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# Effects of high altitude and nutritional status over the physical fitness of young Nepalese residing in Pokhara, Kaski district of western Nepal

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## Abstract

Pokhara is situated over 5,577ft above sea level in The Kingdom of Nepal. Such high-hilly regions of Nepal contain only one-third as much oxygen as sea level air and in order to acclimatize to such environmental hypoxia, a series of metabolic and musculocardio-respiratory adaptations initiate that influence oxygen transport and utilization, which is necessary to achieve optimal physical performance at altitude. The health of people residing at such high altitude is determined not only by the environment but also by means of nutritional determinants. The present study was conducted to explicate the effect of high altitude environment with nutritional factors over physical fitness of young Nepalese of Pokhara. Twenty-five male young Nepalese were randomly selected from Pokhara, Nepal (mean age 21.6) and twenty-five sedentary college students of Kolkata, India (mean age 21.9) were taken as controls. Results showed a significant difference in BMI, body fat percentage, pre- and post-exercise BP, PFI, $VO_{2max}$, energy expenditure and anaerobic power ($P<0.05$). Young adults of Nepal are also found to be deficient in protein, calcium and iron in their diet, describing their poor nutritional status. Together these data entail that the physical fitness of young adults of Nepal is under the influence of environmental factors as well as their nutritional status.

**Keywords:** Anaerobic power, Body fat, Harvard Step Test, High altitude, Physical fitness, Nepal.

## Introduction

The Kingdom of Nepal is a landlocked country bordered by the Tibet, an Autonomous Region of the People's Republic of China in the north and of the Republic of India in all other directions. It is situated between the 26°22'N and 30°27'N latitudes and 80°4'E and 88°12'E longitudes. Its altitude varies from 80 meters above mean sea level in the southern Terai to 8,848 meters above mean sea level in the north at 28.25°N, 83.99°E.[1] Physiographically, Nepal is divided into five zones: high Himal zone, high mountain zone, middle mountains, Siwaliks and Terai.[2]

The peoples residing in the high-hilly regions of Nepal experience the climate's effect on their physical fitness and that refers the full range of physical qualities which can be understood as an integrated measurement of all functions and structures involved in the performance.[3] In adults, low cardiorespiratory fitness seems to be a stronger predictor of both cardiovascular and all-cause mortality than any other well established risk factors.[4] Extremely high-hilly regions of Nepal contain only one third as much oxygen as sea-level air which should have an impact over the health of people.[5] But reports about the overall physical fitness pattern with special reference

## Practice points

- Health of people residing at high altitude is shaped not only by the low-oxygen environment, but also by population ancestry, socio-cultural determinants as well as nutritional factors.
- Present study revealed that young Nepalese residing in mid-mountain regions are positively influenced by environmental and nutritional factors on their morphometric parameters and physiological fitness.
- A significant difference was found in BMI, body fat percentage, pre- and post-exercise BP, PFI, $VO_{2max}$, energy expenditure and anaerobic power ($p<0.05$).
- However, young adults of Nepal are found to be deficient in protein, calcium and iron in their diet, describing their poor nutritional status.
- Large-scale studies are required to examine the relationship of high altitude and nutritional status and their impact over the physical fitness of young Nepalese residing other districts of Nepal.

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to their respiratory and cardiac parameters are almost scanty. Thus, the aim of this investigation was to determine the influence of climate as well as nutritional status over the certain fitness parameters of young Nepalese and to check the hypothesis that geographical location and nutrition have an influence on the physical fitness of residents.

## Methods and Materials

Twenty-five male young Nepalese (age of 21.6±4.28) of Pokhara, Nepal (28º 10' N - 28º 16' N) between 18-25 years of age are selected randomly followed by purposive sampling to participate in the present study. Pokhara is situated in middle mountain regions of Kaski district of western Nepal, at an altitude of over 5,577ft above sea level (Table 1).[2] Twenty-five sedentary college students of Kolkata, India, belonging to the same age group were recruited as control for the study (age of 21.9±2.25). Subjects were instructed to take their last meal at least two hours before conducting the test in order to avoid the specific dynamic action (SDA) of food. All tests on young Nepalese were carried out in the respective colonies of Pokhara and the experiments with control subjects were carried out and measurements were taken in temperature of $20^0$-$25^0$C and relative humidity of about 45-50% in winter season in India. To minimize the experimenter bias each measurement was taken for three times and the mean was represented as the final result. Subjects had no history of any major disease and were not under any physical conditioning program and or medication. Each subject was given sufficient rest before each experiment to get an accurate result.

**Table 1:** Geographical location of Pokhara, Nepal

| Location | Latitude 28º 10' N - 28º 16' N Longitude 83º 58'30" E-80º02'30" E |
|---|---|
| Highest elevation | 1,700 m (5,577 ft) |
| Lowest elevation | 827 m (2,713 ft) |
| Average elevation | 941 m (above 3,087 ft.) |
| Total population (As per 2001census) | 156312 |
| An average family size | 6.1 |

Body mass index (BMI),[6] body fat percentage (BF%),[7] body surface area (BSA),[8] resting heart rate[9] and blood pressure,[10] physical fitness index (PFI),[11-12] Anaerobic Power by Margaria Double Step Test,[13] Aerobic Capacity ($VO_{2\ max}$),[14] Energy Expenditure[15] are measured along with nutritional anthropometric measurements[16] of the respondents.

Nutritional status of Nepalese was carried out by dietary survey following an interactive 24-Hour Recall method to gauge a typical day's actual intake. By questionnaire subjects were asked for the volume of food, preparation of food and time of consumption. From this data cooked and raw foods were separated and different nutrients according to their calorific value and other factors were determined.[17]

Data are expressed as mean±SD; comparison of parameters between control subjects and Nepalese was done by two tailed unpaired *t*-test, using Microsoft Excel- 2007 and the result was considered as significant when the two-tailed P value <0.05.[18]

## Results

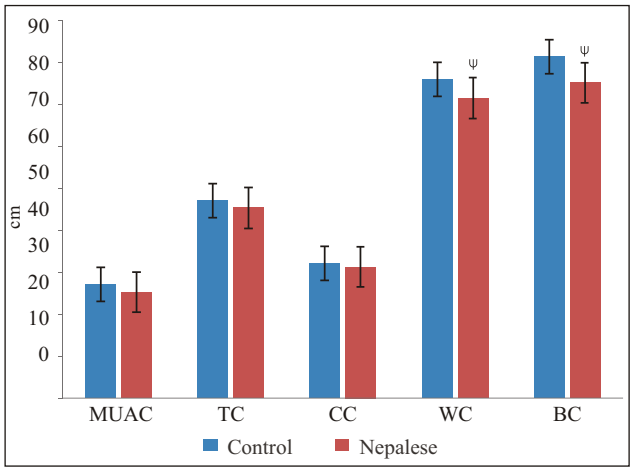
Among physical parameters shown in Table 2, body fat percentage is found to be significant between the two groups ($P<0.05$). Also in physical fitness variables, PFI scores reveal that the young Nepalese have an excellent physical fitness level. Resting heart rate and pre-exercise diastolic pressure also showed better endurance of young Nepalese than control subjects. Table 2 also represents the comparative aspect of anaerobic power, energy expenditure and predicted aerobic capacity ($VO_{2max}$). Nepalese showed a greater anaerobic power and $VO_{2max}$ but less expenditure of energy for a specific work than control subjects.

**Table 2:** Physical variables, anaerobic power, aerobic capacity and energy expenditure of the Nepalese and control group

| Variables | Control | Nepalese |
|---|---|---|
| Height (cm) | 164.6 ± 7.21 | 156.0 ± 8.31* |
| Body weight (kg) | 59.3 ± 7.50 | 54.3 ±12.00 |
| BMI ($Kg/m^2$) | 21.7 ±1.93 | 21.9±1.50 |
| Body Fat % | 20.5±1.73 | 17.7± 1.92* |
| BSA ($m^2$) | 1.68 ±0.08 | 1.53± 0.15$^{*}$ |
| Resting Heart Rate (Beats/min) | 76.2 ±8.10 | 72.6±6.00$^{\dagger}$ |
| Pre-exercise SBP (mm Hg ) | 123±4.62 | 126.0 ±6.83$^{\dagger}$ |
| Pre-exercise DBP (mm Hg) | 84.1±6.84 | 79.2 ±8.16$^{\dagger}$ |
| Post-exercise SBP (mm Hg) | 135.0±10.62$^{\S}$ | 132.3±6.16$^{\S\dagger}$ |
| Post-exercise DBP (mm Hg) | 82.2±7.92 | 77.4±11.1$^{\dagger}$ |
| PFI | 69.9±4.80 | 82.2 ±9.92$^{\dagger}$ |
| Anaerobic power ($kg.m^{-1}.sec^{-1}$) | 12.3±2.46 | 15.1 ±3.12$^{\#}$ |
| $VO_{2\ max}$ (liters.$min^{-1}$) | 3.12±0.33 | 3.24 ±0.42$^{\#}$ |
| Energy expenditure (K.Cal. $min^{-2}$) | 5.67±0.57 | 4.44 ±0.69$^{\#}$ |

Keys: SBP - Systolic Blood Pressure, DBP - Diastolic Blood Pressure. Values are mean± SD, sample size ($n_1=n_2=25$). Superscripts (*, #, §, †) indicate significant difference by two tail unpaired t-test (for equal variances) at $P<0.05$. $^{\S}$indicates significant differences within control group and within Nepalese group, $^{\dagger}$represents significant difference between control versus Nepalese.

**Figure 1:** Nutritional anthropometry of Nepalese and control group




MUAC: Mid-upper arm, HC: head, TC: mid-thigh, CC: calf muscle of the leg, WC: waist, BC: buttock; sample size ($n_1$=$n_2$= 25). Superscript ($^{\Psi}$) indicates significant difference by two tail unpaired t-test (for equal variances) at $P$<0.05

**Table 3:** Categories of food items consumed by the Nepalese

| Group | Food Items |
|---|---|
| Cereals | Rice, Chura (beaten rice), Bread |
| Legumes | Beans, Melon, Dal (Masur) |
| Vegetable | Vegetables (leafy and fruit), tomato, Aloo Tama (Potato Bamboo Shoots) |
| Fats and Oils | Butter, Ghee, vegetable oil |
| Fruits | Orange, Banana |
| Beverages | Tea, Coffee, Alcohol, Tongba (homemade wine), Rakshi (millet based distilled alcoholic drink), lassi |
| Meat | Beef, Pork, Chicken |
| Fish | Fish of all kinds |
| Other Animal Product | Milk, Eggs |

Figure 1 represents the anthropometric measures that reflect the nutritional status of both groups which may affect the fitness pattern. Among these WC and BC are found to be significant between two groups (P<0.05).

Table 3 represents common food items consumed by Nepalese as noted during the interactive questionnaire. Based on the data the nutritional assessment of Nepalese was done. It has been found that Nepalese diet is deficient in protein, but they consume more fat than their RDA recommends (Table 4). They also are deficient in iron and calcium in their diet. An interactive dietary survey also showed that the average monthly income of the families of subjects was about 4000 rupees which indicates the poor socio-economic condition of the subjects. The average family size was found to be 6.1, which also correlates to lower income.

## Discussion

The present study reveals young adults of Nepal was found to have less body fat percentage than the sedentary population. This may be due to study populations which are young adults and they may have a propensity for being leaner rather than obese.[19] It may also be due to their adaptive physiological changes for residing in such high altitude. Though BSA of the subjects of both groups is within normal range, but BSA of young Nepalese is found to be significantly less than control subjects which may be because of their ectomorphic stature, which is again attributable to the environmental conditions they live in. Among reliable and valid measures of cardio- respiratory fitness[20] and endurance,[21-22] resting heart rate and aerobic capacity ($VO_{2max}$), a lower resting heart rate and more $VO_{2max}$ was observed in Nepalese than the control subjects that signify the better endurance. Such physical differences may be due to their lifestyle in hilly areas which require extra energy expenditure for their daily activities resulting in some adaptive changes.[23] $VO_{2max}$ in high altitude is determined by many factors like barometric pressure, cardiac output of the subject, hemoglobin saturation with oxygen.[24]

**Table 4:** Assessment of nutritional status of the Nepalese

| Nutritional status and dietary Allowance[bc] | Energy[a] | Protein[b] | Fat[b] | Iron[c] | Calcium[c] | Dietary Vitamins | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Vitamin A[d] | Thiamin[c] | Riboflavin[c] | Niacin[c†] | Vitamin C[e] | Folic acid[e] |
| Nepalese | 2373.18 (±22.20) | 51.78 (±8.94) | 33.45 (±9.75) | 12.20 (±4.80) | 204.21 (±21.30) | 2415.09 (±144.3) | 1.2 (±0.20) | 1.4 (±0.24) | 18.81 (±2.41) | 40 (±10.2) | 87.74 (±13.6) |
| Recommended Dietary Allowance[bc] | 2875 | 56 | 20 | 8 | 1000 | 3000 | 1.2 | 1.3 | 16 | 90 | 400 |

Keys: Data are represented in mean (±SD); [a]Kcal/day; [b]g/day; [c]mg/day; [d]International Unit (IU); [e]µg/day; [†]as niacin equivalents; 1 mg of niacin=60 mg of tryptophan.

Strength demanding activities increase ventricular muscle mass[23,25,26] resulting in increased force of contraction and hence cardiac output which may be the cause significant increase of resting or pre-exercise blood pressure[19]. But, during exercise stretching of muscle causes vasoconstriction which resulted in restriction of blood flow and in turn increased systolic pressure[27] and pooling of blood in many parts of the body causes vasoconstriction in muscles and thus increased the diastolic pressure. But, in the present study, systolic pressure showed an increase after exercise, but the diastolic pressure showed a decrease in both cases. Control subjects showed more increase in systolic blood pressure after exercises which than Nepalese. This may be an indicator of better cardio-respiratory condition of Nepalese. Brouha *et al.*[11] suggested that for a specific workload, better the physical condition of the individual, more rapid will be the return of heart rate to its pre-exercise level and consequently lower recovery cardiac cost. Similar results were found in Nepalese where the return of the heart rate to its resting level was more rapid than that of control subjects. Moreover, the peak heart rate is lesser in comparison to Control subjects indicating their better physical condition. Their pulse rate recovered quickly which an indicator of better fitness which is reflected in significantly higher PFI and lower energy expenditure and they also have better anaerobic power than sedentary workers. These data suggest Nepalese have a better Cardio-respiratory fitness.

According to their life-style in high altitude young Nepalese perform work related to strength more than control sedentary subjects, so they should have more upper arm circumference which are an estimate of energy storage and protein mass of the body which is an indirect estimate of strength,[28-31] but no significant difference was observed in upper arm circumference between the two groups.

The present paper also reports nutritional status of twenty-five sex-matched young adults of Nepal as found in dietary survey. It has been found that young Nepalese are lack in energy intake, and, in the physiological parameters they are found to expend less energy for a particular work than control subjects. These data supports their BMI values which are found to be insignificant while comparing with their control counterparts. They also lack sufficient protein in their diet, but, more fat consumption was observed in interactive 24-hour recall method. They also deficient in iron and calcium in diet Though, it has been reported previously that people of Nepal are aware of the necessity of micronutrients, as shown by the fact that even in 2004 it is customary in many districts of Nepal for people to drink fresh yak blood about twice a year. The vein of the animal is lanced and people collect the fresh blood in their mugs and drink the fluid immediately. The belief is that as the yak grazes on Himalayan herbs, it has a lot of essential nutrients, which are beneficial also to humans. They also believe that drinking of *rakshi* or alcohol immediately, helps to get benefit from this intake of fresh blood. Dietary iron consumption was found to be sufficient in Nepalese, in the present study, though, it was reported that nutritional anemia is very prevalent public health problem in Nepal. A large percentage of preschool children, pregnant and non-pregnant women were found to be anemic. The prevalence of anemia among the community adolescents was 46%: the prevalence of mild anemia was 38%, moderate 8% and severe 0.4%.[32] This study also indicates less Vitamin A intake of young Nepalese, which may be due to a relatively high fat intake and very low consumption of fruits and vitamin A rich vegetables. It has been reported that 5% of women and 1% of preschool children of Nepal suffers from night blindness. The National Vitamin A Program (NVAP) covers currently 42 districts. The recommendation is that the bi-annual Vitamin A capsule supplementation should be continued and expanded to cover all the 75 districts of the country.[33] Vitamin C, which is beneficial for endurance and better physical performance, was also found to be inadequate in diet of young Nepalese. Conversely, dietary intake of Vitamin $B_1$ (thiamin), Vitamin $B_2$ (riboflavin) and niacin in Nepalese were found to be sufficient which may be correlated to their excellent physical fitness level, because these vitamins play a major role in maintaining muscular strength and endurance.[34,35]

## Conclusion

The health of young people residing at such high altitude of Nepal is determined not only by the environment but also by means of nutritional determinants. Present study reveals young Nepalese residing in mid-mountain regions of Pokhara are positively influenced by environmental and nutritional factors on their morphometric parameters and physiological fitness. However, large-scale studies are required to examine the relationship of high altitude and nutritional status and their impact over the physical fitness of young Nepalese residing other districts of Nepal.

## Conflict of interest

There is no conflict of interest about the publication of this article.

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