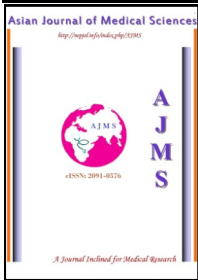


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Assessment of Physical Fitness Status of Young Sikkimese Residing in High-Hill Temperate Regions of Eastern Sikkim under the Influence of Climate and Socio-Cultural Factors

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Abstract

Objective: The least populated state of India, Sikkim is situated over 6,000 ft as of the sea level. The health of people residing at high altitude is shaped not only by the low-oxygen environment, but also by population ancestry and socio-cultural determinants. These factors may also have an influence over their physical fitness level. Thus the present survey work was designed in order to assess the influence of high altitude on physical fitness and anaerobic power.

Material & Methods: The study was conducted in randomly selected young adult male residents of Gangtok, Sikkim (mean age 22.0) and the college students of Kolkata (mean age 21.9) served as controls. Some parameters of physical fitness and endurance were measured using resting heart rate, blood pressure, PFI, energy expenditure, VO_{2max} etc.

Results: A significant difference ($p < 0.05$) in blood pressure, PFI, energy expenditure, BF% and anaerobic power were found in Sikkimese.

Conclusion: This study implies health of young Sikkimese is not only under the influence of low-oxygen environment but also by their socio-cultural factors over their physical parameters.

Key Words: Physical fitness; Step Test; Body Mass Index; body fat; blood pressure; Sikkim

1. Introduction

Sikkim, "the land of orchids" is situated in the Eastern Himalayas from longitude 88 degree 03'40" to 88 degree 57'19" East and from latitude 27 degree 03'47" to 28 degree 07'34" North, became the twenty second state of India on April 26, 1975, spread below the Mount Kanchenjunga (8,598 m), the third highest mountain in the world and revered by the Sikkimese as their protective Deity, this tiny state (total area of 7,096 sq.km, 114 km from north to south and 64 km from east to west), bigger only than Goa and Delhi, lies tucked in between Nepal and Bhutan in India's eastern region.¹

Sikkim is picturesque and verdant with clean crisp air, deep blue mountain lakes and hillsides ablaze with rhododendrons against a backdrop of snow-clad

mountains. The capital of the state, Gangtok is a town situated in eastern Sikkim, has the height of 1870 meters above sea level. The entire state is mountainous, with altitudes ranging from 300 to 8,586 meters. The climate of the state varies from cold temperate and alpine in the northeast to subtropical in the south. Agro climatically, the state is divided into four zones, viz., the subtropical zone (below 1,000 meters); the humid zone (1,000-1,600 meters); the mid-hill dry zone (again at altitudes ranging from 1,000-1,600 meters); and high hill temperate zone (with an altitude of above 1,600 meters).²

The peoples residing in high-hilly regions of Sikkim supposed to be affected by the climate over their physical fitness which not only refers cardiorespiratory fitness and muscular strength, but also in 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 physical fitness (mainly cardiorespiratory fitness) seems to be a

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stronger predictor of both cardiovascular and all-cause mortality than any other well established risk factors.⁴ High-hilly regions of Sikkim contain almost 50% oxygen in the air that of sea level which should have an impact over the health of people. But not only the climate but also the socio-cultural factors are the major determinants of their physical fitness. Among household members (of age 15 and above) 20% of men and 8% of women smoke, 32% of men and 17% of women drink alcohol and 40% of men and 19% of women chew tobacco.⁵ Several reports suggest Sikkimese suffer mainly from tuberculosis (1002:100000 populations), reproductive health problems and several child health problems. Anemia is also found to be prevalent among women and children. But reports about the overall physical fitness pattern with special reference to their respiratory and cardiac parameters are almost scanty.⁶ Thus the aim of this investigation was to determine the physical fitness of Sikkimese population and to test the hypothesis that geographical location and socio-cultural determinants have an influence on the physical fitness of residents.

2. Material and Methods

2.1. Selection of Subjects

Two distinctly different groups of 15 male subjects between 18-25 years of age are randomly selected to participate in the present study. Subjects of one group are young Sikkimese (age of 22.0 ± 4.32) selected randomly from the peoples of Gangtok ($27^{\circ} 20' N$ $88^{\circ} 37' E$), Sikkim, India; the other group consists of college students of Kolkata (age of 21.9 ± 2.16) (control). For the control population, college students of Kolkata of same age group are randomly selected, as the city is near sea level, with the average elevation being 17 feet. 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 the experiments were carried out and measurements were taken in temperature of 20° - $25^{\circ}C$ and relative humidity of about 45-50% in winter season in India, both in control subjects and Sikkimese, to avoid the seasonal influence on the fitness pattern. To minimize the experimenter bias each measurement was taken for three times and the mean was represented as the final result. Subjects with any type of disease, specially cardiac and respiratory ailments were not taken for experiments, only healthy subjects are chosen for each experiment. Each subject was given sufficient rest before each ex-

periment to get an accurate result.

2.2. Assessment Body Mass Index (B.M.I.)

The body mass index (or *Quetelet Index*) is the statistical measure which compares a person's weight and height by the formula, $BMI = mass (kg) / (Height in m^2)$.^{7, 8}

The WHO regards a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI greater than 25 is considered overweight and above 30 is considered obese.⁹

2.3. Body Fat % Measurement (From BMI, Age And Gender)

Body fat can be estimated from the Body mass index (BMI). There is a linear relationship between densitometrically-determined body fat percentage (BF %) and BMI, taking age and gender into account. Based on which following prediction formulas have been derived which showed a valid estimates of body fat at all ages, in males and females. But, in obese subjects the prediction formulas are slightly overestimated. The prediction error is comparable to other methods of estimating BF%, such as skinfold thickness measurements or bioelectrical impedance.¹⁰⁻¹²

The following formula was used to predict the body fat percentage is based on current BMI, age, and gender (Gender values for male = 1, female = 0): *Adult body fat percentage = [(1.20 x BMI) + (0.23 x Age) - (10.8 x gender) - 5.4]*.¹²

2.4. Body Surface Area (BSA)

In Physiology, the body surface area (BSA) is the measured or calculated surface of a human body. Various calculations have been published to arrive at the BSA without direct measurement. Dubois & Dubois formula were used for estimating body surface area (BSA).¹³

2.5. Resting Heart Rate

Baseline HR was obtained after five minutes rest in the sitting position. The resting heart beat was measured at carotid pulse. When two successive heart rate scores become equal then it was considered as resting heart rate.¹⁴

2.6. Blood Pressure

Arterial pressure is most commonly measured with a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating

pressure.¹⁵ BP values were obtained after five minutes rest in the sitting position.^{16,17}

2.7. Physical Fitness Index (PFI)

PFI was calculated by measuring heart rate after performing the Harvard step test (HST) developed by Brouha et al. in the Harvard Fatigue Laboratories using long form PFI equation.¹⁸ But, following modified HST under Indian condition, using stool of 51 cm high stepping up and down with a rate of 30 cycles/ min for 3 minutes or up to exhaustion. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 seconds.^{19,20} The recovery pulse was counted at 1 to 1.5, 2 to 2.5 and 3 to 3.5 minutes of recovery.

2.8. Anaerobic Power Test by Margaria Double Step Method

The Margaria double step method is performed by the subjects for the calculation of anaerobic power. It is a short-term anaerobic test or a power test in which the subject is taking two steps at a time, the height of the stairs is measured by measuring tape. To calculate the anaerobic power; the height of ascend, the body weight, and the duration (sec) are noted by the stopwatch.²¹ Work done is calculated by the following formulae, *Work done (Kg/meter) = body weight × height of ascend × 0.002342*. Then the work done was divided by duration of work (sec) to get anaerobic power (kg/meter/sec).

2.9. Determination of Aerobic Capacity (V̇O₂ MAX)

It is the maximum amount of O₂ consumed during rhythmic dynamic progressively increasing exercise done by any kind of ergometer (treadmill, stationary bicycle ergometer, hand cranking etc.) at sea level under thermally neutral condition when more muscle mass recruited then the capacity of O₂ is increased. Nomogram of Astrand was used to determinate the VO_{2 max}.²²

2.10. Energy Expenditure (EE)

Energy expenditure for any kind of job is normally measured by different calorimetric methods. It is also determined by many predictive equations. The following formula, *Energy Expenditure (Kcal min⁻²) = -1.42 + (0.045 × peak H.R)*, has been used for this study.²³

2.11. Nutritional Anthropometry

Curvilinear distances (circumferences) taken around the mid-upper arm (MUAC), head (HC), mid-thigh (TC), calf muscle of the leg (CC), waist (WC) and buttock (BC). WC and BC are used to predict the body fat content. MUAC is an index of body Energy store and protein mass.

Sometime it is combined with skin fold thickness to calculate the areas of arm muscle and adipose tissue. TC indicates muscle atrophy due to disease or atrophy and CC provides an estimate of cross-sectional and adipose tissue areas of the calf.²⁴

2.12. Stastical Analysis

Data are expressed as mean ± SD. Comparison of parameters between control and Sikkimese 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.^{25, 34}

3. Results

The height (cm) and body weight (kg) of 15 control subjects is 164.6 ± 7.21 and 59.3 ± 7.5 (mean± SD) respectively and those of Sikkimese are 155.7 ± 8.40 and 55.8 ± 12.15 (mean± SD) respectively. All mean values of physical parameters (BMI, BSA) are represented in Table 1. Other than body fat percentage no significant differences were found in the physical parameters between the two groups.

Table-1: Comparing Physical Parameters

	Control	Sikkimese	P
BMI (Kg/m ²)	21.9±2.49	22.0±2.52	0.105
Body Fat %	20.5±1.73	18.3±3.21*	0.063
BSA (m ²)	1.77±0.21	1.54±0.20	0.591

Values are mean± SD, sample size (n₁=n₂= 15). Superscript (*) indicates significant difference by two tail unpaired *t*-test (for equal variances) at P<0.05

Table 2 represents comparative aspects of physical fitness variables (including PFI). PFI scores reveal that the young Sikkimese has an excellent physical fitness level.

Table-2: Physical fitness variables

	Control	Sikkimese
Resting Heart Rate (Beats/min)	76.2±8.10	71.7±6.02 [†]
Pre-exercise Systolic Blood Pressure (mm Hg)	123±4.62	127.8±6.83 [†]
Pre-exercise Diastolic Blood Pressure (mm Hg)	84.1±6.81	77.8±8.16 [†]
Post-exercise Systolic Blood Pressure (mm Hg)	138.2±10.62 [§]	134.3±6.16 ^{§†}
Post-exercise Diastolic Blood Pressure (mm Hg)	80.1±7.98	75.3±11.8 [†]
PFI	69.9±4.80	83.1±9.92 [†]

Values denote mean± SD, sample size (n₁=n₂= 15). Superscript (†, §) indicates significant difference by two tail unpaired *t*-test (for equal variances) at P< 0.05. § indicates significant differences within control group and within Sikkimese group, † represents significant difference between control versus Sikkimese.

On the other hand, resting heart rate and pre-exercise diastolic pressure shows the better endurance of Sikkimese than control subjects. Table 3 mainly

represents the comparative aspect of anaerobic power, energy expenditure and predicted aerobic capacity ($V\text{O}_2\text{max}$). Sikkimese showed a greater anaerobic power and $V\text{O}_2\text{max}$ but less expenditure of energy for a specific work than control subjects.

Table-3: Comparison of anaerobic power, aerobic capacity and Energy expenditure between control and Sikkimese

	Control	Sikkimese	P
Anaerobic power ($\text{kg}\cdot\text{m}^{-1}\cdot\text{sec}^{-1}$)	12.3±2.46	15.1 ±3.12 [#]	0.048
$V\text{O}_2\text{max}$ (liters. min^{-1})	3.12±0.33	3.30 ±0.42 [#]	0.081
Energy expenditure (K.Cal. min^{-2})	5.67±0.57	4.32 ±0.69 [#]	0.003

Values denote mean± SD, sample size ($n_1=n_2= 15$). Superscript ([#]) indicates significant difference by two tail unpaired t-test (for equal variances) at $P<0.05$

Table-4: Anthropometric measures reflecting nutritional status of Sikkimese

Group	Control	Sikkimese
Mid Upper Arm Circumference (cm)	27.0±4.11	25.2±4.80
Thigh Circumference (cm)	47.1±5.55	45.3±5.22
Calf Circumference (cm)	32.1±3.78	31.2±4.08
Waist Circumference (cm)	75.9±4.53	71.5±6.15 ^u
Buttock Circumference (cm)	81.3±6.03	75.2±6.12 ^u
Waist-to-Hip ratio	0.92±0.02	0.91±0.07

Values denote mean± SD, sample size ($n_1=n_2= 15$). Superscript (^u) indicates significant difference by two tail unpaired t-test (for equal variances) at $P<0.05$

Table 4 represents the anthropometric measures that reflect the nutritional status of both groups which may affect the fitness pattern. But among these measures only WC and BC is found to be significant ($p<0.05$), but other parameters showed no significant difference with control subjects.

4. Discussion

The result of the present study reveals that BMI and BSA of Sikkimese did not significantly differ from the control group, but, young Sikkimese was found to have less body fat percentage than the sedentary population (Table 1) which may be due to their young age; hence have a propensity for being leaner rather than obese.²⁶ In Sikkim more than 22.6 percent of children born are reported to be underweight but reports about the body weight of the adult Sikkimese is almost scanty to support the finding of present study.²⁷

Resting heart rate and aerobic capacity or maximum oxygen uptake capacity ($V\text{O}_2\text{max}$) has widely been considered to be a reliable and valid measure of cardio-respiratory fitness and endurance.²⁸ In the present study, a lower resting heart rate was observed in Sikkimese than the control subjects that indicate the

better physical condition (endurance) of the Sikkimese. 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.²⁹

Activities that demand strength increases ventricular muscle mass³⁰ which results in increased force of contraction and hence cardiac output which may be the cause significant increase of resting or pre-exercise blood pressure.³¹ But, during exercise stretching of muscle causes vasoconstriction which resulted in restriction of blood flow and in turn increased systolic pressure.³² Pooling of blood in many parts of the body causes vasoconstriction in muscles and thus increased the diastolic pressure. Astrand also found a significant increase of systolic and diastolic pressure during exercises²². But in the present study, the change in systolic and diastolic blood pressure as recorded was not totally concomitant of the findings of Astrand. Though the 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 Sikkimese. This is an indicator of better cardio-respiratory condition of Sikkimese.

Brouha et al. 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.¹⁸ Similar results were found in Sikkimese 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 (Table 2) and lower Energy Expenditure and they also have better anaerobic power than sedentary workers (Table 3).

As young Sikkimese performs work related to strength more than control subjects, according to their life-style in high altitude, so they should have more upper arm circumference (Table 4) which are an estimate of energy storage and protein mass of the body which is an indirect estimate of strength²⁶, but no significant difference was observed in upper arm circumference between the two groups. Waist to hip ratio³³ found to be insignificant while comparing to control subjects which are another indicator of less fat percentage in Sikkimese

than control subjects, which is caused by their poor nutritional status, which again attributable to their economic condition.^{5, 35}

However, this investigation is a directive study which has given an apparent idea about better fitness pattern among young Sikkimese population. But as it has been carried out in small population of young adults, a detailed study would be carried out in future using other sophisticated cardio-respiratory parameters to have clear idea about the fitness pattern of entire population of Sikkim.

5. Conclusion

Present study indicates that the physical fitness of young Sikkimese residing at high hill temperate regions is better than the control subjects and low-oxygen environment as well as other socio-cultural determinants has an influence over their physical parameters.

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