate treatment for BP elevations in this type of situation. The effects of altitude, acclimatization, exposure durations, and patient susceptibilities require more investigation.

## REFERENCES

1. Sizlan A, Ogur R, Ozer M, Irmak MK. Blood pressure changes in young male subjects exposed to a median altitude. *Clin Auton Res* 2008 Apr;18(2):84-89.
2. Handler J. Altitude-related hypertension. *J Clin Hypertens (Greenwich)* 2009 Mar;11(3):161-165.
3. Luks AM. Should travelers with hypertension adjust their medications when traveling to high altitude? *High Alt Med Biol* 2009 Spring;10(1):11-15.
4. Faeh D, Gutzwiller F, Bopp M; Swiss National Cohort Study Group. Lower mortality from coronary heart disease and stroke at higher altitudes in Switzerland. *Circulation* 2009 Aug;120(6):495-501.
5. Rimoldi SF, Sartori C, Seiler C, Delacrétaiz E, Mattle HP, Scherrer U, Allemann Y. High-altitude exposure in patients with cardiovascular disease: risk assessment and practical recommendations. *Prog Cardiovasc Dis* 2010 May-Jun;52(6):512-524.
6. Hasler E, Suter PM, Vetter W. Race specific altitude effects on blood pressure. *J Hum Hypertens* 1997 Jul;11(7):435-438.
7. Hannon JP, Sudman DM. Basal metabolic and cardiovascular function of women during altitude acclimatization. *J Appl Physiol* 1973 Apr;34(4):471-477.
8. Malhotra MS, Selvamurthy W, Purkayastha SS, Mukherjee AK, Mathew L, Dua GL. Responses of the autonomic nervous system during acclimatization to high altitude in man. *Aviat Space Environ Med* 1976 Oct;47(10):1076-1079.
9. Palatini P, Businaro R, Berton G, Rossi GP, Zanin L, Bongiovi S, Casiglia E, Pessina AC, Dal Palù C. Changes in arterial pressure and adrenergic activity during a holiday at a mountain at low altitude. *G Ital Cardiol* 1989 May;19(5):456-461.
10. Levine BD, Zuckerman JH, deFilippi CR. Effect of high-altitude exposure in the elderly: the tenth mountain division study. *Circulation* 1997 Aug;96(4):1224-1232.
11. Somers VK, Mark AL, Abboud FM. Potentiation of sympathetic nerve responses to hypoxia in borderline hypertensive subjects. *Hypertension* 1988 Jun;11(6 Pt 2):608-612.
12. Vogel JA, Hansen JE, Harris CW. Cardiovascular responses in man during exhaustive work at sea level and high altitude. *J Appl Physiol* 1967 Oct;23(4):531-539.
13. Bartsch P, Gibbs JS. Effect of altitude on the heart and the lungs. *Circulation* 2007 Nov;116(19):2191-2202.
14. Parati G, Bilo G, Faini A, Bilo B, Revera M, Giuliano A, Lombardi C, Caldara G, Gregorini F, Styczkiewicz K, et al. Changes in 24 h ambulatory blood pressure and effects of angiotensin II receptor blockade during acute and prolonged high-altitude exposure: a randomized clinical trial. *Eur Heart J* 2014 Nov;35(44):3113-3122.
15. Savonitto S, Cardellino G, Doveri G, Pernpruner S, Bronzini R, Milloz N, Colombo MD, Sardina M, Nassi G, Marraccini P. Effects of acute exposure to altitude (3460 m) on blood pressure response to dynamic and isometric exercise in men with systemic hypertension. *Am J Cardiol* 1992 Dec;70(18):1493-1497.
16. Wu TY, Ding SQ, Liu JL, Yu MT, Jia JH, Chai ZC, Dai RC, Zhang SL, Li BY, Pan L, et al. Who should not go high: chronic disease and work at altitude during construction of the Qinghai-Tibet rail road. *High Alt Med Biol* 2007 Summer;8(2):88-107.
17. D'Este D, Mantovan R, Martino A, D'Este F, Artusi L, Allibardi P, Franceschi M, Zerio C, Pascotto P. The behavior of the arterial pressure at rest and under exertion in normotensive and hypertensive subjects exposed to acute hypoxia at a median altitude. *G Ital Cardiol* 1991 Jun;21(6):643-649.
18. Mingji C, Onakpoya IJ, Perera R, Ward AM, Heneghan CJ. Relationship between altitude and the prevalence of hypertension in Tibet: a systematic review. *Heart* 2015 Jul;101(13):1054-1060.
19. Preidt, R. Everest study finds high altitude affects BP. *Norwalk (CT): HealthDay New*; 2014. [cited 2014 Aug 27]. Available from: <https://www.webmd.com>.
20. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, et al. The seventh report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA* 2003 May;289(19):2560-2572.
21. West, BS.; Schoene, RB.; Luks, AM.; Milledge, JS. High altitude medicine and physiology. Boca Raton (FL): CRC Press, Taylor & Francis Group; 2013.
22. Hanna JM. Climate, altitude, and blood pressure. *Hum Biol* 1999 Aug;71(4):553-582.
23. Mancia G, Laurent S, Agabiti-Rosei E, Ambrosioni E, Burnier M, Caulfield MJ, Cifkova R, Clément D, Coca A, Dominiczak A, et al. Reappraisal of European guidelines on hypertension management: a European Society of Hypertension Take Force document. *J Hypertens* 2009 Nov;27(11):2121-2158.
24. Rhodes HL, Chesterman K, Chan CW, Collins P, Kewley E, Pattinson KT, Myers S, Imray CH, Wright AD; Birmingham Medical Research Expeditionary Society. Systemic blood pressure, arterial stiffness and pulse waveform analysis at altitude. *J R Army Med Corps* 2011 Mar;157(1):110-113.