Comparative Study of Electrolyte Excretion in Residents of Aizawl (Mizoram) and Varanasi (Uttar Pradesh) in Relation to Environmental Factors

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By

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CERTIFICATE

I, Shailendra Kumar Tripathi, hereby declare that the subject matter of this thesis is the record of work done by me, that the content of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other university/Institute.

This is being submitted to Mizoram University for the degree of Doctor of Philosophy in Environmental Science.

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Aizawl *Shailendra Kumar Tripathi*

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Chapter-1

Introduction

Ever since the inception of life primordia, there has been constant interaction between biotic and abiotic components of life with environment, which resulted in the evolution of different species on this planet. This evolution not only affected the flora and the fauna but was also responsible for agricultural and industrial revolution especially in last two millenniums. The agricultural revolution changed the culture of human being with a transition from non vegetarian to vegetarian diet. However agricultural revolution and food production, which grew parallel to the cultural evolution of the society, got affected by spurt of physical and environmental disaster and natural calamity. Human race, which evolved through various coastal area as well as bank of great rivers remain dependent upon sea food because it's readily availability, however those who migrated to the hill and plain area had to put hard effort for cultivation and preservation of the food during hostile weather. This interaction between food and environment led to the development of skilled labourers, who not only protected the forest and natural flora, which were traditionally used for food, but also deforested to create newer soil for cultivation of crop.

The earlier system of agriculture was primarily based upon the technique which required assistance from larger mammals like horse, buffalo and bull, which became the integral component of the agricultural growth, whereas smaller mammals like sheep goat and different forms of birds continued to remain part of the non vegetarian food items. These raw food items had many advantages, however they also had disadvantage of accumulating certain electrolyte, fat and protein, which could be a causative factor in certain diseases. Better farming techniques and temptation to produce more by increasing the fertility of the soil led to invention of chemical and synthetic fertilizers, which further contaminated the soil and water with heavy metal and trace elements, which led to accumulation of certain toxic electrolytes in human system and resulted into many diseases.

In last two millenniums the major breakthrough was industrialization and its effect on human civilization. The concept of conversion of static energy into kinetic energy was the major invention by human being which led to mechanical transformation and generation of machines which were initially driven by natural sources such as solar energy, wind mills and hydro power. In the beginning of 16th century electromagnetic forces were recognized and its association with steam and mechanical engines led to establishment of mechanical forming, engine driven irrigation and hydraulic system, which were latter on used in the transportation and distribution of potable water and organized system of sanitation. All these revolution changed the spectrum of life and cohorts of the individuals started migrating in search of better opportunity at far distance places. Due to invention of steam engine mining became an important industry, which was the mother of many metallic ores, basic chemical elements as well as petroleum products. These revolutions had created an opportunity for majority of the population to take up hard manual work, segregation of laborers into different community and class difference of the worker in the society. Many of these manual workers have to be in active operation of the factory or industries, which required continuous uninterrupted working, whereas there were organizers, managers and the elite class of supervisors who work in different environmental atmosphere and became white collar workers. These two different class of people became the integral component of the social milieu and were interdependent to each other in spite of the white collar individual became the privileged class and indirectly ruled over blue collar worker. The elite class of the society member did not prefer to migrate, whereas labourers, farmers and skilled workers had to move far of distance places in order to search better opportunity and often resulted into acquisition of privileged area in form of war and revolution. The migration of skilled and unskilled population from one geographical area to other demanded some modification in life style as well as in food habit in the area of new settlement and often they had to compromise with hostile environment either on seashore, bank of river, high altitude, deserts or dense forest. These physical factors had initially adverse effect on the health of the migrants and newer settlers, but over the period of centuries and decades the individuals learned to acclimatize. There were physiological adaptations in response to intense heat, freezing cold and torrential rain. Accordingly food habits also changed and those who could better adapt against the environmental odds ultimately became the victorious and survived.

By this time better understanding of human physiology could suggest to adopt preventive measure to remain healthy and productive to sustain the progeny as well as the individual culture by modifying food consumption, preservation and its storage, which grew another parallel industry and was also responsible in shaping the cultural aspects of the society.

In the 20th century majority of industrialized developed world changed their dietary habit from non-vegetarian to vegetarian and the immergence of fast food culture led to outburst of obesity, which was further complicated by lack of manual work consequences to mechanical industrialization. This culture has disadvantages that most of the non-vegetarian food required processing and the refrigeration technology became one of the important assets in food preservation. Many preservatives had also deleterious effect on health and the natural preservative lost its relevance because they could not be sustained in fast changing environmental conditions. Thus the fast food culture resulted into high consumption of fat with added salt and spices and especially in non-vegetarian population the least opportunity of high potassium containing diets, which were in abundance in fresh crop and fruit. On other hand vegetarian diet consumer had to preserve their food with extra salt, oil and spices, which also created an artificial situation in which consumption of natural food became less and less. All these factors where further compounded by nature of job as well as temperature and humidity. The native individuals, who confined themselves to their primitive place and did not migrate remained in better state of health rather than those, who migrated in different environmental area to which they were not acclimatized. At many places both of the population grew together but resulted into two different socio-cultural milieu. Those who accepted the challenges of environment and lived at par with the natural climatic variation, adapted the food habits and worked accordingly, ultimately sustained the challenges and could survived in the society. Many western countries, who migrated and ruled over the other continent started analyzing the effect of environment on their soldiers as well as immigrants and formulated various preventive measures to be taken in the adverse hostile environment. However developing and under developed nations, who had more than one geographical areas did not undertake such studies and were affected by natural calamity and food scarcity at the time of sudden migration or aggression by other population. The understanding of these environmental factors are now much important when the concept of global village is emerging fast and one has to understand the environmental constrain of a new place, where he has to survive. Sodium (Na^+) being one of the important constituents of food in the form of common salt or its base both in vegetarian and non-vegetarian diet affects milieu interior of the biological system in energy transport system through membrane, micro and mille electro potential gradient, diffusion and excretion to make living being in a healthy states. In human it is also responsible to maintain the water balance as well as blood pressure by conserving or excreting salt through skin and kidney during ambient temperature variation, humidity and rain fall. The body surface area, body mass index and food also have important contribution in regulating temperature and water balance at different work place and altitudes. The role of other electrolytes is also equally important like potassium, magnesium and chloride in relation to its consumption in form of food and beverages. The other component of the food like protein, carbohydrate and fat also contribute in the electrolytes pool of the body by donating various ions, which regulate the health of individual and keep them acclimatized against environmental variation.

Henceforth the present study has been conceive to explore the major biological and physiological parameter, which contributes for better preservation of health as well as food in two different bio-diversified situations in our country to understand the role of these electrolytes and food components in relation to ambient temperature variation, humidity and work place with special reference to excretion of sodium, chloride and other ions consumed with food.

Chapter-2

Review of Literature

2.1 Evolution of environment on planet

2.1.1 Origin of the solar system

The Solar System evolved from a large, rotating cloud of interstellar dust and gas called the solar nebula, orbiting the Milky Way's galactic center, which was composed of hydrogen and helium created shortly after the Big Bang 13.7 Billion years and heavier elements ejected by supernovas (Levin 1972) (Chaisson 2005). About 4.6 billion years ago, the solar nebula began to contract, possibly due to the shock wave of a nearby supernova. Such a shock wave would have also caused the nebula to rotate and gain angular momentum. As the cloud began to accelerate its rotation, gravity and inertia flattened it into a proto-planetary disk oriented perpendicularly to its axis of rotation. Most of the mass concentrated in the middle and began to heat up, but small perturbations due to collisions and the angular momentum of other large debris created the means by which proto-planets up to several kilometers in length began to form, orbiting the nebular center.

The in fall of material, increase in rotational speed and the crush of gravity created an enormous amount of kinetic heat at the center. Its inability to transfer that energy away through any other process at a rate capable of relieving the build-up resulted in the disk's center heating up. Ultimately, nuclear fusion of hydrogen into helium began, and eventually, after contraction, a star named T Tauri ignited to create the Sun. Meanwhile, as gravity caused matter to condense around the previously perturbed objects outside the gravitational grasp of the new sun, dust particles and the rest of the proto-planetary disk began separating into rings. Successively larger fragments collided with one another and became larger objects, ultimately becoming proto-planets (Chaisson 2005). These included one collection about 150 million kilometers from the center Earth. The planet formed about 4.54 billion years ago (Dalrymple 1991, 2001) and was largely completed within 10–20 million years (Yin *et al* 2002). The solar wind of the newly formed T Tauri star cleared out most of the material in the disk that had not already condensed into larger bodies.

2.1.2. Origin of the Earth's core and first atmosphere

The Proto-Earth grew by accretion, until the inner part of the proto-planet was hot enough to melt the heavy, siderophile metals. Such liquid metals, with now higher densities, began to sink to the Earth's center of mass. This so called iron catastrophe resulted in the separation of a primitive mantle and a metallic core only 10 million years after the Earth began to form, producing the layered structure of Earth and setting up the formation of Earth's magnetic field. During the accretion of material to the proto-planet, a cloud of gaseous silica condensed afterwards as solid rocks on the surface. The material left surrounding the planet was an early atmosphere of light (atmophile) elements from the solar nebula, mostly hydrogen and helium.

The radiometric ages show the Earth existed already for at least 10 million years before the impact, enough time to allow for differentiation of the Earth's primitive mantle and core. Then when the impact occurred, only material from the mantle was ejected, leaving the Earth's core of heavy siderophile elements untouched.

The impact had some important consequences for the young Earth. It released an enormous amount of energy, causing both the Earth and Moon to be completely molten. Immediately after the impact, the Earth's mantle was vigorously convecting, the surface was a large magma ocean. The planet's first atmosphere must have been completely blown away by the impact (Benz and Cameron 1990). The impact is also thought to have changed Earth's axis to produce the large 23.5° axial tilt that is responsible for Earth's seasons. It may also have sped up Earth's rotation.

2.1.3. Origin of the oceans and atmosphere

As the Earth lacked an atmosphere immediately after the giant impact, cooling must have occurred quickly. Within 150 million years, a solid crust with a basaltic composition must have formed. The felsic continental crust of today did not yet exist. Within the Earth, further differentiation could only begin when the mantle had at least partly solidified again. Nevertheless, during the early Archaean (about 3.0 billion years ago) the mantle was still much hotter than today, probably around 1600°C. This means the fraction of partially molten material was still much larger than today.

Steam escaped from the crust, and more gases were released by volcanoes, completing the second atmosphere. Additional water was imported by bolide collisions, probably from asteroids ejected from the outer asteroid belt under the influence of Jupiter's gravity.

As the planet cooled, clouds formed. Rain created the oceans. Recent evidence suggests the oceans may have begun forming by as early as 4.4 billion years (Wilde *et al* 2001). In any event, by the start of the Archaean eon the Earth was already covered with oceans. The new atmosphere probably contained water vapor, carbon dioxide, nitrogen, and smaller amounts of other gases. As the output of the Sun was only 70% of the current amount, significant amounts of greenhouse gas in the atmosphere most likely prevented the surface water from freezing (Sagan and Mullen 1972). Free oxygen would have been bound by hydrogen or minerals on the surface.

Volcanic activity was intense and, without an ozone layer to hinder its entry, ultraviolet radiation flooded the surface.

Stromatolites were formed by colonies of single celled organisms like cyanobacteria or chlorophyta. These colonies of algae entrap sedimentary grains, thus forming the draped sedimentary layers of a stromatolite. Archaean stromatolites are the first direct fossil traces of life on Earth, even though little preserved fossilized cells have been found inside them. The Archaean and Proterozoic oceans could have been full of algal mats like these.

2.1.4. First continents

Mantle convection, the process that drives plate tectonics today, is a result of heat flow from the core to the Earth's surface. It involves the creation of rigid tectonic plates at mid-oceanic ridges. These plates are destroyed by subduction into the mantle at subduction zones. The inner Earth was warmer during the Hadean and Archaean eons, so convection in the mantle must have been faster. When a process similar to present day plate tectonics did occur, this would have gone faster too. Most geologists believe that during the Hadean and Archaean, subduction zones were more common, and therefore tectonic plates were smaller.

The initial crust, formed when the Earth's surface first solidified, totally disappeared from a combination of these fast Hadean plate tectonics and the intense impacts of the Late Heavy bombardment. It is, however, assumed that this crust must have been basaltic in composition, like today's oceanic crust, because little crustal differentiation had yet taken place. The first larger pieces of continental crust, which is a product of differentiation of lighter elements during partial melting in the lower crust, appeared at the end of the Hadean, about 4.0 billion years. The left of these first small continents are called cratons. These pieces of late Hadean and early Archaean crust form the cores around which today's continents grew.

The oldest rocks on Earth are found in the North American craton of Canada. They are tonalites from about 4.0 Billion years. They show traces of metamorphism by high temperature, but also sedimentary grains that have been rounded by erosion during transport by water, showing rivers and seas existed then (Lunine 1999).

2.1.5. Oxygen revolution

The first cells were likely heterotrophs, using surrounding organic molecules (including those from other cells) as raw material and the source of energy (Dawkins 2004). As the food supply diminished, a new strategy evolved in some cells. Instead of relying on the diminishing amounts of free-existing organic molecules, these cells adopted sunlight as an energy source. Estimates vary, but by about 3 Billion years ago, something similar to modern oxygenic photosynthesis had probably developed, which made the sun's energy available not only to autotrophs but also to the heterotrophs that consumed them (De and David 2000, Olson 2006). This type of photosynthesis, which became by far the most common, used the abundant carbon dioxide and water as raw materials and, with the energy of sunlight, produced energy-rich organic molecules (carbohydrates).

Moreover, oxygen was released as a waste product of the photosynthesis (Holland 2006). At first, it became bound up with limestone, iron, and other minerals. There is substantial proof of this in iron-oxide rich layers in geological strata that correspond with this period. The reaction of the minerals with oxygen would have turned the oceans green. When most of the exposed readily-reacting minerals were oxidized, oxygen finally began to accumulate in the atmosphere. Though each cell only produced a minute amount of oxygen, the combined metabolism of many cells over a vast time transformed Earth's atmosphere to its current state (Fortey 1999). Among the oldest examples of oxygen-producing life forms are fossil stromatolites. This was Earth's third atmosphere.

Some of the oxygen was stimulated by incoming ultraviolet radiation to form ozone, which collected in a layer near the upper part of the atmosphere. The ozone layer absorbed a significant amount of the ultraviolet radiation that once had passed through the atmosphere. It allowed cells to colonize the surface of the ocean and eventually the land (Chaisson 2005) without the ozone layer, ultraviolet radiation bombarding the surface would have caused unsustainable levels of mutation in exposed cells.

Photosynthesis had another, major, and world-changing impact. Oxygen was toxic probably much life on Earth died out as its levels rose, which is known as the "oxygen catastrophe" (Chaisson 2005). Resistant forms survived and thrived, and some developed the ability to use oxygen to increase their metabolism and obtain more energy from the same food.

2.1.6. Snowball Earth and origin of ozone layer

An oxygen-rich atmosphere had two principal advantages for life. Organisms not using oxygen for their metabolism, such as anaerobe bacteria, base their metabolism on fermentation. The abundance of oxygen makes respiration possible, a much more effective energy source for life than fermentation. The second advantage of an oxygen-rich atmosphere is that oxygen forms ozone in the higher atmosphere, causing the emergence of the Earth's ozone layer. The ozone layer protects the Earth's surface from ultraviolet radiation, which is harmful for life. Without the ozone layer, the development of more complex life later on would probably have been impossible (Lunine 1999).

The natural evolution of the Sun made it progressively more luminous during the Archaean and Proterozoic eons. The Sun's luminosity increases 6% every billion years (Lunine 1999). As a result, the Earth began to receive more heat from the Sun in the Proterozoic eon. However, the Earth did not get warmer. Instead, the geological record seems to suggest it cooled dramatically during the early Proterozoic. Glacial deposits found in all cratons show that about 2.3 Billion years ago, the Earth underwent its first big ice age (the Makganyene ice age). Some scientists suggest this and following Proterozoic ice ages were so severe that the planet was totally frozen over from the poles to the equator, a hypothesis called Snowball Earth. Not all geologists agree with this scenario and older, Archaean ice ages have been postulated, but the ice age 2.3 Billion years ago is the first such event for which the evidence is widely accepted.

The ice age around 2.3 Billion years ago could have been directly caused by the increased oxygen concentration in the atmosphere, which caused the decrease of methane (CH_4) in the atmosphere. Methane is a strong greenhouse gas, but with oxygen it reacts to form CO_2, a less effective greenhouse gas (Lunine 1999). When free oxygen became available in the atmosphere, the concentration of methane could have decreased dramatically, enough to counter the effect of the increasing heat flow from the Sun.

2.1.7. Origin of life

The details of the origin of life are unknown, but the basic principles have been established. There are two thought about the origin of life. First suggests that organic components arrived on Earth from space while the other argues that they originated on Earth. Nevertheless, both suggest similar mechanisms by which life initially arose. If life arose on Earth, the timing of this event is highly speculative perhaps it arose around 4 Billion years ago (Chaisson 2005). It is possible that, as a result of repeated formation and destruction of oceans during that time period caused by high energy asteroid bombardment, life may have arisen and extinguished more than once (Wilde *et al* 2001).

In the energetic chemistry of early Earth, a molecule gained the ability to make copies of itself as replicator. It promoted the chemical reactions, which produced a copy of itself. The replication was not always accurate some copies were slightly different from their parent. If the change destroyed the copying ability of the molecule, the molecule did not produce any copies, and the line died out. On the other hand, a few rare changes might make the molecule replicate faster or better, those strains would become more numerous and successful. This is an early example of evolution on abiotic material. The variations present in matter and molecules combined with the universal tendency for systems to move towards a lower energy state allowed for an early method of natural selection. As choice raw materials i.e. food became depleted, strains, which could utilize different materials, or perhaps halt the development of other strains and steal their resources, became more numerous (Dawkins 2004).

2.1.8. DNA Synthesis

So far nature learnt either to create a new chemical genes combination to consolidate the physical forces and energy or to destroy and the many destruction and creation would have taken place on this planet before non organic compound could combine to form an organic substance, which has replicate a sequence of nucleic acid with bases in the form of DNA.

The nature of the first replicator is unknown because its function was long since superseded by life's current replicator DNA. Several models have been proposed explaining how a replicator might have developed. Different replicators have been posited, including organic chemicals such as modern proteins, nucleic acids, phospholipids, crystals (Dawkins 1996), or even quantum systems (Davies 2005). There is currently no way to determine whether any of these models closely fits the origin of life on Earth.

One of the older theories, which has worked out in some details, will serve as an example of how this might occur. The high energy from volcanoes, lightning, and ultraviolet radiation could help drive chemical reactions producing more complex molecules from simple compounds such as methane and ammonia. Among these were many of the simpler organic compounds, including nucleobases and amino acids, which are the building blocks of life. As the amount and concentration of this "organic soup" increased, different molecules reacted with one another. Sometimes more complex molecules would result perhaps clay provided a framework to collect and concentrate organic material (Fortey 1999).

Certain molecules could speed up a chemical reaction. All this continued for a long time, with reactions occurring at random, until by chance it produced a replicator molecule. In any case, at some point, the function of the replicator was superseded by DNA. All known life (except some viruses and prions) use DNA as their replicator, in an almost identical manner.

Modern life has its replicating material packaged inside a cellular membrane. It is easier to understand the origin of the cell membrane than the origin of the replicator, because a cell membrane is made of phospholipid molecules, which often form a bilayer spontaneously when placed in water (Fortey 1999).

The prevailing theory is that the membrane formed after the replicator was perhaps RNA (the RNA world hypothesis), along with its replicating apparatus and other bio-molecules. Initial proto-cells may have simply burst when they grew too large; the scattered contents may then have recolonized other "bubbles". Proteins that stabilized the membrane, or that later assisted in an orderly division, would have promoted the proliferation of those cell lines.

RNA acts as an early replicator, it can store genetic information as well catalyze reactions. At some point DNA took over the genetic storage role from RNA, and proteins known as enzymes took over the catalysis role, leaving RNA to transfer information, synthesize proteins and regulate the process. There is increasing belief that these early cells evolved in association with undersea volcanic vents known as black smokers (Fortey 1999) or even hot, deep rocks (Dawkins 1996).

It is believed that of this multiplicity of proto-cells, only one line survived. Current phylogentic evidence suggests that the last universal common ancestor lived during the early Archean eon, perhaps roughly 3.5 Billion years ago or earlier. This "LUCA" cell is the ancestor of all life on Earth today. It was probably a prokaryote, possessing a cell membrane and probably ribosomes, but lacking a nucleus or membrane-bound organelles such as mitochondria or chloroplasts. Like all modern cells, it used DNA as its genetic code, RNA for information transfer and protein synthesis, and enzymes to catalyze reactions. Some scientists believe that instead of a single organism being the last universal common ancestor, there were populations of organisms exchanging genes in lateral gene transfer (Penny and Anthony 1999).

2.1.9. Proterozoic development of life

Modern taxonomy classifies life into three domains. The time of the origin of these domains is uncertain. The Bacteria domain probably first split off from the other forms of life (sometimes called Neomura), but this supposition is controversial. Soon after this, by 2 Billion years ago, the Neomura split into the Archaea and the Eukarya. Eukaryotic cells (Eukarya) are larger and more complex than prokaryotic cells (Bacteria and Archaea), and the origin of that complexity is only now becoming known.

Around this time, the first proto-mitochondrion was formed. A bacterial cell related to today's Rickettsia (Andersson *et al* 1998), which had learned how to metabolize oxygen, entered a larger prokaryotic cell, which lacked that capability. Perhaps the large cell attempted to ingest the smaller one but failed, possibly due to the evolution of prey defenses. The smaller cell may have tried to parasitize the larger one. In any case, the smaller cell survived inside the larger cell. Using oxygen, it metabolized the larger cell's waste products and derived more energy. Some of this excess energy was returned to the host. The smaller cells were replicated inside the larger one. Soon, a stable symbiosis developed between the large cell and the smaller cells inside it. Over time, the host cell acquired some of the genes of the smaller cells, and the two kinds became dependent on each other, the larger cell could not survive without the energy produced by the smaller ones and these in turn could not survive without the raw materials provided by the larger cell. The whole cell is now considered a single organism, and the smaller cells are classified as organelles called mitochondria.

A similar event occurred with photosynthetic cyanobacteria (Berglsand and Robert 1991) entering large heterotrophic cells and becoming chloroplasts (Fortey 1999 and Dawkins 2004). Probably as a result of these changes, a line of cells capable of photosynthesis split off from the other eukaryotes more than 1 billion years ago. There were probably several such inclusion events, as the figure at right suggests. Besides the well-established endosymbiotic theory of the cellular origin of mitochondria and chloroplasts, it has been suggested that cells led to peroxisomes, spirochetes led to cilia and flagella, and that perhaps a DNA virus led to the cell nucleus (Takemura 2001 and Bell 2001), though none of these theories is widely accepted (Gabaldón *et al* 2006).

Algal species namely, *Volvox* is believed to be first multi-cellular plant. Archaeans, bacteria, and eukaryotes continued to diversify, and to become more complex and better adapted to their environments. Each domain repeatedly split into multiple lineages, although little is known about the history of the archaea and bacteria. Around 1.1 Billion years ago, the supercontinent Rodinia was assembling (Hanson *et al* 2004)). The plant, animal, and fungi lines had all split, though they still existed as solitary cells. Some of these lived in colonies, and gradually some division of labor began to take place; for instance, cells on the periphery might have started to assume different roles from those in the interior. Although the division between a colony with specialized cells and a multicellular organism is not always clear, around 1 billion years ago the first multicellular plants emerged, probably green algae (Bhattacharya and Linda 1998). Possibly by around 900 million years ago (Dawkins 2004) true multicellularity had also evolved in animals.

At first it probably resembled today's sponges, which have the cells that allow a disrupted organism to reassemble itself (Dawkins 2004). As the division of labor was completed in all lines of multicellular organisms, cells became more specialized and more dependent on each other, isolated cells would die.

2.1.10. Late Proterozoic climate and life

The end of the Proterozoic saw at least two Snowball Earths, so severe that the surface of the oceans may have been completely frozen. This happened about 710 and 640 Million years ago, in the Cryogenian period. These severe glaciations are less easy to explain than the early Proterozoic Snowball Earth. Most paleoclimatologists think the cold episodes had something to do with the formation of the supercontinent Rodinia. As Rodinia was centered on the equator, rates of chemical weathering increased and carbon dioxide (CO_2) was taken from the atmosphere. As CO_2 is an important greenhouse gas, climates cooled globally.

In the same way, during the Snowball Earths most of the continental surface was in permafrost, which decreased chemical weathering again, leading to the end of the glaciations. An alternative hypothesis is that, enough carbon dioxide escaped through volcanic out gassing that the resulting greenhouse effect raised global temperatures (Hoffman *et al* 1998). Increased volcanic activity resulted from the break-up of Rodinia at about the same time.

The Cryogenian period was followed by the Ediacaran period, which was characterized by a rapid development of new multicellular life forms. If there is a connection between the end of the severe ice ages and the increase in diversity of life, is not clear, but it does not seem coincidental. The new forms of life, called Ediacara biota, were larger and more diverse than ever. Most scientists think some of them may have been the precursors of the new life forms of the following Cambrian period. Though the taxonomy of most Ediacaran life forms is unclear, some are proposed to have been ancestors of groups of modern life (Xiao and Laflamme 2009). Important developments were the origin of muscular and neural cells. None of the Ediacaran fossils had hard body parts like skeletons. These first appear after the boundary between the Proterozoic and Phanerozoic eons or Ediacaran and Cambrian periods.

2.1.11. Paleozoic era

The Paleozoic era was the first era of the Phanerozoic eon, lasting from 542 to 251 Million years ago. During the Paleozoic, many modern groups of life came into existence. Life colonized the land first plants then animals. Life usually evolved slowly. At times, however, there are sudden radiations of new species or mass extinctions. These bursts of evolution were often caused by unexpected changes in the environment resulting from natural disasters such as volcanic activity, meteorite impacts or climate changes.

The continents formed at the break-up of Pannotia and Rodinia at the end of the Proterozoic would slowly move together again during the Paleozoic. This would eventually result in phases of mountain building that created the supercontinent Pangaea in the late Paleozoic.

One of the central problems of the earliest stage of evolution, which is at present little spoken of, is the ratio of physicochemical factors of the environment to organic molecules the elements that underlay the formation of life molecules and then the assemblage of the first cell.

To form a membrane, a system of synthesis is necessary. This was only possible, when the RNA world appeared, i.e., the system of synthesizing the first peptidic molecules the chemical organic elements of life, without which it cannot develop. The physicochemical condition on the earth has to be optimal for the development of life, the ionic composition, pH, and osmolality being of primary importance.

Therefore, the inorganic components of the environment, in which macromolecules were synthesized, is fraught with an incorrect assessment of the conditions under which life took its first steps. Hence, it is very important to penetrate into the essence of events that took place 3 to 3.5 billion years before the Cambrian. It is necessary to propose a modern concept of arguments to substantiate the hypothesis that life began in the sea. However, under thorough physiological analysis, the thesis that life originated from the marine environment not only seems questionable but also open to contest on the basis of many facts and logical constructions of the physiological evolution of living beings.

2.2 Environment of proto-cells

The salt composition of the environment where the first forms of life appeared could comprise salt solutions, in which the concentration of ions was friendly for the functioning of elements of gene matter (RNA or DNA), chemical reactions of protein synthesis, and other vital biochemical processes. Nature's conservative attitude to fundamental principles of constructing living systems most probably showed in the qualitative similarity of the concentrations of ions, which ensure vital functions in the series of next generations, from the first forms of life to modern individuals.

To understand the physicochemical conditions of the environment where life formed, it is necessary to analyze the geological past of the planet's surface. As for inorganic ions, tissues of living beings contain macro element such as cations of potassium, sodium, calcium, and magnesium. Paleogeochemical data are necessary to estimate the ionic composition of the environment in the epoch when living beings appeared. Certain information about the environment in which animal cells appeared may be derived by comparing petrological chemical indices of the sodium and potassium content in argillaceous deposits of different periods of the earth's history. Clays and their derivatives (argillites and aleuropelites) are characterized by a high sorption capacity, which makes it possible to judge about the proportion of sodium and potassium cations in probable environments of the development, if not the origin, of initial forms of living organisms. Studies have shown that in superficial rocks, potassium ions usually prevailed compared to sodium ions. The highest content of potassium in rocks is characteristic of the early Proterozoic (the first third of the Riphean), when the initial forms of animal cells eukaryotes probably developed. During the next 3 billion years, there were periods when the ratio of sodium ions to potassium ones in the superficial rocks changed the content of sodium became equal to that of potassium or even higher. These are the Sumian-Sariolian (more than 2.5 billion years ago) and Kalevian (approximately 2 billion years ago) periods (Natochin 2007).

The systematized data show that to synthesize a protein in vivo and in vitro, 5–20 mM of Mg^{++} ions and about 100 mM of K^+ ions are necessary, while Na^+ ions are not only incapable of substituting K^+ ions but also inhibit the operation of the protein synthesis system. It is believed that in the ribosome, magnesium and potassium ions favor complex formation and the fixation of components of the protein synthesis system and act as catalysts in peptide bond synthesis. The cell of modern vertebrates retains the same optimum of cations about 13 mM of Mg^{++} ions and 100 mM of K^{+} ions (Natochin 2007).

It is logical to assume that the initial forms of cells, from which life on the earth began, could have qualitatively similar physicochemical parameters. These initial forms may be called proto-cells to distinguish them from modern or fossil organisms. Protocol has the physiological characteristic of cells at the initial stage of their development, when they had no plasmatic membrane in the modern sense of the word. They could have only an envelope that prevented the newly formed organic molecules of this organism from transferring into the environment and held them inside the cell. It is reasonable to suppose that the concentration of monovalent ions and the osmotic pressure under the proto-cell's envelope (membrane) were equivalent to those in the environment. Any deviations in these parameters from the habitat would require special membrane macromolecules, similar to ion pumps, ion channels, and water channels. However, such molecular devices require the presence of protein syntheses systems in the cell. One can hardly assume that such systems existed at the early stage of life, and they had not existed prior to its beginning.

This membrane was roughly analogous to the structures found in modern cells and organisms. There are organisms with simpler structures compared to the plasmatic membrane. The pellicle that covers microbial communities and certain types of membrane like formations, such as diaphragms over endothelial pores of glomerular capillaries or slit membranes between the podocyte "pedicels" in the kidney, may exemplify this.

Table No 2.1. Concentration of electrolytes and osmolality in blood plasma or hemolymph in animals and humans

Subject of enquiry	Osm	Na^+	K^+	Ca^{++}	Mg^{++}
Mussel *Mytilus edulis*, 34%*	1100	479 ± 4	10.9 ± 0.2	18.8 ± 0.7	56.7 ± 2
Fresh water pearl mussel *Margartifera margaritifera*	32 ± 1.2	14.7 ± 0.4	0.37 ± 0.02	1.86 ± 0.08	0.41 ± 0.02
American cockroach *Periplanta Americana*	421 ± 3	116 ± 8	11.3 ± 1.3	3.6 ± 0.6	4.9 ± 0.7
Starry sturgeon *Acipencer stellatus*	304 ± 3	122 ± 2.5	1.3 ± 0.1	2.2 ± 0.2	1.7 ± 0.2
Sockeye salmon *Oncorhynchus nerka*	289 ± 4	141 ±1.4	2.0 ± 0.2	2.8 ± 0.4	1.1 ± 0.1
Common frog *Rana temporaria*	222 ± 2	108 ± 1.5	3.4 ± 0.2	2.12 ± 0.08	1.2 ± 0.04
Russian tortoise *Testudo horsfieldi*	295 ± 6	135 ± 2.5	5.5 ± 0.4	2.7 ± 0.03	1.3 ± 0.12
Rock pigeon *Columba livia*	295 ± 3	147 ± 1.7	2.4 ± 0.3	2.6 ± 0.04	0.68 ± 0.03
Wistar rat	294 ± 3	140 ± 0.20	3.9 ± 0.4	2.3 ± 0.06	1.03 ± 0.05
Great gerbil *Rhombomys opimus*	-	155 ± 1	7.3 ± 0.26	1.4 ± 0.07	0.9 ± 0.05
Human	287 ± 2	143 ± 1	4.5 ± 0.1	2.27 ± 0.07	0.85 ± 0.03

*Saltiness of the habitat of the mussels is % of seawater of the Barents Sea.

Note: The concentration of electrolytes in mM/l, and osmolality in mosm/kg H_2O.

Measurements of the concentration of ions in cells and the extra-cellular fluid in modern animals testify to the fact that the main intracellular cation is potassium in the hemolymph, blood plasma, and extra-cellular fluid of the majority of animals, sodium dominates. When potassium ions dominate in cells, the share of sodium in tissues is lower and that of potassium is higher than in the hemolymph or blood plasma, which shows the prevailing accumulation of potassium in cells. The same tendency is observed in the cells of protozoans. For example, in the amoeba *Amoeba proteus*, the content of potassium is 0.376, sodium 0.026, calcium 0.063 and magnesium 0.217 μM per 1 mg of dry matter. Thus, in the amoeba cell, the content of potassium ions is 14.5 times higher than that of sodium ions. In muscle cells of mammals, the concentration of potassium ions is about 150–160, while that of sodium ions is 12–16 mM/l i.e., the ratio of K^+ to Na^+ is more than 11 (Natochin 2007). Consequently, cells with very different levels of development and specializations show significant similarity in their physicochemical organization. It is highly probable that in animal cells, from unicellular forms to higher multi-cellular organisms, the potassium cation continues to dominate. This is vitally important for preserving the physicochemical properties of the intracellular environment from the moment of its formation to the present day, i.e., over billions of years. Rare exceptions (for example, sodium nucleus-free red blood cells of certain animal lines) only confirm the above regularity, because sodium replaces potassium in the cell when there is no need to synthesize protein at the latest stages of the life of a given type of cells.

Table No.2.2 Concentration of electrolytes in aquatic environments and lithosphere of the earth, in plants, and in tissues of animals and humans (Natochin 2007)

Subject of enquiry	Na^+	K^+	Ca^{++}	Mg^{++}
Lithosphere (% to mass)	2.83	2.59	3.63	2.09
Human (% to dry matter)	0.47	1.09	4.67	0.16
Rat, kidney, cortex	73.9 ± 5.2	80.9 ± 1.9	-	9.2 ± 0.25
Atlantic cod *Gadus morhua,* muscle	26.3 ± 2.8	129 ± 4	-	12.1 ± 0.46
American cockroach *Periplanta Americana*, muscle	21.7 ± 4.8	85.6 ± 2.6	-	23.3 ± 0.7
Common sawfly *Rhadinoceraea micas,* muscle	72.3 ± 6.8	190 ± 12	-	34.2 ± 4.8
Plants (µM/g of dry matter)	0.4	250	125	80
Ocean water	457	9.7	10	56
Black Sea (Karadag)	227	5.4	7.2	25.5
White Sea, Chupinskii Inlet	310	6.9	8.5	37
Lake Baikal	0.18	0.025	0.39	0.12

Note: The concentration of cations is in mM/l in tissues, in mM/g of damp matter, in other cases as specified.

Therefore, the main point in contention is that, contrary to prior beliefs, the first cellular forms emerged not in the "sodium ocean" but in potassic water basins, rich with magnesium ions, which contain organic substances, including nucleic and amino acids. Macromolecules could be synthesized and organic products could be preserved under the proto-cell envelope in such water basins. Apparently, their subsequent development and propagation took place in a potassium environment with a minimal content of sodium ions; the cell's content and its environment were isoosmotic to each other. This environment was probably shallow reservoirs on the earth's surface. The aforementioned petrographic indices of the sodium and potassium content relate to clayey deposits.

2.2.1. Role of sodium in the cell's function

Upon the emergence of proto-cells, a plasmatic membrane began to form, which was another stage of physiological evolution. The potassium proto-cell had been developing in potassic basins. Geological evolution was accompanied by volcanic eruptions; as the earth's crust and the architecture of the earth's surface changed, the content and ratio of ions in basins changed too. As is known, volcanic ash is characterized by high concentrations of sodium ions. In basins where sodium dominated, only those cells that had acquired a plasmatic membrane and were able to preserve the potassic cytoplasm in the sodium salt environment could survive; in other words, the membrane should have a sodium pump. We may assume that sodium ions stimulated the formation of the plasmatic membrane, which replaced the cellular envelope, and natural selection helped these cells survive.

The appearance of the membrane, which separated fluids with different ionic compositions, was connected with the formation of sodium pumps and sodium channels in this membrane; this could become the starting point of cellular differentiation and then organogenesis. In our opinion, the key role in these cases belonged to sodium-dependent physiological processes. They included the appearance of membrane electrogenesis and the formation of sodium-dependent co-transporters in the plasmatic membrane, which ensured the transportation of glucose, amino acids, and certain inorganic ions to the cell. These molecular mechanisms opened new possibilities in the cell's evolution and participation in the formation of multi-cellular organisms.

Let us consider the physiological role of sodium dependent macromolecules, which gave an evolutionary advantage to multi-cellular animals compared to other groups of living beings. Na^+, K^+ ATPase of the plasmatic membrane ensured the restoration of the cellular potassic cytoplasm in the sodium external environment. The Na^+/K^+ gradient favored the emergence of an electric potential on the plasmatic membrane of this cell, which later made it possible to realize a number of functions; in the first place, it became a prerequisite for the formation of the nervous cell i.e., it ensured fast information exchange and control of cells in the organism as a whole. Synthesis of physiologically active substances in such a cell ultimately resulted in the development of neurosecretion humoral control of functions in a multi-cellular organism and the endocrine system, which formed in close connection with the nervous system (Natochin 2007).

By removing sodium ions from the cell, Na^+, K^+ ATPase created prerequisites for a sodium-dependent mechanism of supplying organic and inorganic substances to the cell. In the course of further cellular differentiation, this mechanism participated in the formation of special epithelia, which played a leading role in organogenesis during the formation of sorbing epithelia of integuments, the alimentary canal, excretory organs, and salt glands.

Sodium-dependent processes could also stimulate cellular differentiation. The presence of sodium pumps and sodium channels in the plasmatic membrane was perhaps the starting point for cellular differentiation (Natochin 2007). In initial cells, sodium-dependent macromolecules are randomly distributed in the plasmatic membrane. However, there are cases when ionic channels are concentrated in one part of the membrane, while ionic pumps are in the other part (Fig.2.1). An accidental redistribution of the channels and pumps may lead to the formation of a polarized, or asymmetric, cell, whose membrane will concentrate mainly ionic channels in one part and sodium pumps in the other (Na^+, K^+ ATPase). This process could precondition the formation of epithelial cells. As for modern organisms, asymmetry is inherent in the skin cells of amphibians and in the cells of some parts of the alimentary tract and excretory and other organs. In multi-cellular organisms, there are also symmetrical cells (for example, red blood cells and myocytes), whose heterogeneous plasmatic membrane is characterized by a uniform distribution of channels and pumps. Consequently, macromolecules of the plasmatic membrane, involved in the transportation of sodium ions, could become a source of a new morpho functional cellular organization, cellular differentiation and lead to the formation of epithelial cells. Coelenterates already have different cellular layers. Between the cellular layers that form the ectoderm and the endoderm, there is the mesogloea, whose ionic composition in medusae is close to that of the environment ocean water. The extra-cellular fluid (hemolymph) in marine organisms, for example, in mollusks and ascidians, is also close to the concentration of sodium and potassium ions in the marine environment.

Problems of evolutionary physiology are closely associated with analysis of the essence of evolutionary process. With time, debates on the origin of life and the ways of evolution of living creatures not only are not decreasing, but even, to different extent, are intensified.

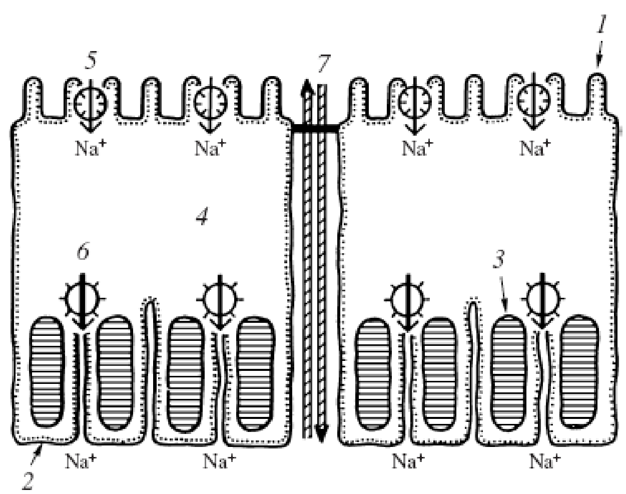


Fig.2.1. The scheme of sodium transportation in the asymmetrical cell of the osmoregulating epithelium. (*1*) apical plasmatic membrane, (*2*) basal plasmatic membrane, (*3*) mitochondrion, (*4*) cytoplasm, (*5*) sodium channel, (*6*) sodium pump, and (*7*) the intercellular junction zone; arrows indicate the direction of the flow of ions depending on the gradient of their concentration.

2.2.2. Evolutionary adaptation of membranes to temperature

At increased cellular temperatures the proportion of saturated fatty acids increased and the unsaturation index decreased; the correlation between these indices and the measured expression of membrane dynamic structure was highly significant. It is concluded that the homeoviscous compensation of synaptic membrane function is an important component of temperature adaptation (Cossins and Prosser 1978).

2.2.3. Sodium and homeostasis

Certain physicochemical parameters of the environment in which life began were critical for the development of living beings and underlay the formation of basic functions in the initial precellular forms of life, the first cells, and then multi-cellular organisms. There is no doubt that the aquatic environment was the stage on which chemical processes of life played. Upon the formulation of the notion of physicochemical parameters of the internal environment relative to the external one, or the notion of homeostasis, hypotheses appeared concerning interrelations between organisms and their habitats during the formation of internal environment fluids.

Humans and animals form blood, extra-cellular fluid, and lymph systems and develop mechanisms of stabilizing their volume and composition. Since the time of C. Bernard, the central idea of physiology has been the recognition that the stability of the internal environment ensures free life (Natochin 2007). Excretory organs are of special importance in keeping and maintaining a constant composition of the internal environment. In the majority of cases, their function is based on a two phase principle, first, protein-free fluid ultra filtration occurs from the blood plasma or hemolymph through the kidney tubule and then a part of sodium ions, many physiologically important organic substances (glucose, amino acids, etc.), and certain anions return in necessary amounts to the fluids of the internal environment using sodium-dependent mechanisms, and the remaining part is excreted.

The choice of sodium ions as a counter cation to the intracellular potassium cation was of special importance in the evolution of humans and animals. In the initial forms of eukaryotes that gave rise to the kingdom of plants, sodium was not used to perform these basic functions (Table 2.2). In the extra-cellular fluid of practically all invertebrates and vertebrates, sodium is the dominating cation. In addition, in a very broad range of its concentrations from 15 to 500 mM/l the ratio of potassium ions to sodium ions remains stable (Fig. 2.2). In vertebrates, especially in humans and other mammals, not only are the physicochemical parameters of the blood plasma and extracellular fluid stabilized but also the environment where the nervous system functions. This is ensured by a special fluid outside the blood–brain barrier. There are other similar physiological mechanisms, such as the blood–aqueous barrier; the endolymph and perilymph are formed in the inner ear.

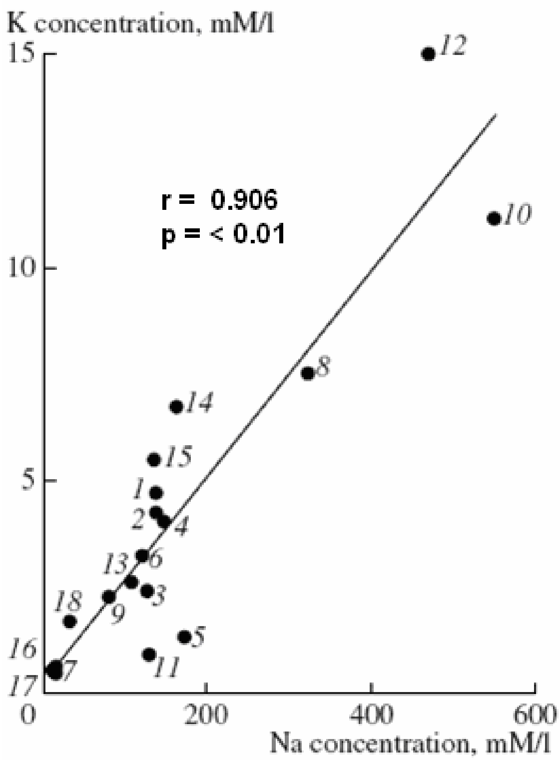


Fig. 2.2. Ratio of sodium ions to potassium ions in the blood plasma and hemolymph of animals and humans. (*1*) pink-eyed white rat, (*2*) human, (*3*) *Acipenser güldenstädti*, (*4*) *Columba livia*, (*5*) *Gadus morhua*, (*6*) *Lampetra fluviatilis*, (*7*) *Margaritifera margaritifera*, (*8*) *Mytilus edulis*, (*9*) *Mytilus trossulus*, (*10*) *Myxine glutinosa*, (*11*) *Oncorhynchus nerka,* (*12*) *Pecten islandicus*, (*13*) *Rana temporaria*, (*14*) *Rhombomys opimus*, (*15*) *Testudo horsfieldi*, (*16*) *Unio pictorum*, (*17*) *Unio tumidus,* and (*18*) *Viviparus viviparus* (Natochin 2007)

As for the dominating cation in animal cells and the extra-cellular fluid, there are only a few exceptions, which only confirm the concept of the sodium potassium homeostasis. They include the hemolymph in certain species of insects and the endolymph of the inner ear in mammals, in which the concentration of potassium ions is higher than that of sodium ions. However, the content of potassium ions even in the muscles of these insects is higher than in the "potassic" hemolymph. For example, in the muscle of the common sawfly, the K^+/Na^+ ratio (tissue/hemolymph) is 2.7. To ensure such a high gradient of potassium ion concentration in insects with the potassic hemolymph, nonstandard adaptive mechanisms were employed: high values of hemolymph osmolality are due to the fact that organic substances accumulate in the hemolymph. Owing to this, prerequisites are created for maintaining a higher level of potassium in cells.

The proto-cell could exist in stabilized physicochemical environmental conditions (osmolality, potassium ion concentration, and pH), the parameters of which were practically similar to those of the intracellular content. With regard to physiology, the characteristic feature of the evolution of multi-cellular animals is the development and continual improvement of the system that regulates the parameters of the fluids of the internal environment. The above studies made it possible to discover the most strictly stabilized physicochemical parameters of vertebrates' blood plasma, which have reached the highest level in humans. They include osmolality and the concentration of sodium ions and ionized calcium in blood plasma. The explanation is obvious that the osmolality of blood and the concentration of sodium ions determine the volume of each cell and bioelectric processes on the plasmatic membrane. Potassium ions regulate many processes inside the cell (Natochin 2007).

2.2.4. Sodium in the evolution of physiological systems of animals

The definition of the notion of life includes the energy-consuming process that implies the maintenance and self-reproduction of the characteristic structure of an individual. In modern terms, this means the appearance of the genetic matrix as the base of synthesizing protein molecules and other components of living structures. It is highly probable that the basic principles have survived from the primary forms into the most complex modern organisms; the same is true with respect to the ratio of organic substances to inorganic ones in these beings. This may single out two components in physiological evolution, obligatory or stable and adaptive. In other words, changes in the environmental conditions required an adequate response from the organism, which should be based, however, on stable and invariably preserved features. Physicochemical conditions that are necessary for the functioning of the living cell apparently belong to the preserved and protected only those features change that ensure a better adaptation to new conditions of existence.

The most popular hypothesis concerning the formation of the eukaryotic cell is the symbiotic approach (Natochin 2007). At one of the evolutionary stages, along with the world of prokaryotes, new kingdoms of living beings began to develop, which determined the rise of plants, fungi, and animals. With regard to physicochemical conditions inside the cell, including the dominant cation, they sought for mechanisms that would allow them to adapt to the external environment. It is assumed that animals formed in a pericellular environment where sodium ions dominated, while the cell itself contained the potassium ion, the strategy of plants comprised searching for such structures of envelopes that would withstand osmotic forces.

In multi-cellular animal organisms coelenterates and worms, mollusks and insects, as well as different classes of vertebrates there are several fluid phases. One of them is intracellular fluid and another is extra-cellular fluid. They are separated from each other by the cell's plasmatic membrane. The concentrations of individual ions and non-electrolytes in the two fluids are different, but the total concentration of osmotically active substances is practically the same, and the values of the osmotic pressure are similar. The adaptation of the iso-osmotic cell to the sodium environment of the ocean provided exclusive opportunities for the development of animals. Later, these living beings migrated from the sea to fresh waters and land. In all the cases, the osmolalities of the intracellular and extra-cellular fluids changed simultaneously, but the principle of their functioning remained the same.

The majority of works on evolutionary physiology are devoted to analyzing the mechanisms of developing physiological functions. The term evolutionary physiology was proposed by A.N. Severtsov in 1914, when the first works on the evolution of functions had already appeared. The first generalizations in evolutionary physiology appeared in the early 1930s this trend began to develop especially rapidly in the mid-20th century. A wide range of problems, associated mainly with the evolution of the functions of the nervous and digestive systems, water–salt metabolism, and kidneys, was studied (Natochin 2007).

Orbeli formulated a system of ideas of evolutionary physiology as an independent trend in physiology (Natochin 2007). Within the framework of his concept, two tasks of evolutionary physiology were determined. One of them was studying the evolution of functions, i.e., the development and improvement of functions of different systems of organisms. The other implied understanding why the evolution of this or that function proceeds in one direction and not in another one. The approaches proposed in this article are beyond the scope of both tasks.

The origin of the cell, the role of physicochemical factors, and the role of sodium ions can hardly be considered as the evolution of physiological functions, such as respiration, blood circulation, digestion, excretion, and so on. The discussion and solution of the task posed in this article can hardly be attributed to the evolution of functions. The development of evolutionary physiology in Orbeli's constructions makes us pose another task, which may be called physiological evolution. It may be formulated as the formation of physiological processes and functions under the rise of organic elements of life and independent self-reproducing organisms in inorganic nature, which were capable of realizing the minimum of physiological functions that underlie life. These are physiological functions of the initial cell, the ways by which cellular functions appeared and developed, and the formation of respiration, digestion, excretion, and other organs and systems (Natochin 2007).

2.2.5. Development strategies

One can assume that initial organism ancestors of eukaryotes, common to plants, fungi, and animals lived in a potassic environment. At that time, precursors of each of the above groups had to choose a strategy of adaptation to the environment, in which sodium ions had begun to dominate.

Previously, nobody paid attention to the fact that the content of potassium in plants per unit of the mass of dry matter exceeds the total amount of sodium 600 times (Natochin 2007). In animals and humans, this ratio is qualitatively different. For example, in humans, the share of potassium is two times higher than that of sodium (Table 2.2). In the plasmalemma of plants, potassium, calcium, and anionic channels have been discovered; some of them are potential-dependent and are activated by stress, light, and other factors. Just as in membranes of animal cells, the water permeability of plasmatic and vacuolar membranes in the cells of plants is regulated with the participation of aquaporins. In tracheophytes, there are intracellular pre- and postphloemic and pre- and postxylemic transportation systems. In animal cells, the situation is different the most important role in their plasmatic membrane belongs to molecular mechanisms for sodium trans-membrane transport, such as sodium channels and pumps, as well as developed vascular networks of blood and lymph circulatory systems.

It seems highly probable today that there were two strategies of adaptation to the sodium environment. One of them implied the creation of the plasmatic membrane and considerable energy consumption associated with the constant removal of sodium ions and the preservation of the potassium environment. In this case, the osmotic pressure on both sides of the membrane should be the same and sodium ions should dominate in the external environment. Such are the external environments of mono or multi-cellular marine organisms and the extra-cellular environments of freshwater or land animals or homoiosmotic marine organisms. The osmotic pressures inside and outside the cell remained equal. The other evolutionary strategy could imply preserving the potassic cell and providing it with an envelope that would be able to withstand the high osmotic pressure inside the cell. Under these conditions, the cell may be surrounded be water or some other liquid, but the organism in question has no internal environment and does not lose energy for homeostasis. Plants have been evolving in this way.

The system of equal osmolalities in the intra- and extra-cellular fluids and the ionic gradient under equal osmolalities implied considerable energy consumption, but later this led to the formation of a centralized regulation system, the nervous system, and a special system of stabilizing the composition and volume of fluids of the internal environment. In humans and other mammals, this function is largely performed by the kidneys, which receive 25% of the minute blood volume at a time. Kidneys purify blood and return necessary substances to it. This implies a constant loss of more than 10% of cellular respiration energy, this energy only stabilizing the conditions under which all bodily cells can work. As a rule, the Malpighian glomeruli of a person, who weighs 70 kg filter about 25000 mM of sodium every day, 99%

of which is again absorbed by blood. This keeps stable physicochemical parameters of the blood and extra-cellular fluid (Natochin 2007).

2.3. Adaptive thermoregulation in different species of animals

The lowest temperature on Earth has been reported to happen in Antarctica, while the highest one, in geothermal springs has reached over 350°C (Knut 1990). The most amazing adaptations can take place at extreme temperatures: survival in inactive states, freezing, however temperatures not only vary geographically but also within a given region, temperatures can change drastically between seasons or within a given day.

Temperature can be defined as a measure of the molecular motion (Lehninger 1964). There is usually a limit beyond which an organism's biochemical processes and tissues are deeply affected and even damaged. Enzymes are also dependent on temperature changes, so their activity can be altered by them as well as the activities of their substrate and the intracellular department they act on. If the temperature changes persist, protein synthesis and degradation can also be altered, sometimes this leads to differential gene expression in order to create different isozymes (that are synthesized according to the temperature of the environment) (Prosser 1952).

On the cellular level, the membrane is kept in its usual fluid state for homeoviscous adaptation that promotes a variation of the fatty acids composition in the lipids. Even though the cell membrane constituents are the most directly affected by temperature changes, other cell constituents can also be influenced negatively, like microtubuline in mammals. Finally, temperature also induces the formation of heat shock proteins (HSP), molecular chaperones that induce thermo tolerance.

Physiologically, organisms can be affected both by low and high temperatures. Animals that are able to survive low temperatures usually face the problem of the possibility of having their contained water frozen. Some animals present freeze-tolerance, which allows them to survive ice formation in their bodies. This is quite typical in many invertebrates (insects, gastropods, nematodes). Other animals (like marine fish) directly avoid freezing, they are freeze-intolerant. They possess antifreeze compounds. Freeze tolerance can be quite a cheap strategy that is very suited for organisms living in very cold areas, whereas freeze-intolerance is better suited for more variable climates. Regarding high temperatures, animals usually show an upper critical temperature, which, if surpassed, can affect metabolical pathways, membrane structures and tissues (Hoar 1966). The heat production should equal heat loss to maintain the body's temperature.

The earliest terms used to separate the animal patterns of body temperature were simply "warm-blooded" and "cold-blooded animals". Then the terms poikiloterm and homeoterm were applied to animals according to the constancy of their body temperature (Hoar 1966). Presently we use the terms "endothermic" and "ectothermic" animals, referring to the heat sources they use. Ectotherms depend mostly on external heat sources (mainly the sun), while endotherms depend basically on their inner metabolical heat.

Endotherms have a higher mitochondrial concentration in their tissues, which enables them to produce more metabolic heat than ectotherms. Their mitochondria are also different; their uncoupled oxidative phosphorilation enables them to produce four to eight times more heat than ectotherms. Their temperature varies with activity: in birds and mammals, thoracic and abdominal organs produce most of the inner heat, but during intense activity, they can produce ten times as much heat (Willmer *et al* 2000).

Since heat is always produced by the body, its production takes lot of energy in endotherms, energy that cannot be used for other important functions such as growth and reproduction. It is crucial for these animals to remain within the thermo neutral zone, in which heat production will not vary. Heat production can be increased in three ways (Hoar 1966). First by voluntary muscular activity (physical exercise) mainly used by humans and even by certain insects, that can fly for small distances just to keep their bodies hot. Secondly, shivering (all endotherms, some ectotherms), which is directly associated to the use of oxygen. Thirdly, there exists non-shivering thermogenesis (placental mammals, marsupials, some birds) (Stott 1985). It occurs, for instance, in fat cells with many mitochondria, in much vascularised mammalian tissues (brown adipose tissue) (Svendsen 1974).

There can also be countercurrent heat exchanges that act preserving the body heat and are found in the extremities of animals living in cold climates (legs or flippers of whales, seals, gulls, horns of ungulates, tails of beavers, etc). In this case, warm blood in the arterioles runs close to the venous return, which results in the appendage being always cool. This gives way to regional heterothermy, a thermal gradient along the extremity.

Another way of preserving heat gain is insulation. Mammals can change insulation intensity by pilo-erection, the angle of the hair being changed by muscles at its root. Birds can also lower their body temperature by pilo-erection (feather fluffing), having a better control of their feathers than that of mammals with their hairs. Birds also have an uropygial gland that lubricates their feathers. This prevents the feathers from getting wet and so ensures insulation (Hutchinson 1954).

Aquatic mammals take the blood out of the body surface, an adipose layer in between the two. This is an internal insulation system. Animals also seek to adapt their temperature by looking for better environments. Small terrestrial animals can look for better microclimates: choice between sun and shade, hide-outs, nests (Prosser 1952).

Reptiles and insects also like to bask in the sun, exposing through crests and sails as much surface as they are able to. Mammals also change postures, choosing to expose either fur or naked skin depending on their heat needs. Bees are able to share their body heat in their tight hive colonies. Tundra and polar bears huddle.

Transient hyperthermia is used by large animals that live in areas where nights are very cold and by small animals living in cold hide-outs. In this way, these animals avoid having specific mechanisms to lose heat.

Animals can also regulate temperature loss by modifying the properties of the surfaces of their bodies. Humans can easily take clothes off, birds and furry animals flat their feathers and furs and sometimes can get them wet. Some animals living in very hot climates, like camels, increase the thickness of their furs, for, since their body temperature exceeds that of the air, they don't take in so much heat. Others, like lizards and a few frogs can also change their body colors through reflective crystalling platelets located within their cells, so they can be cool (Willmer *et al* 2000).

The best strategy for heat loss in the case of larger terrestrial animals is obviously evaporation. Birds and mammals develop it mainly by sweating from glands located on the body surface (Mount 1965) and panting (breathing) through their mouth, in order to lose water (Hutchinson 1954, Findlay *et al* 1950 and Findlay *et al* 1954).

In vertebrates, especially in mammals, there are hormones (adrenaline, steroids) responsible for glycogen breakdown that increase metabolic rates. Thyroid hormones have the same effect in most endotherms and also in lizards, allowing them to increase their activity (Knut 1990).

It is seen that the different strategies adopted by different species of animals to cope with temperature changes, help them to lose more heat in a controlled way. It allows more forceful muscle action and faster neurological and hormonal function, in other words a faster physiological response and more sophisticated behavior.

2.4. Cenozoic era (Recent life)

2.4.1. Human evolution

A small African ape living around six million years ago was the last animal whose descendants would include modern humans and their closest relatives, the bonobo and chimpanzees (Dawkins 2004). Only two branches of its family tree have surviving descendants. Very soon after the split, for reasons that are still debated, apes in one branch developed the ability to walk upright (Dawkins 2004). Brain size increased rapidly, and by 2 million years ago, the first animals classified in the genus *Homo* had appeared (Fortey 1999). The line between different species or even genera is somewhat arbitrary as organisms continuously change over generations. Around the same time, the other branch split into the ancestors of the common chimpanzee and the ancestors of the bonobo as evolution continued simultaneously in all life forms (Dawkins 2004).

The ability to control fire probably began in *Homo erectus* or *Homo ergaster*, probably at least 790,000 years ago (Goren-Inbar *et al* 2004) but perhaps as early as 1.5 million years ago (Dawkins 2004). In addition, it has sometimes suggested that the use and discovery of controlled fire may even predate Homo erectus. Fire was possibly used by the early Lower Paleolithic (Oldowan) hominid *Homo habilis* or strong australopithecines such as Paranthropus (McClellan 2006).

It is more difficult to establish the origin of language, it is unclear whether *Homo erectus* could speak or if that capability had not begun until *Homo sapiens* (Dawkins 2004). As brain size increased, babies were born earlier, before their heads grew too large to pass through the pelvis. As a result, they exhibited more plasticity, and thus possessed an increased capacity to learn and required a longer period of dependence. Social skills became more complex, language became more sophisticated, and tools became more elaborate. This contributed to further cooperation and intellectual development (McNeill 1999). Modern humans (*Homo sapiens*) are believed to have originated somewhere around 200,000 years ago or earlier in Africa; the oldest fossils date back to around 160,000 years ago (Gibbons 2003).

The first humans to show signs of spirituality are the Neanderthals, who buried their dead, often apparently with food or tools (Hopfe 1987). However, evidence of more sophisticated beliefs, such as the early Cro-Magnon cave paintings (probably with magical or religious significance) did not appear until some 32,000 years ago. Cro-Magnons also left behind stone figurines such as Venus of Willendorf, probably also signifying religious belief (Hopfe 1987). By 11,000 years ago, *Homo sapiens* had reached the southern tip of South America, the last of the uninhabited continents except for Antarctica, which remained undiscovered until 1820 AD (Patrick 2003). Tool use and communication continued to improve, and interpersonal relationships became more intricate.

2.4.2. Human Civilization

Throughout more than 90% of its history, *Homo sapiens* lived in small bands as nomadic hunter-gatherers (McNeill 1999). As language became more complex, the ability to remember and communicate information resulted in a new replicator, the meme (Dawkins 1989). Ideas could be exchanged quickly and passed down the generations.

Cultural evolution quickly outpaced biological evolution, and history proper began. Somewhere between 8500 and 7000 BC, humans in the Fertile Crescent in Middle East began the systematic husbandry of plants and animals in agriculture (Tudge 1998). This spread to neighboring regions, and developed independently elsewhere, until most *Homo sapiens* lived sedentary lives in permanent settlements as farmers.

Not all societies abandoned nomadism, especially those in isolated areas of the globe poor in domesticable plant species, such as Australia (Diamond 1999). However, among those civilizations that did adopt agriculture, the relative stability and increased productivity provided by farming allowed the population to expand.

Agriculture had a major impact humans began to affect the environment as never before. Surplus food allowed a priestly or governing class to arise, followed by increasing division of labor. This led to Earth's first civilization at summer in the Middle East, between 4000 and 3000 BC (McNeill 1999). Additional civilizations quickly arose in ancient Egypt, at the Indus River valley and in China.

2.5. Temperature homeostasis (thermoregulation)

Animals that maintain a fairly constant body temperature (birds and mammals) are called endotherms, while those that have a variable body temperature (all others) are called ectotherms. Endotherms normally maintain their body temperatures at around 35 - 40°C, so are sometimes called warm-blooded animals.

In humans, body temperature is controlled by the thermoregulatory centre in the hypothalamus. It receives input from two sets of thermo-receptors. Receptors in the hypothalamus itself monitor the temperature of the blood as it passes through the brain (the core temperature), and receptors in the skin especially on the trunk monitor the external temperature. Both sets of information are needed so that the body can make appropriate adjustments.

The thermoregulatory centre sends impulses to several different effectors to adjust body temperature.

The first response of human body to encountering hotter or colder condition is voluntary. If too hot, we may decide to take some clothes off, or to move into the shade; if too cold, we put extra clothes on or turn the heating up. It is only when these responses are not enough that the thermoregulatory centre is stimulated. This is part of the autonomic nervous system, so the various responses are all involuntary.

The thermoregulatory centre normally maintains a set point of 37.5 ± 0.5 °C in most mammals. However the set point can be altered in special circumstances:

- **Fever**. Chemicals called pyrogens released by white blood cells raise the set point of the thermoregulatory centre causing the whole body temperature to increase by 2-3 °C. This helps to kill bacteria, inhibits viruses, and explains why you shiver even though you are hot.
- **Hibernation**. Some mammals release hormones that reduce their set point to around 5°C while they hibernate. This drastically reduces their metabolic rate and so conserves their food reserves e.g. hedgehogs.
- **Torpor**. Bats and hummingbirds reduce their set point every day while they are inactive. They have a high surface area/volume ratio, so this reduces heat loss.

2.5.1. Adapting to climate extremes

Humans and many other mammals have unusually efficient internal temperature regulating systems that automatically maintain stable core body temperatures in cold winters and warm summers. In addition, people have developed cultural patterns and technologies that help them adjust to extremes of temperature and humidity.

In very cold climates, there is a constant danger of developing hypothermia, which is a life threatening drop in core body temperature to subnormal levels. The normal temperature for humans is about 98.6°F. However, individual differences in metabolism, hormone levels, physical activity, and even the time of day can cause it to be as much as 1°F higher or lower in healthy individuals. Hypothermia begins to occur when the core body temperature drops to 94°F. Below 85°F, the body cools more rapidly because its natural temperature regulating system in the hypothalamus usually fails. The now rapid decline in core body temperature is likely to result in death. However, there have been rare cases in which people have been revived after their temperatures had dropped to 57- 60°F and they had stopped breathing.

In extremely hot climates or as a result of uncontrollable infections, core body temperatures can rise to equally fatal levels. This is hyperthermia. Life threatening hyperthermia typically starts in humans when their temperatures rise to 105-107°F. Only a few days at this extraordinarily high temperature level are likely to result in the deterioration of internal organs and death.

2.5.2. Bergmann's Rule

In 1847, the German biologist **Carl Bergmann** observed that within the same species of warm-blooded animals, populations having less massive individuals are more often found in warm climates near the equator, while those with greater bulk, or mass, are found further from the equator in colder regions (O'Neil 2010). This is due to the fact that big animals generally have larger body masses which result in more heat being produced. The greater amount of heat results from there being more cells. A normal byproduct of metabolism in cells is heat production. Subsequently, the more cells an animal has, the more internal heat it will produce.

In addition, larger animals usually have a smaller surface area relative to their body mass and, therefore, are comparatively inefficient at radiating their body heat off into the surrounding environment. The relationship between surface area and volume of objects was described in the 1630's by Galileo (O'Neil 2010). It can be demonstrated with the cube shaped boxes shown below. Note that the volume increases twice as fast as the surface area. This is the reason that relatively less surface area results in relatively less heat being lost from animals.

Polar bears are a good example of this phenomenon. They have large, compact bodies with relatively small surface areas from which they can lose their internally produced heat. This is an important asset in cold climates. In addition, they have heavy fur and fat insulation that help retain body heat.

A study of 100 human populations showed a strong negative correlation between body mass and mean annual temperature of the region. In other words, when the air temperature is consistently high, people usually have low body mass. Similarly, when the temperature is low, they have high mass (O'Neil 2010).

A corollary of Bergmann's rule stated that a linear shaped mammal will lose heat to the environment faster than a more compact one of similar size. The boxes below illustrate this fact. Note that the long, narrow box has the same volume but greater surface area. It is comparable to a tall, slender animal (O'Neil 2010).

2.5.3. Allen's Rule

In 1877, the American biologist **Joel Allen** went further than Bergmann in observing that the length of arms, legs, and other appendages also has an effect on the amount of heat lost to the surrounding environment (O'Neil 2010). He noted that among warm blooded animals, individuals in populations of the same species living in warm climates near the equator tend to have longer limbs than do populations living further away from the equator in colder environments. This is due to the fact that a body with relatively long appendages is less compact and subsequently has more surface area. The greater the surface area, the faster body heat will be lost to the environment.

This same phenomenon can be observed among humans. Members of the Masai tribe of East Africa are normally tall and have slender bodies with long limbs that assist in the loss of body heat. This is an optimal body shape in the hot tropical parts of the world but would be at a disadvantage in subarctic regions. In such extremely cold environments, a stocky body with short appendages would be more efficient at maintaining body heat because it would have relatively less surface area compared to body mass (O'Neil 2010).

2.5.4. Cold Climate Responses

Many people living in freezing climates drink alcohol to warm themselves. This increases blood flow to the body extremities, thereby providing a feeling of warmth. However, it results only in a temporary warming and can speed up the loss of heat from the vital internal organs, resulting in more rapid death from hypothermia. A much more effective cultural response to extremely cold temperatures is the use of insulating clothing, houses, and fires. People all over the world also adapt by limiting outdoor activities to warmer times of the day. In some societies, sleeping in family groups with bodies pushed up against each other is also done in order to minimize heat loss during the cold months of the year.

As Bergmann and Allen observed, the human physiological response to cold commonly includes the evolution of more massive, compact bodies with relatively less surface area. Shivering can also cause a short-term warming effect. The increased muscle activity in shivering results in some heat production. There are three additional important types of biological responses to cold conditions found among humans around the world:

1. Increased basal metabolic rate
2. Fat insulation of vital organs
3. Change in blood flow patterns

Different populations usually develop at least one of these important adaptive responses to consistently cold conditions. People living in harsh subarctic regions, such as the Inuit (Eskimo) of the far northern regions of the western hemisphere and the Indians of Tierra del Fuego at the southern end, traditionally consumed large quantities of high calorie fatty foods. This significantly increases the basal metabolic rate, which, in turn, results in the production of extra body heat. These peoples also wore heavy clothing, often slept in a huddle with their bodies next to each other, and remained active when outdoors (O'Neil 2010).

2.5.5. Hot Climate Responses

Adapting to hot environments is as complex as adapting to cold ones. However, cold adaptation is usually more difficult physiologically for humans since we are not subarctic animals by nature. We do not grow dense fur coats nor do we usually have thick layers of fat insulation like polar bears.

The effect of heat on our bodies varies with the relative humidity of the air. High temperatures with high humidity make it harder to lose excess body heat. This is due to the fact that when the moisture content of air goes up, it becomes increasingly more difficult for sweat to evaporate. The sweat stays on our skin and we feel clammy. As a result, we do not get the cooling effect of rapid evaporation.

In dry hot weather, humidity is low and sweat evaporates readily. As a result, we usually feel reasonably comfortable in deserts at temperatures that are unbearable in tropical rain forests. The higher the desert temperatures, the more significant of a cooling effect we get from evaporation. This relationship between relative humidity and air temperature is quantified below. When the apparent temperature is in the light yellow range, heat exhaustion and cramps are likely for humans. In the bright yellow range, life threatening heat stroke is likely.

Most people have the ability to physiologically acclimatize to hot conditions over a period of days to weeks. The salt concentration of sweat progressively decreases while the volume of sweat increases. Urine volume also reduces. In addition, vasodilation of peripheral blood vessels results in increased heat loss through radiation. Vasodilation also causes flushing, or reddening, of the skin since more blood is close to the surface (O'Neil 2010).

2.5.6. Thermoregulation in humans

Thermoregulation is an important aspect of human homeostasis. Most body heat is generated in the deep organs, especially the liver, brain, and heart, and in contraction of skeletal muscles (Guyton and Hall 2006). Humans have been able to adapt to a great diversity of climates, including hot humid and hot arid. High temperatures pose serious stresses for the human body, placing it in great danger of injury or even death. For humans, adaptation to varying climatic conditions includes both physiological mechanisms as a byproduct of evolution, and the conscious development of cultural adaptations (Harrison *et al* 1988 and Weiss and Mann 1985).

There are four avenues of heat loss, convection, conduction, radiation, and evaporation. If skin temperature is greater than that of the surroundings, the body can lose heat by radiation and conduction. But if the temperature of the surroundings is greater than that of the skin, the body actually gains heat by radiation and conduction. In such conditions, the only means by which the body can rid itself of heat is by evaporation. So when the surrounding temperature is higher than the skin temperature, anything that prevents adequate evaporation will cause the internal body temperature to rise (Guyton and Hall 2006). During sports activities, evaporation becomes the main avenue of heat loss (Wilmore and Costill 1999). Humidity affects thermoregulation by limiting sweat evaporation and thus heat loss (Guyton 1976).

In hot conditions sweat glands under the skin secrete sweat (a fluid containing mostly water with some dissolved ions) which travels up the sweat duct, through the sweat pore and onto the surface of the skin. This causes heat loss via evaporative cooling; however, a lot of essential water is lost. The hairs on the skin lie flat, preventing heat from being trapped by the layer of still air between the hairs. This is caused by tiny muscles under the surface of the skin called erector pili muscles relaxing so that their attached hair follicles are not erect. These flat hairs increase the flow of air next to the skin increasing heat loss by convection. When environmental temperature is above core body temperature, sweating is the only physiological way for humans to lose heat. Arterioles Vasodilation occurs this is the process of relaxation of smooth muscle in arteriole walls allowing increased blood flow through the artery. This redirects blood into the superficial capillaries in the skin increasing heat loss by convection and conduction.

2.5.7. Thermoregulation in hot and humid conditions

In general, humans appear physiologically well adapted to hot dry conditions (Jones *et al* 1994). However, effective thermoregulation is reduced in hot, humid environments such as the Red Sea and Persian Gulf (where moderately hot summer temperatures are accompanied by unusually high vapor pressures), tropical environments, and deep mines where the atmosphere can be water-saturated (Harrison *et al* 1988 and Jones *et al* 1994). In hot-humid conditions, clothing can impede efficient evaporation (Weiss and Mann 1985). In such environments, it helps to wear light clothing such as cotton that is pervious to sweat but impervious to radiant heat from the sun. This minimizes the gaining of radiant heat, while allowing as much evaporation to occur as the environment will allow. Clothing such as plastic fabrics that are impermeable to sweat and thus do not facilitate heat loss through evaporation, can actually contribute to heat stress (Guyton 1976).

In cold conditions sweat production stops. The minute muscles under the surface of the skin called erector pili muscles attached to an individual hair follicle contract (piloerection), lifting the hair follicle upright. This makes our hairs stand on end which acts as an insulating layer, trapping heat. This is what also causes goose bumps since humans don't have very much hair and the contracted muscles can easily be seen. Arterioles carrying blood to superficial capillaries under the surface of the skin can shrink (constrict), thereby rerouting blood away from the skin and towards the warmer core of the body. This prevents blood from losing heat to the surroundings and also prevents the core temperature dropping further. This process is called vasoconstriction. It is impossible to prevent all heat loss from the blood, only to reduce it. In extremely cold conditions excessive vasoconstriction leads to numbness and pale skin. Frostbite only occurs when water within the cells begins to freeze, this destroys the cell causing damage. Muscles can also receive messages from the thermo-regulatory center of the brain the hypothalamus to cause shivering. This increases heat production as respiration is an exothermic reaction in muscle cells. Shivering is more effective than exercise at producing heat because the animal remains still. This means that less heat is lost to the environment via convection. There are two types of shivering, the low intensity and high intensity. During low intensity shivering animals shiver constantly at a low level for months during cold conditions. During high intensity shivering animals shiver violently for a relatively short time. Both processes consume energy although high intensity shivering uses glucose as a fuel source and low intensity tends to use fats. This is a primary reason why animals store up food in the winter. Mitochondria can convert fat directly into heat energy, increasing the temperature of all cells in the body. Brown fat is specialized for this purpose, and is abundant in newborns and animals that hibernate.

2.5.8. Human temperature variation effects

2.5.8.1. Hot condition

- **37 °C (99 °F)** - Normal body temperature, which varies between about 36.12–37.5 °C (97–100 °F)
- **38 °C (100 °F)** - Sweating, feeling very uncomfortable, slightly hungry.
- **39 °C (102 °F)** - Severe sweating, flushed and very red. Fast heart rate and breathlessness. There may be exhaustion accompanying this. Children and people with epilepsy may be very likely to get convulsions at this point.
- **40 °C (104 °F)** - Fainting, dehydration, weakness, vomiting, headache and dizziness may occur as well as profuse sweating. Starts to be life-threatening.
- **41 °C (106 °F)** - (Medical emergency) - Fainting, vomiting, severe headache, dizziness, confusion, hallucinations, delirium and drowsiness can occur. There may also be palpitations and breathlessness.
- **42 °C (108 °F)** - Subject may turn pale or remain flushed and red. They may become comatose, be in severe delirium, vomiting, and convulsions can occur. Blood pressure may be high or low and heart rate will be very fast.

- **43 °C (109 °F)** - Normally death, or there may be serious brain damage, continuous convulsions and shock. Cardio-respiratory collapse will likely occur.
- **44 °C (111 °F) or more** - Almost certainly death will occur; however, patients have been known to survive up to 46.5 °C (115.7 °F).

2.5.8.2. Cold condition

- **37 °C (99 °F)** - Normal body temperature, which varies between about 36–37.5 °C (97–100 °F)
- **36 °C (97 °F)** - Mild to moderate shivering in which body temperature may drop this low during sleep. May be a normal body temperature.
- **35 °C (95 °F)** - (Hypothermia) is less than 35 °C (95 °F) - Intense shivering, numbness and bluish/grayness of the skin. There is the possibility of heart irritability.
- **34 °C (93 °F)** - Severe shivering, loss of movement of fingers, blueness and confusion. Some behavioral changes may take place.
- **33 °C (91 °F)** - Moderate to severe confusion, sleepiness, depressed reflexes, progressive loss of shivering, slow heart beat, shallow breathing. Shivering may stop. Subject may be unresponsive to certain stimuli.
- **32 °C (90 °F)** - (Medical emergency) Hallucinations, delirium, complete confusion, extreme sleepiness that is progressively becoming comatose. Shivering is absent (subject may even think they are hot). Reflex may be absent or very slight.
- **31 °C (88 °F)** - Comatose, very rarely conscious. No or slight reflexes. Very shallow breathing and slow heart rate. Possibility of serious heart rhythm problems.

- **28 °C (82 °F)** - Severe heart rhythm disturbances are likely and breathing may stop at any time. Patient may appear to be dead.
- **24–26 °C (75–79 °F) or less** - Death usually occurs due to irregular heart beat or respiratory arrest; however, a woman named Anna Bågenholm was recorded to have survived with body temperatures as low as 13.7 °C (56.7 °F).

2.6. Adapting to High Altitude

There are two major kinds of environmental stresses at high altitude for humans. First, there are the alternating daily extremes of climate that often range from hot, sun burning days to freezing nights. In addition, winds are often strong and humidity low, resulting in rapid dehydration. Second, the air pressure is lower. This is usually the most significant limiting factor in high mountain regions (O'Neil 2010).

The percentage of oxygen in the air at two miles (3.2 km.) is the same as at sea level (21%). However, the air pressure is 30% lower at the higher altitude due to the fact that the atmosphere is less dense--that is, the air molecules are farther apart.

The oxygen easily pass through selectively permeable lung membranes into the blood, when we breathe air at sea level with the atmospheric pressure of about 14.7 pounds per square inch (1.04 kg. per cm.2) and at high altitudes, the lower air pressure makes it more difficult for oxygen to enter our vascular systems resulting hypoxia or oxygen deprivation. Hypoxia usually begins with the inability to do normal physical activities, such as climbing a short flight of stairs without fatigue. Other early symptoms of high altitude sickness include a lack of appetite, distorted vision, and difficulty with memorizing and thinking clearly. In serious cases, pneumonia-like symptoms (pulmonary edema) and an abnormal accumulation of fluid around the brain (cerebral edema) develop, leading to death within a few days if there is not a return to normal air pressure levels. There is also an increased risk of heart failure due to the added stress placed on the lungs, heart, and arteries at high altitudes.

When we travel to high altitudes, our bodies initially develop inefficient physiological responses. There is an increase in breathing and heart rate to as much as double even while resting. Pulse rate and blood pressure go up sharply as our hearts pump harder to get more oxygen to the cells. These are stressful changes, especially for people with weak hearts.

Later, a more efficient response normally develops as acclimatization takes place. More red blood cells and capillaries are produced to carry more oxygen. The lungs increase in size to facilitate the osmosis of oxygen and carbon dioxide. There is also an increase in the vascular network of muscles which enhances the transfer of gases.

However, successful acclimatization rarely results in the same level of physical and mental fitness that was typical of altitudes close to sea level. Strenuous exercise and memorization tasks still remain more difficult. In addition, the rate of miscarriages is usually higher at altitudes above two miles.

On returning to sea level after successful acclimatization to high altitude, the body usually has more red blood cells and greater lung expansion capability than needed. Since this provides athletes in endurance sports with a competitive advantage, the U.S. maintains an Olympic training center in the mountains of Colorado. Several other nations also train their athletes at high altitude for this reason. However, the physiological changes that result in increased fitness are short term at low altitude. In a matter of weeks, the body returns to a normal fitness level.

`There is considerable variability between individuals and between populations in their ability to adjust to the environmental stresses of high mountain regions. Usually, the populations that are most successful are those whose ancestors have lived at high altitudes for thousands of years. This is the case with some of the indigenous peoples living in the Andes Mountains of Peru and Bolivia as well as the Tibetans and Nepalese in the Himalaya Mountains. The ancestors of many people in each of these populations have lived above 13,000 feet (ca. 4000 meters) for at least 2,700 years (O'Neil 2010).

The implication is that natural selection over thousands of years results in some populations being genetically more suited to the stresses at high altitude. However, different populations respond physiologically to low oxygen pressure in somewhat different ways. The primary solution of Indians from the high mountain valleys in Peru and Bolivia has been to produce more hemoglobin in their blood and to increase their lung expansion capability. Both result in an increase of oxygen carried by the blood. In contrast, the common solution of Tibetans and Nepalese who live at high altitudes generally has been to breathe faster in order to take in more oxygen and to have broader arteries and capillaries, thereby allowing much higher rates of blood flow and subsequently greater amounts of oxygen delivered to their muscles despite the fact that they have relatively low hemoglobin levels. A recent study of Tibetan villagers who live their lives at around 15,000 feet has shown that they have 10 oxygen-processing genes not commonly found in lowland populations. The EPAS1 gene is particularly important in adapting to environments with consistently low oxygen pressure (O'Neil 2010).

2.7. Human adaptation to heat

When humans are exposed to a hot environment, there is an accumulation of metabolic heat produced in the body that results hyperthermia due to a decrease in heat dissipation. Hyperthermia is also induced by an increase in metabolic heat production during exercise. In order to lessen the rise in body temperature due to heat load produced by a hot environment and/or by massive metabolic heat production during physical work, physiological responses in favor of heat dissipation, such as sweating and adjustments in cutaneous blood flow, are brought about by a rise in body temperature. Human adaptation to heat is comprehensive of a broad problem. Heat acclimatization is a term used to express heat adaptation caused by an artificially hot environment. In a hot environment, heat acclimatized individuals can be characterized by a higher core temperature, marked cardiovascular strain indicated by a higher heart rate, and limited work capacity. After repeated exposure to heat, subjects can work longer with a lower increase in heart rate and a lower rise in core temperature. This is due to an increase in sweat volume with a lower salt concentration, enabling the individual to tolerate more severe heat load. However these adaptive changes in physiological responses to heat observed during short term heat adaptation gradually disappear over a period of several weeks after a cessation of heat exposure. During long term acclimatization, fully heat acclimatized individuals such as residents of tropical zone areas sweat less there rise in core temperature and increase in heart rate or also less at a given heat load, when compared with heat un-acclimatized individuals. These adaptive changes to heat exposure obtain during long term heat adaptation are stable and maintained for a long period. Heat adaptation appears at various levels in the body i.e. the subcellular level, the cellular level, and the organ level. Exposure of human cells to heat induces the production of heat shock proteins, molecular chaperones. A transient resistance to subsequent heat treatments and tolerance of cell to heat may be associated with the production of heat shock proteins. However, specific mechanisms of thermo tolerance in humans due to production of heat shock proteins have not been well elucidated (Hori 1995).

2.7.1. Basal metabolism

In order to maintain a constant body temperature, heat produced in the body must be transferred from the body to the environment. In hot environments the body heat content of resting subjects increases more slowly then that of working subjects, because metabolic heat production at west is smaller that that during work. Since the metabolic rate is approximately proportional to the basal metabolic rate a lower basal metabolism is more favorable with regard to the maintenance of the lower body temperature in a hot environment and tolerance to heat. Many investigations have been carried out on the seasonal variation of basal metabolism over the last 45 years in Japan. Researchers have reported the existence of an inverse relationship between basal metabolism and ambient temperature. A study of the correlation between basal metabolism and monthly mean ambient temperature in 134 young men living in different part of Japan was reported by Ogata and Sasaki (1975). They observed a linear correlation between basal metabolism and mean outdoor temperature within a temperature range of 10-25^{o}C. They found that a rise of 10^{0}C in monthly mean ambient temperature was accompanied by a fall of 2.5-3.5 kilo calorie/m^2/h in basal metabolism. The basal metabolism is linearly correlated with the monthly mean ambient temperature with in a temperature range of 10-27^{o}C. Basal metabolism can also be seen to decrease at a rate of 2.1 k cal/m^2/h with an increase of 10^{o}C in the monthly mean ambient temperature.

According to Yoshimura *et al* (1978) a high intake of carbohydrate tends to accelerate the reduction of basal metabolism and the release of thyroxin caused by heat acclimatization, while high intake of fat inhibits this. The reduction of basal metabolism of subjects in hot climate is considered to be one of the most important physiological adaptations during heat adaptation. This is because the metabolic heat produced in the body must be dissipated into the environment in order to maintain a constant body temperature.

Heat un-acclimatized subjects who perform moderate work in hot environments are characterized by a high rise in core temperature, marked cardiovascular strain, higher concentration of plasma lactate and severe fatigue when compared with heat acclimatized subjects. After successive heat exposures or physical training, subjects have been found to be able to work longer, have a greater work capacity with slower heart rate, lower metabolic rate, lower rise in core temperature and a lower concentration of plasma lactate during exercise in heat. Successive exposure to a combination of exercise and environmental heat cause rapid adaptive changes in physiological responses to heat such as a decrease in ventilation, a decrease in heart rate and a smaller rise in core temperature during heat exposure and exercise in heat when compared with repeated exposures to heat at. The decrease in metabolic heat production during heat exposure or exercise in heat occurs slowly during heat adaptation. A decrease in the metabolic rate is caused by a reduction in ventilatory volume and heart rate, as well as smaller energy expenditure, due to a lower rise in core temperature. A reduction in ventilatory volume might be the result of a lower concentration of blood lactate. The lower accumulation of plasma lactate during exercise is caused by a decrease in the amount of lactate produced by working muscle tissue due to an improvement of circulation in muscle tissue accompanied by a lower core temperature.

2.7.2. Subcutaneous fat and cutaneous circulation

The exchange of heat by radiation, convection and conduction between the body and the environment depends on the difference in temperature between the body surface and the environment; evaporative heat dissipation from the body is determined by the rate of evaporation of water from the skin, air passages and lungs. Non-evaporative heat dissipation from the body to the air occurs when the skin temperature is higher than the air temperature and the amount of heat dissipation is proportional to the temperature gradient between the skin surface and the air. Skin temperature is determined mainly by the thickness of subcutaneous fat and cutaneous circulation at a given ambient temperature before sweating occurs. Subcutaneous fat prevents transference of metabolic heat produced in the body from the core to the cell and results in a lower skin temperature. The capacity to dissipate heat from the body to the environment is proportional to the body surface area and the metabolic heat produced in the body is proportional to the body weight when moving as in the case of walking and running. A decrease in the subcutaneous fat layer causes a change in the body shape, such that the ratio of body surface area to body weight is increased. Thus a reduction in subcutaneous fat in a hot climate is considered to be favorable for heat dissipation from the body to the environment. This is due to an improved capacity for non-evaporative heat dissipation induced by a higher skin temperature and a greater ratio of body surface area to body weight (Hori 1995).

2.7.3. Sweating

Sweating is the main mechanism of heat dissipation for human is a hot environment. Adaptive changes in sweating to heat have been studied by many investigators. It is now well recognized that different characteristics of heat acclimatization with regard to the sweat reaction between short term heat acclimatization and long term heat acclimatization exist. The adaptation of sweating implies two phenomenon's. The first is the adaptation of the sweat gland to heat and second is the adaptive changes in the sweating centers. An adaptation of sweating during short term heat acclimatization is distinctly different from that during long term heat acclimatization (Hori 1995).

2.7.4. Body fluid

It is known that the volume and constituents of body fluid change during heat adaptation. Adult water loss through the kidney, skin and respiratory tract ranges from 2.5 l/day in sedentary subjects in a cool environment to 10 l/day in subjects working for a long time in a hot environment. Most water loss in hot environments is caused by profuse sweating, which is proportional to the need for cooling the body by evaporation of water in sweat. The volume of water intake needed to balance water loss in sweat in hot environments depends upon the degree of thirst caused by dehydration and the increase in osmolarity of body fluid caused by sweating. Subjects usually drink at a rate of 50-70 % of their sweating rate and this state of dehydration after profuse sweating is called voluntary dehydration by Adolph (1947). The volume of voluntary dehydration in heat un-acclimatized subjects who secrete less sweat with a higher salt concentration is usually greater due to less water intake caused by a smaller rise in the osmotic pressure of extra cellular fluid, whereas that of heat acclimatized subjects who secrete a larger volume of sweat containing a relatively low concentration of salt is small. In transitory adaptation to heat total water loss, total water intake, circulating serum volume, extra cellular fluid volume and total body water increase gradually.

Seasonal variation in the serum volume and concentration of serum constituents have been reported by many investigators. The seasonal differences in osmolarity, concentrations of sodium chloride, potassium and antidiuretic hormone (ADH) of serum hematocrit value and blood volume measured under basal condition are present in the table 2.3. Osmolarity and concentration of sodium and potassium decrease during the summer, whereas concentration of ADH increases during summer. The concentration of chloride and hematocrit value decrease slightly and the blood volume increases in summer. The decrease in the hematocrit value during the summer is caused by an increase in the circulating plasma volume. These seasonal changes in serum constituents and serum volume are caused by changes in body fluid, particularly extra cellular fluid. The most remarkable seasonal change is observed in the concentration of serum (ADH). The magnitude of physiological strain induced in the body in terms of water metabolism at a given sweat volume is lessened by an increase in volume of circulating plasma and body fluid during the summer.

Table No. 2.3 Seasonal changes in blood constituents and blood volume (Hori 1995)

Parameter	Winter (Mean ± SD)	Summer (Mean ± SD)	*p Value*
Osmolarity (mOsm/kg H_2O)	287.2 ± 3.6*	282.9 ± 4.5	0.001
Sodium (meq/l)	139.6 ± 4.5	129.8 ± 3.1	0.001
Chloride (meq/l)	104.7 ± 3.5	103.6 ± 2.3	n.s.
Potassium (meq/l)	4.0 ± 0.1	3.9 ± 0.2	0.05
Hematocrit (%)	44.2 ± 2.4	43.7 ± 3.3	n.s.
Anti Diuretic Harmone (μU/ml)	5.8 ± 0.8	12.6 ± 1.6	0.001
Blood volume (ml/kg)	85.5 ± 7.4	86.2 ± 9.1	n.s.

2.7.5. Body temperature

The amount of heat dissipation from the body both radiation and convection is proportional to the temperature gradient between the skin surface and the surrounding air. Thus an individual's ability to dissipate heat without sweating is dependent upon his capacity to raise the mean skin temperature in accordance with a rise in ambient temperature the mean skin temperature is thought to be the best index when measuring the capacity of heat dissipation trough radiation and convection.

2.7.6. Influence of age sex on heat adaptation

Basal metabolic rate and resting metabolic rates of children in relation to their body surface area are greater due to rapid synthesis of cellular materials and growth when compared to adults. However the basal metabolic rate per body surface area in children decreases with age. In order to maintain a constant body temperature, metabolic heat produced within the body must be dissipated into the environment at the same rate as its production. Since heat dissipation by radiation convection and conduction is proportional to the temperature gradient between the skin surface and the environment, the mean skin temperature for children is maintained at a higher level due to greater internal heat stress accompanied by a higher metabolic rate that that of an adult. The rate of sweating per body surface area for a child is greater than that of an adult due to greater number of active sweat glands per unit skin area. However the secretory activities of individual sweat glands are lower. The density of sweat glands on the skin surface decreases and their secretory activities increases as children grow. The magnitude of environmental heat stress in a child with a greater ratio of body surface area to body weight is usually greater than that in an adult. Sweating in children occurs earlier and its rate increases more rapidly when compared with adults during exposure to hot environments. It is known that an adult sweats more profusely in summer than in winter and an increase in the sweat rate in summer occurs as a consequence of heat adaptation. Seasonal changes in the sweat rate is less in children than in adults and the difference in sweat volume between children and adults is smaller in summer than in winter, this fact may be because of the greater frequency of sweating in children during winter.

Women have a lower basal metabolic rate per body surface area and thicker subcutaneous fat layer than men and their core body temperature is 0.4 to 0.5^{o}C higher during the luteal phase than in the follicular phase under basal conditions. The rate of rise in the skin temperature with a rise in ambient temperature is greater in women than in men and the skin temperature of women can be raised higher during exposure to extreme heat. The increase in metabolic rate accompanied by a rise in body temperature tends to be a smaller in women than in men. Women can keep a lower core temperature than men due to a smaller temperature difference between the air and skin surface as well as a lower metabolic rate when the ambient temperature is higher than the skin temperature. It is generally believed that the female sweat rate is lower than that of male and hidromeiosis develops more readily and to a greater extent. When women and men performs the same work load, the greater rise in core temperature and greater increase in heart rate for women than for male are attributable to the greater work rate per body surface area for women. However, women can exercise at a given work load with a smaller rise in core temperature and a lower increase in heart rate due to a lower increase in metabolic rate with a rise in ambient temperature. Adaptive changes in physiological response to heat exposure or a combination of exercise and environmental heat induced by repeated exposure to heat for women are similar to those for men and essentially the same differences in the physiological responses of both sexes to heat exposures at rest and a combination of exercise and environmental heat are maintained after repeated exposure to a hot environment. Thus it can be said that the differences in adaptive changes in physiological responses to heat between women and men are quantitative rather than qualitative (Hori 1995).

2.8. Contribution of modern science in electrolyte excretion and environmental factors in 20th century

In the last millennium during industrial revolution there has been tremendous migration of the human being for a better job, social security and living being which resulted into exploration of newer countries and settlements with diverse environmental situation. Migration of population did not limit only to industrial town but also to remote areas of different altitude as well as tropical and temperate zones which had better resources as well as raw material for starting new industries and cultivation of agricultural products. Apart from the availability of raw material and natural resources there were also health related challenges to the individuals and those who could sustain the extreme variation of environmental factors and adverse climatic changes survived and sustained the development in that particular geographical situation. Countries which had abundance of natural resources as well as food faced the problem of foreign intruders and segregation of various political systems led to explosion of war and this was a new challenge to the invaders who had to survive in different environmental conditions of which does not exist before in their native countries.

2.8.1. Body mass index and blood pressure

In the beginning of 19^{th} century the need for an index of normal relative body weight was recognized soon after the actuaries noted the increased death claim of their obese policy holders (Medico –Actuarial mortality investigation 1912). Adolphe Quetelet in 1932 was the first person who developed height and weight table to study its relationship, which was known as the Quetelet Index (Billewicz *et al* 1962 and Khosla and Lowe 1967). The validity of Quetelet Index in epidemiological studies was first studied during the fourth examination of the Framingham study (Florey 1970). Ancel Keys confirmed the validity of Quetelet Index and named it the body mass index (Keys *et al* 1972). The WHO has identified (WHO 1997) four categories of body mass index, which are as follows under weight <18.5 kg/m^2, normal 18.5 – 24.9 kg/m^2, overweight 25.0 – 29.9 kg/m^2 and obese > 30kg/m^2.

An Australian study by Allman-Farinelli *et al* (2010) found significantly higher body mass index of white collar male subject (27.3 ± 4.4) than blue collar male (26.3 ± 4.8). However a reverse pattern was observed in female white collar (24.9 ± 4.8) and blue collar (25.6 ± 5.1). In a Northeast Indian study by Khongsdier on tribal group found high body mass index in Mechs (20.49 ± 1.13) (tribes from Assam) than Pnars (19.85 ± 1.46) (tribes from Meghalaya) (Khongsdier 2001). Another Indian study form Jalandhar, Punjab on female labourers found significantly high body mass index in house wife (24.82 ± 4.45) than labourers (19.58 ± 2.68) (Koley *et al* 2009).

A study by Kasl and Cobb (1970) found elevated systolic and diastolic blood pressure among blue collar men than female. Gyntelberg and Meyer (1974) and Stamler *et al* (1978) showed a positive linear relationship between blood pressure and relative body weight. Another study by Arnetz *et al* (1988) found slightly lower blood pressure in blue collar female worker than male. Another different study by Sanchez *et al* (1987) and Stamler *et al* (1997) observed that the person with higher body mass index consume more sodium. A study from Africa and Caribbean men and women found positive correlation between body mass index and blood pressure in both sex (Kaufman *et al* 1997). A London based study on white collar men and women found low systolic and diastolic blood pressure in women than men whereas low body mass index was observed in men (Ferrie *et al* 1998).

An Indian study North-East on Assam tea garden laborers found the systolic and diastolic blood pressure rise with age more so in female than in male which followed the same fashion as examined by Hamilton *et al* (2006) in London (Wilson 1954). A significant correlation between systolic blood pressure and age was also reported in a study from India (Singh *et al* 1997). Another Northeastern study on Mizos, Assamese and tea garden worker found significant positive correlation between age and systolic blood pressure in Mizos (Hazarika *et al* 2000).

In studies from Nigeria and Tanzania the significant correlation is observed between body mass index and blood pressure (Kadiri *et al* (1999) and Njelekela *et al* (2001)). Another study from Lithuania on adolescent boys and girls showed a significant positive correlation between mean blood pressure and height in boys, whereas no such relationship was observed in girls (Jankunas *et al* 2001). A Japanese study found significant negative correlation between calcium intake and blood pressure in women than men. However negative association of urinary sodium excretion with blood pressure was observed in both sexes. The body mass index, blood pressure (systolic and diastolic), urinary sodium and potassium excretion was found significantly high in men than women (Morikawa *et al* 2002). A study by Guimont *et al* (2006) in Quebec City found the significant higher systolic and diastolic blood pressure (121.4 ± 12 and 76.4 ± 9.1) in men than women white collar individuals (110.8 ± 11.6 and 70.3 ± 8.8). Another study by Tefaye *et al* (2007) found significant positive correlation between body mass index and blood pressure in three populations of Indonesia, Ethiopia and Vietnam. Another Nigerian study on adults found significant positive correlation of weight and body mass index with systolic and diastolic blood pressure. The female had shown significantly high body mass index and diastolic blood pressure than male. However systolic blood pressure was observed high in male subjects (Adedoyin *et al* 2008). In a Turkey based study found significantly higher body mass index, systolic and diastolic blood pressure in girls than boys (Gundogdu 2008). Another study by Sanya *et al* (2009) found significant linear correlation between blood pressure and body mass index.

In a Northeast Indian study a significant negative correlation was observed between age and body mass index (Khongsdier 2002). In another Wardha based Indian study found a strong correlation between body mass index and systolic and diastolic blood pressure. In this study men had significantly high body mass index (19.1 ± 4.23) than women (18.8 ± 6.08). Similar pattern was observed in systolic and diastolic blood pressure in men (120.2 ± 17.6 and 77.7 ± 12.4) and women (118.4 ± 20.7 and 76.3 ± 74.7) (Deshmukh *et al* 2006). A study by Sarkar *et al* (2009) found significantly low body mass index in men than women, whereas systolic and diastolic blood pressure was observed significantly high in men. The body mass index was positive correlated with systolic and diastolic blood pressure in both sex. A Tibetans study by Tripathy and Gupta (2007) found strong positive correlation between age and blood pressure in both male and female.

2.8.2. Blood pressure and electrolytes

The British study by Bulpitt *et al* (1981) found inverse relationship between serum sodium and blood pressure. The Kesteloot and Geboers (1982) and Kesteloot (1986) found a highly significant positive relationship between Serum calcium and blood pressure. A Belgian based similar type of study found a highly significant negative correlation between serum sodium and systolic and diastolic blood pressure whereas serum calcium correlated positively with both systolic and diastolic blood pressure in men but in women only with diastolic blood pressure. However serum potassium correlated negatively with blood pressure only in men (Kesteloot and Joossens 1988). In a study by Jorde *et al* (1999) from Municipality of Tromso found higher serum calcium level in men then women, which was significantly and positively correlated with systolic and diastolic blood pressure.

In a Lithuania based study found significantly high urinary chloride excretion in male than female. The blood pressure was positively correlated with urinary chloride excretion in male only. The systolic blood pressure was found high in male than female. The height and body weight significantly correlated with blood pressure in male only. Urinary chloride showed strong correlation with urinary sodium in both sex. However a significantly weak correlation was found in urinary chloride and urinary potassium in male only (Jankunas *et al* 2002). Another study by Jankunas *et al* (2002) found that urinary sodium excretion was negatively correlated with diastolic blood pressure in female than male.

2.8.3. Vegetarian and non-vegetarian diet and electrolyte excretion pattern

Diet and blood pressure have been a recent observation as one of the important contributing factor in the middle of 20th century. In 1930 Saile first hinted that vegetarians have lower blood pressure than meat eater of the same age. Another study from University of Western Australia by Armstrong *et al* (1979) reported low mean blood pressure and higher urinary sodium and potassium excretion in vegetarian than non-vegetarian. The urinary sodium to potassium ratio was found to be positively correlated with systolic diastolic blood pressure in non-vegetarian. The sodium intake was found similar in both vegetarian and non-vegetarian. A similar study by Israeli vegetarian association study found low blood pressure in vegetarian (126 & 77 mm Hg) than non-vegetarian (146.8 & 87.6 mm Hg). The vegetarian showed significantly high urinary potassium excretion and low mean Na^+/K^+ excretion ratio than nonvegetarian. The relative body weight of vegetarian was significantly lower than non-vegetarian (Ophir *et al* 1983). In a study by Ko and Chang (1983) found significantly higher diastolic blood pressure in vegetarian female than non-vegetarian. Another study from Pudue University found low body mass index, systolic and diastolic blood pressure in black and white vegetarian than non-vegetarian. The dietary intake of protein, carbohydrate, fat, sodium and potassium intake were also followed the similar pattern (Christopher *et al* 1989). Another study by Wyatt *et al* (1995) from Mexico found a significant lower body mass index and mean blood pressure (110 and 86 mm Hg) in vegetarian than non-vegetarian. However low sodium intake (1367 ± 919 mg/d) and high potassium intake (3700 ± 2294 mg/d) was found in vegetarian. A Chinese study on elder subjects found lower total energy, fat and protein intake in vegetarian than non-vegetarian, while carbohydrate, calcium and potassium intake were higher (Woo *et al* 1998). An Oxford based study found low mean body mass index in non-meat eater than meat eater (Appleby *et al* 1998).

In a Melbourne based study by Duo *et al* (2000) found significantly lower dietary sodium/ potassium ratio in vegetarian than meat eater. In addition meat eater had a significantly higher dietary calcium and sodium intake than vegetarian. However potassium intake was slightly higher in vegetarian. Another Sweden based study the body mass index of male vegetarian was found significantly lower than male non-vegetarian (Larrson and Johansson 2002). Similar Oxford based study found significantly higher body mass index in meat eater than vegetarian. The vegetarian men and women showed low systolic and diastolic blood pressure than non-vegetarian. Overall energy consumption has been found positively associated with blood pressure in both men and women. The carbohydrate intake was inversely associated with systolic blood pressure in men only whereas fat intake was inversely associated with systolic blood pressure in both sex. However the positive association of calcium intake with systolic blood pressure was found only in women (Appleby *et al* 2002). In a study from Taiwan on preschool children and their parents found significantly higher protein, fat and fiber intake in non-vegetarian child and their parents than vegetarian. The carbohydrate, total energy and calcium intake was found high in vegetarian than non-vegetarian. The nonvegetarian child and parents had significantly higher body mass index, systolic and diastolic blood pressure than vegetarian (Yen *et al* 2008). Another study from Taiwan observed significantly lower systolic blood pressure in vegetarian (114 ± 15.7 mm Hg) than non-vegetarian (119.7 ± 18.5 mm Hg). However diastolic blood pressure was found significantly higher in vegetarians (77.0 ± 10.0 mm Hg) than non-vegetarians (73.3 ± 10.1 mm Hg). The urinary sodium excretion was found significantly low in vegetarian (139 ± 7.4 mm Hg) than non-vegetarian (144.3 ± 2.3 mm Hg) (Lin *et al* 2010).

2.8.4. Dietary electrolyte constituent and blood pressure

The role of potassium salts in declining blood pressure was first found by Addison (1928). A Georgia based study on blacks and white showed a negative correlation between blood pressure and dietary potassium (Grim *et al* 1980). These had been confirmed by several studies (Ueshima *et al* 1981). Another Rancho Bernardo based study by Khaw and Connor (1987) found the similar significant inverse correlation of dietary potassium intake with blood pressure in both male and female. A similar study from Netherland found higher potassium intake in boys than girls and urinary potassium excretion was strongly and inversely associated with systolic blood pressure (Geleijnse *et al* 1990). A Rotterdam study on older subjects found an inverse correlation between potassium intake and magnesium intake with systolic and diastolic blood pressure (Geleijnse *et al* 1996). The study of Ascherio *et al* (1998) found a significant inverse relationship between potassium intake and blood pressure in men.

Another similar type of study from US found significantly negative correlation between potassium intake and body mass index and blood pressure. However dietary intake of energy was positively correlated with potassium intake (Ascherio *et al* 2001). Another study from Honolulu found inverse correlation of potassium intake and serum potassium with blood pressure in older individuals (Green *et al* 2002). In a study by Kaplan & Rose (2009) found significant positive correlation between dietary potassium intake and urinary sodium excretion. In a only one study from India Krishna *et al* (1989 and 1991) found a low potassium diet increase significantly mean blood pressure.

The electrolyte calcium in plasma exists in 3 major forms. Approximately 50% is in the free or ionized form, which is physiologically the important fraction, 40% is bound to albumin, and the remaining 10% is in soluble complexes with anions such as bicarbonate, phosphate and lactate (Moore 1970). A study in 1977 by W.M. Smith found the inverse association between calcium intake and blood pressure. The epidemiologic link between dietary calcium intake and blood pressure was first found by McCarron *et al* (1982). A Belgian based study the serum calcium level was found to be increase with dietary calcium intake (Kesteloot and Joossens 1988). Another study by Wittman *et al* (1989) reaffirmed the above hypothesis and found linear correlation between dietary calcium intake and blood pressure. In a similar Japan based study found inverse association between dietary calcium intake and blood pressure (Iso *et al* 1991). In a study by Osborne *et al* (1996) found negative association between the dietary calcium intake and blood pressure.

A Japanese study by Kihara *et al* (1983) found positive link of sodium intake and negative link of potassium intake with blood pressure. Another US based study by Vollmer *et al* (2001) found positive correlation between sodium intake and blood pressure in older age group above 45 years. In a study from West Africa by Francesco *et al* (2006) found significant positive correlation between salt intake and both systolic and diastolic blood pressure. However the urinary sodium had significant positive correlation with only systolic blood pressure. Another study by Nowson and Morgan (2007) found a significant positive correlation between dietary sodium/potassium ratio and urinary sodium potassium ratio. The blood pressure was positive correlated with sodium intake and negative with potassium intake.

The Japanese study by Kimula (1977) reported the first time an inverse relation between the amount of protein in the diet particularly animal protein and blood pressure. The Yamori *et al* (1981) found a significant inverse relation of total carbohydrate in take to systolic blood pressure. In a Zulphen based study Kromhout e*t al* (1982) found inverse relationship between dietary fiber intake and blood pressure. Another Southern California based study by

Ackley *et al* (1983) found the similar pattern in men. A study by Liu *et al* (1993) on British adults found a significant inverse correlation between total carbohydrate intake and systolic blood pressure. This was confirmed by Stamler *et al* in 1996.

2.8.5. Association of seasonal variation and altitude with blood pressure

The seasonal influence on blood pressure was first described in Britain by Rose in 1961. Heller *et al* (1978) reported an inverse relationship between diastolic blood pressure and the room temperature. Another similar study by Medical Research Council, Harrow, Middlesex found higher systolic and diastolic blood pressure in winter than in summer. The urinary sodium excretion was significantly higher in winter than summer. This seasonal variation in blood pressure and urinary sodium excretion was greater in older than younger subjects (Brennan *et al* 1982). Studies from Unites states, Great Britain and Australia in school children found a significant correlation between air temperature and bloods pressure (Swiet *et al* (1984) and Jenner *et al* 1987). The blood pressure was found to be significantly low in summer and high in winter (Woodhouse *et al* 1993). A study by Kristal-Boneh *et al* (1996) found the inverse association between seasonal variations in blood pressure and body mass index in both sex. Another study by Argiles *et al* (1998) from Germany found the highest mean systolic and diastolic blood pressure during the winter (153 ± 3 mm Hg and 82 ± 2 mm Hg) and lowest during summer (141 ± 3 mm Hg and 75 ± 2 mm Hg). Blood pressure was inversely correlated with temperature and positively with humidity.

In a study by Modesti *et al* (2006) found inverse correlation between air temperature and systolic blood pressure. Another study by Rosenthal (2007) found inverse correlation between blood pressure and ambient temperature. The blood pressure was observed high in cold and low in summer. In a study from 3 French cities found significant inverse correlation between ambient temperature and systolic and diastolic blood pressure in the elder subjects. The blood pressure was observed significantly low in spring and summer (145.8 ± 22.1 mm Hg, 80.9 ± 12.0 mm Hg and 144 ± 22.4 mm Hg, 81.0 ± 11.7 mm Hg), whereas increased in winter (149 ± 22.4 mm Hg and 82.1 ± 12.3 mm Hg) (Alperovitch *et al* 2009). Another study from Boston found significant inverse correlation between ambient temperature and blood pressure (Halonen *et al* 2010).

In the beginning of 1910 S.C.Harvey demonstrated that excretion of electrolytes have an important role, when an individual is exposed to high altitude of 18000 feet above sea level by compensating forced breathing of air, which could result in a diuresis of an alkaline urine. In 1919 J.B.Leathes also supplemented the same observation, which was supported by Devies *et al* in 1920-21. In 1929 M.Norn found that the peak of sodium, potassium and chloride excretion occurs early in morning between 3-6 am at the rise from the bed. In 1944 by Marie *et al* from department of physiology, North Western University medical school, Chicago conducted a study with a fixed diet of 2750 calorie and containing 3.29 gm of sodium and 3.27 gm of potassium with addition of 4.93 gm of chloride on each subject, who consumed 5 gm of chloride daily at stimulated altitude of 18000 feet. The study was conducted on the excretion pattern of all three electrolytes i.e. sodium, potassium and chloride. Under the stimulated experimental condition there was temporary rise in the excretion of all three electrolytes and also in the urine volume. In a study by Hannon *et al* (1970) from USA found significant decrease of serum sodium and potassium at high altitude (above 4300 m) in female, whereas serum calcium and chloride was observed significantly high in female. Another Japanese study on mountaineers found significantly low serum sodium and calcium and high serum potassium at high altitude. However urinary sodium and potassium was observed high at high altitude (Galster and Morrison 1974). An altitude based study from Saudi Arabia found significantly higher blood pressure and body mass index in highlanders (3150 m above sea level) compared with lowlanders (500 m above sea level) (Khalid *et al* 1995). A comparative study on human acclimatization at high altitude by Zaccaria *et al* (1998) found gradual increase in urinary sodium excretion (from 166 ± 34 to 257 ± 34) with increasing altitude (from 1300 m to 5050 m above sea level). In a study from Turkey on children found significantly positive correlation between body mass index and systolic and diastolic blood pressure at altitude 1725 m. (Arslan *et al* 2003).

In an Indian study from hill and plain subjects found low body mass index (22.1 ± 2.3) at high altitude (3600 meter) than plains (22.7 ± 1.8). However the systolic and diastolic blood pressure was observed high in subjects of high altitude (128.0 ± 12.4 mm Hg and 77.9 ± 8.0 mm Hg) than subjects from plains (110.7 ± 20.1 mm Hg and 65.8 ± 9.10 mm Hg) (Amitabh *et al* 2009).

This prompted to study the science of adaptation and acclimatization in bio-diversified social and cultural milieu and various dietary factor where identified to modify the life style as well as the food habit to sustain the adversities with special reference to Gangetic plain of Varanasi and North-East hill area of Aizawl in Mizoram.

Chapter-3

Aims and Objectives

The major objectives of the proposed study envisage the followings

- To study the variation in environmental conditions like temperature, humidity and rain fall between Aizawl (Mizoram) and Varanasi (eastern U.P.).
- To study the difference of work place, sun exposure and body surface area between two populations.
- To study the pattern of dietary consumption in relation to electrolyte intake (sodium, potassium, calcium and chloride).
- To study the pattern of urinary electrolyte excretion in the two representative populations.
- To asses the risk of environmental factors in relation to above variables.

Chapter-4

Material and Methods

The present study has been conducted between two geographical diversified site of north-east India and Gangetic plain. The first study site being Aizawl (Mizoram), which represents North-east India and Varanasi was the second site representing Eastern part of Uttar Pradesh in the Gangetic plain. The study was conducted to evaluate the variation of the various environmental factors such as humidity, temperature in relation to food habit, electrolyte pattern present in the food items in the form of micronutrients as well as the urinary excretion of electrolytes with anthropometric measurements (Height, weight, Body mass index, Blood pressure) during the period of December 2008 to November 2010 in the Department of Environmental Science, Mizoram University, Aizawl in collaboration with Department of Medicine, IMS, Banaras Hindu University, Varanasi.

4.1 Site selection criteria

The proposed two different sites were selected, because of the different altitude, distinct environmental conditions, food habits and body constitutions with different working environment and other biodiversities.

4.1.1 Site No.1

Aizawl is an extreme north part of the country which shares the eastern border with Myamar. The western border is formed by Bangladesh and the northern part is the Mizoram and Assam having an ethnic and biological similarity between Mangolian race where there has been a common food habit and most of the cultural and industrial evolution has been centered around the natural forest product, limited cultivation and non-vegetarian products as staple diet. The altitude of the Aizawl is about more than 2000 meter above the sea level with deep terrain, dense forest and limited space available for traditional farming predisposes the individual to consume animal products in form poultry products and live stock with limited consumption of cereals which are usually transported from the neighboring state of the India. The humidity is above 90% during monsoon months and torrential rain fall approximately lasting for 6 months limits outdoor working of the individual and with a temp range of 2 to 32^0C, predisposes the body to retain more water and salt and there by compensated with other metabolic activity for healthy body homeostasis.

The routine working of the individual are climbing on the high hill that exposes individuals for physical exercise. This helps them to get rid of extra dietary Sodium load and evaporation through sweat further compensate to prevent diseases like hypertension, obesity, diabetes and other metabolic disorder.

Since there is a limited option of agricultural activities, most of the food items consumed by the tribal are bamboo shoot, leafy vegetables, meat, pork etc. These meat products contain high protein as well as micronutrients and the processing of food is more of traditional cooking, less frying and preserving the nutrient components make them more healthier and disease free.

As there are no big industries, the local people confined them selves to the small scale industries and white collar office jobs which expose them to less environmental pollution.

In the major tribal area the transport facility is limited, therefore no pollution by petroleum based products and industrial pollutants.

4.1.2 Site No.2

Varanasi is one of the most ancient city of Asia and probably the only one living city of the world, which has its route from pre-historic era till 10000 BC and has been the center of attraction for the great scholar, tourist, educationist, and artist of various disciplines. Its culture has been preserved over 3500 years with the migration of people from different walk of life with rich cultural diversity representing each and every parts of India as well as western world.

The river Ganges is the life line of the city linking its route with business and transport with water ways as well as roads from different part of country. The greater cultural acceptability and the tolerance for the other religions has attracted the people of different sect and cast live here over many generation and flocking of many international travelers with the long stay in the city have changed its impact on the environment and the food habits.

Varanasi is situated in the middle of Gangetic plain at an average height of 76 m above sea level. The temperature ranges from 4 to 46 ^{0}C, which promotes excessive loss of fluid and water. The humidity pattern remains high during winter, when the temperature excursion occurs at extremes 0 to 2 ^{0}C and the highest temperature is recorded during summer months is 44 to 46 ^{0}C. These environmental conditions may be responsible for the massive loss of electrolytes and fluid in summer.

The neighboring area of the city has many industries, which is based on coals, smelting units, iron bar foundries, stone crusher unit etc. The open agricultural land with natural irrigation facility nurtures another groups as traditional farmers, who work in the open field with high exposed body surface area during extreme temperature variation and they thrive upon mainly vegetarian diet and dietary products as a part of protein supplement in the food. The diversified cultural amalgamation as well as the highest sect of spirituality provides an opportunity to many of the Hindu residents to observe different ceremony, religious fast and other activity round the year, which has special provision for the consumption of the diet containing only fruits, milk and other non cereal product with high fat and sugar contain, which predisposes the individual to have obesity and other metabolic abnormality. Individual, who work in stone crusher unit and smelting foundries are exposed to high dry heat with minimum protection on their body that has disadvantage of massive loss of fluid from the body and may contribute the fluid and electrolyte balance.

The women folk of the village also work in the open field as well as in the industries and equally contribute to the family economy but are at the high risk of salt and electrolyte abnormality due to the variation of environment and work place.

4.2. Sampling technique and selection of sample

4.2.1. Sample size

For the present work, an attempt has been made to study the dietary electrolyte consumption and its level in serum and urine with respect to seasonal variation in ambient temperature and relative humidity in the healthy subjects between Aizawl and Varanasi. Total 400 individuals were included representing 200 each of the both study site in the present study.

4.2.2. Sample selection criteria

The individuals were selected based on following criteria.

- Age above 15 years.
- Absence of renal diseases.
- Absence of cardiovascular diseases.
- Absence of diabetes.
- Absence of any metabolic and inflammatory disorder

The consent of all above mentioned criteria was obtained from the individuals prior to their inclusion in the study.

4.2.3. Tools and techniques of data collection

The data was collected through interview by using a pre-tested questionnaire. First of all tentative questionnaire was prepared and interview were conducted on 20 healthy subjects of IMS, BHU, Varanasi. The results of dietary interviews were discussed with the supervisors and statistician of the Department of Preventive and Social Medicine, Institute of Medical Sciences, BHU, Varanasi. After proper scrutiny of the questions, the final questionnaire was framed taking following aspects in to consideration:

- Opening questions were made simple and interesting to create the interest of respondents.
- Clear and simple questions were made for easy understanding.
- Words with emotional and personal association were avoided.
- Questionnaire was made as short as possible.

4.2.4. Designing of the questionnaire

The questionnaire was designed in six sections:

Section I – Epidemiological data

- **Age**: All individuals were categorized in three age groups such as below 20 years, between 20 to 40 years and above 40 years for the purpose of data analysis.
- **Sex**: Study included both sex males and females.
- **Occupation**: The subjects were grouped in two categories according to occupation such as blue collar and white collar. The laborers, street venders, manual workers, farmers etc., who are more exposed to external environment were included in Blue collar category, whereas

students, teachers, office staff and others, who work within four walls of the house are less exposed to external environment were included in white collar category.

Section II – Meteorological data

The meteorological parameters included for the study were as under:

- **Temperature**: The ambient temperature plays very important role in consumption of various dietary components and electrolytes excretion in human beings. The maximum and minimum temperature was recorded using Zeal make calibrated thermometer in Deg C. The data of ambient temperature of all seasons throughout the year for Aizawl was collected from meteorological station based at Puspak and for Varanasi collected from meteorological station based at Babatpur Airport.
- **Relative Humidity**: The relative humidity is also very important meteorological parameters involved in regulation of electrolyte excretion in human being. The dry and wet bulb temperature was measured in Deg C using Zeal make calibrated dry and wet bulb thermometer. Then it was placed in the standard chart to find out the relative humidity in %. This data was also collected from the meteorological stations based at Puspak (Aizawl) and Babatpur (Varanasi).

Section III – Anthropometric Data

The anthropometric parameters comprised of following:

- **Height**: The height was measured using measuring scale in centimeter. The procedure of recording the measurement was standardized. The subjects were made to stand erect against the vertical tape after removing the shoes. The subject stood on the flat floor by the scale with feet parallel and heels, buttock and back of head touching the wall. The head was held comparatively erect, while looking straight forward.

The head piece of measuring scale was gently lowered touching the heir and making contact with the top of the head. The horizontal rod was made to touch the highest point on the skull. The corresponding value visible on the scale on vertical rod just below the lower margin of the horizontal rod gave the exact measurement. The procedure was repeated thrice on each subjects and the mean of the three readings was taken as the actual height.

- **Weight**: To measure the body weight, standard weighing scale (Avery make) was used. Subjects were asked to stand erect without shoes or sleepers, with arms hanging by the side and head straight held so that the eyes were directed on the horizon. The weight was recorded in kilogram (kg). The weighing scale was calibrated using standard weights. The subjects were weighted with minimum clothing during study. The procedure on each subject was repeated thrice and the mean of three readings was taken as the actual weight.

- **Body mass index**: The body mass index (BMI) is a statistical measure of body weight based on a person's weight and height. It is the most widely used diagnostic tool to identify the category of obesity. The World Health Organization has identified four categories of obesity based on body mass index, which are as follows under weight <18.5 kg/m^2, normal 18.5 – 24.9 kg/m^2, overweight 25.0 – 29.9 kg/m^2 and obese > 30kg/m^2 (WHO 1997). BMI is calculated by dividing individual's body weight (kg) by the square of his or her height (meter) using following formula:

$$\text{BMI (\%)} = \frac{\text{Weight (kg)}}{\text{Height (meter)}^2} \times 100$$

- **Blood pressure**: The systolic and diastolic blood pressure was measured by automatic blood pressure monitor (OMRON make). The subject was asked to sit in a chair upright with back straight and flat feet on the floor and arm placed on table at the same level of the heart. The subject was kept still without talking during the measurement. The air plug into the air jack and the left arm of the subject put through the cuff loop so as to run down the air tube inside the forearm and be in the line of middle finger. Than the instrument set start to take the reading. The procedure on each subject was repeated thrice and the mean of three readings was taken as the actual blood pressure in mm Hg.

Section IV – Dietary Data

Dietary information included, the items consumed with their quantity during breakfast, lunch, snacks and dinner. Dietary intake was collected based on 24 hour dietary recall protocol. The purpose of the 24 Hour recall is to expedite the process of dietary assessment of a group of individuals while continuing to obtain accurate and reliable dietary intake information. Those individual who could not recall exactly the consumed food, a personal visit is made to the kitchen at the time of cooking to document the type with quantity of food being consumed by the day. The nutrient value of the cooked food items consumed was obtained from the reference values (Swaminathan 1988).

Calculation of nutrient intake

The exact amount of cooked food consumed by the subjects was determined using standard utensils measures chart. The nutritive value of food items was assessed by conversion tables of the nutritive value of Indian foods (Gopalan 1993) per day. Consumption of food stuff was used to calculate the dietary electrolytes, and nutrient intake of each subjects. The electrolytes include sodium, potassium, calcium and chloride. The nutrients included were mainly total calorie, carbohydrate, protein and fat.

Section V – Laboratory Data

This was categorized in two groups urinary and serum electrolytes. Electrolytes were mainly sodium, potassium, calcium and chloride. The electrolytes were analyzed in urine and blood.

4.2.5. Presenting the questionnaire

The questionnaire was presented by interviewing the subjects. The questionnaire was orally translated in Hindi as well as in Mizo language with the help of local volunteer for the illiterate and tribal subjects, who could not understand English.

4.2.6. Collection of biological samples

4.2.6.1. Urine sample

The random urine sample of 25 ml was collected in disposable corning tube with lid. It was assured that individual has not taken at least 24 Hour before any medicine such as diuretic, antibiotic or pain killer, which can affect the excretion of urinary electrolyte. The sample was kept in ice box for transportation to the laboratory and analysed for electrolytes within 72 hours.

4.2.6.2. Blood sample

The selected subjects were undertaken for the random collection of blood sample. Disposable syringes and needles were used to draw 8 -10 ml of blood from the vein under medical supervision. The collected blood was carefully stored into clean, dry, labeled and stoppered vial with EDTA powder and set aside for two hours. Over handling and over mixing were avoided to prevent hemolysis after the clot had retracted completely, the serum was separated and was drawn from the vial into clean, dry labeled and stoppered centrifuge tubes, and than it was balanced in semi clinical centrifuge at a speed of 3000 rpm for 5 -10 minutes. The clear supernatant was transferred with a Pasteur pipette into a clean test tube and kept at 0 - 4^0C in a refrigerator for further analysis. The serum samples were not stored for more than three days. All the investigations were completed within a week of obtaining blood samples.

4.3. Biochemical analysis

The urine and serum sample after the collection were analysed for sodium, potassium, calcium and chloride using AVL 9180 analyser.

4.3.1. Principle of Auto-analyser

The instruments working principle is based on ion-selective electrode measurement. The instrument was provided with five different electrodes for sodium, potassium, calcium and chloride and a reference electrode. Each electrode has an ion-selective membrane that undergoes a specific reaction with the corresponding ions contained in the sample being analysed. The membrane is an ion exchanger reaction to the electrical charge of the ion causing a change in the membrane potential, or measuring voltage, which is built up in the film between the sample and the membrane.

A galvanic measuring chain within the electrode determines the difference between the two potential values on either side of the membrane. The galvanic chain is closed through the sample on one side by the reference electrode close the other side.

A difference in ion concentrations between the inner electrolyte and the sample causes an electrochemical potential to form across the membrane of the active electrode. The potential is conducted by a highly conductive, inner electrode to an amplifier. The reference electrode is connected to ground as well as to the amplifier.

The ion concentration in the sample is than determined by using a calibration curve determined by measured points of standard solution with precisely known ion concentration.

4.3.2 Reagents

- Standard reagent: The calibration of the instrument was done using standard ISE SnapPak™ (BP5186) solution of two grade for higher and lower range.
- Standard A : The active ingredients was Na^+ 150 mmol/L, K^+ 5.0 mmol/L,

  Cl^- 115 mmol/L, Ca^{++} 0.9 mmol/L and LI^+ 0.3 mmol/L.
- Standard B : The active ingredients was Na^+ 100 mmol/L, K^+ 1.8 mmol/L,

  Cl^- 72 mmol/L, Ca^{++} 1.5 mmol/L and LI^+ 0.3 mmol/L
- Stock lithium solution: 95.97 gm of $Li_2SO_4.H_2O$ per liter in deionized water.
- Working lithium solution (15meq/l): Dilute 50 ml stock lithium solution in 5 liters with deionized water.

4.3.3. Procedure

The urine or plasma sample was diluted 1 in 200 dilution with working lithium solution using an automatic diluter. The lithium sensitivity control was adjusted to zero as per instrument manual. The instrument was adjusted using standard A reagent by mean of the selective control knob, until the reading on the scale corresponds to the actual concentration. The same procedure was repeated using standard B. Then the meter of the instrument was set to record urine or plasma concentration according to the instruments manual. The result on the display board of instrument was recorded in meq/l for corresponding electrolyte.

4.4. Statistical analysis

Tabulation of the data was done to compare with each factor studied. Master table was also prepared and standard statistical tools were applied to draw inferences. Incase of quantitative data mean and standard deviation was also worked out using statistical tools of MS Office Excel 2003. The results of both the sites were compared using paired "t" test and the relation between various attributes and parameters were ascertained by Pearson correlation analysis. The statistical analysis was done with the help of statistical software Sigma stats 3.5 version and finally the inferences were drawn accordingly. The steps of the statistical methodologies were as follows.

4.4.1 Measures of central tendency

Measures of central tendency tell us the point about, which data have a tendency to cluster. Such a measure is considered as the most representative figure for the entire mass of data. This is also known as mean or statistical average.

Mean

It is the most common measure of central tendency and may be defined as the value, which we get by dividing the sum of the given data in a series by the total number of data.

$$\text{Mean} = \frac{\text{Sum all of the observations of the data}}{\text{Number of observations in the data}}$$

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$

Where, $\bar{x}$ = The symbol we use for mean (pronounced "x bar")

$\sum$ = Symbol for summation

X_i = Value of the i^{th} item X, i= 1,2,… n

n = Total number of items.

4.4.2 Standard deviation (SD)

In statistics, dispersion is used to mean scatter, deviation, fluctuation, spread or variability of data. Dispersion is used to denote a lack of uniformity in items value of a given variable. The degree to which the individual values of the variable scatter away from the average or the central value is called dispersion. Standard deviation is the most widely used measure of dispersion of series and is commonly denoted by the symbol (σ) (pronounced as sigma).

$$\sigma = \frac{\sqrt{(\sum (x - \bar{x})^2}}{n}$$

Where σ is standard deviation

X is the value of each observation

$\bar{x}$ is the mean value

n = Total number of items.

4.4.3 Correlation coefficient

The statistical tool for measuring the degree of relationship between the two variables (i.e. a change in one variable result a positive or negative change in other variable) is known as correlation. The most widely used statistical method for measuring correlation is "Pearson coefficient correlation". The degree or the extent to which the variable are related with each other is called the coefficient of correlation, denoted by "r". It is a single number that tells us to what extent two things are related and to what extent variation in one go with variation in other (Prasad 2007).

The correlation coefficient is calculated as

$$\rho_{xy} = \frac{Cov(r_x, r_y)}{\sigma_x \sigma_y}$$

Where ρ is symbol of correlation coefficient (pronounced as rho)

Cov (r_x,r_y) = Covariance of variable X and Y

σ_x = Standard deviation value of variable X

σy = Standard deviation value of variable Y

4.4.4 "t" Test (Test of significance)

The statistical tool applied to test the significance of difference between the mean of two samples are called "t" test. One is paired t-test, which is applied in paired observations and the next one is student t-test. In the present study paired t-test have been used (Kothari 1997)

Probability level (p)

The calculated value of a statistic was compared with tabulated values of the statistic given in standard reference table and probability level (p) was ascertained accordingly.

The level of significance

The probability level of 5% that is p = 0.05 was considered cut off point to accept or reject the null hypothesis. For the simplicity following probability level (p) were only presented:

Probability (p)	Level of Significance
• $p \geq 0.05$	Non significant
• $p < 0.05$	Just significant (*)
• $p < 0.01$	Moderately significant (**)
• $p < 0.001$	Highly significant (***)

When the probability level was more than 5% the null hypothesis was accepted and the inference was drawn due to chance factor. On the other hand, when the probability level was less than 5%, the null hypothesis was rejected and the inference was drawn that the difference was due to some real cause.

Degree of freedom (df)

The free movement of a statistic is called as degree of freedom (df). The calculated value of a statistic is compared with tabulated value on the basis of degree of freedom.

Chapter-5

Results

Based on the observation of 400 subjects, this study was conducted at two different environmental and bio-diversified situation between Gangetic plain and North east hill.

Table No. 5.1 Age group distribution at selected sites

AGE GROUP	Below 20 (Mean ± SD)	Between 20 – 40 (Mean ± SD)	Above 40 (Mean ± SD)
Aizawl	18.70 ± 1.10	25.10 ± 4.00	47.79 ± 3.89
Varanasi	17.07 ± 1.01	36.91 ± 1.84	56.00 ± 6.30
***p* Value**	<0.001	<0.001	<0.001

The mean age in all three group of both station was found statistically highly significant. The majority in Aizawl individual found in 20-40 age group (71%), whereas in Varanasi it was above 40 age group (45%).

Fig 5.1

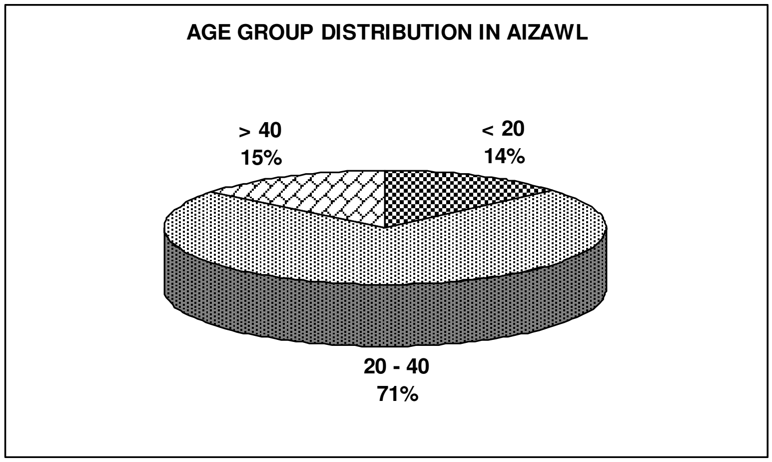


Fig No. 5.2

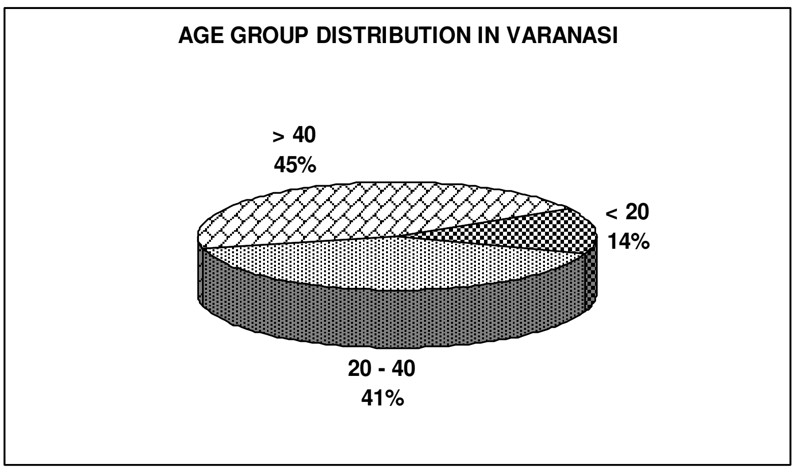


Table No.5.2 Gender distribution at selected sites

GENDER	MALE	FEMALE	TOTAL
Aizawl	124	76	200
Varanasi	146	54	200

The male female ratio was found low in Aizawl (1.63) in relation to Varanasi (2.70). The male population was found high in Varanasi then female (73% and 27%), whereas Aizawl represented the reverse pattern of 62% male and 38% female.

Fig 5.3

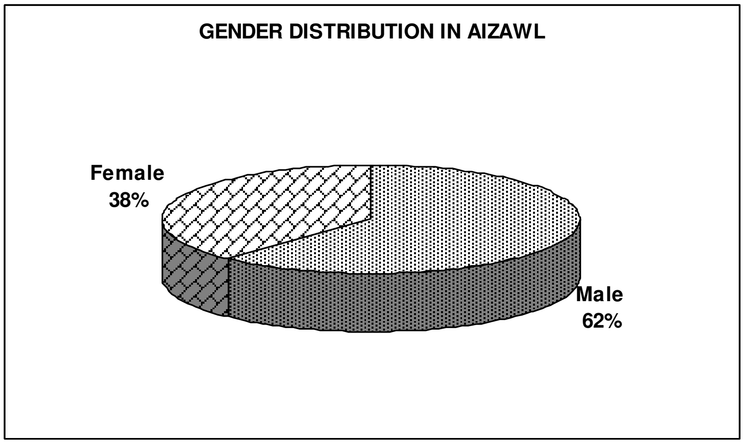


Fig 5.4

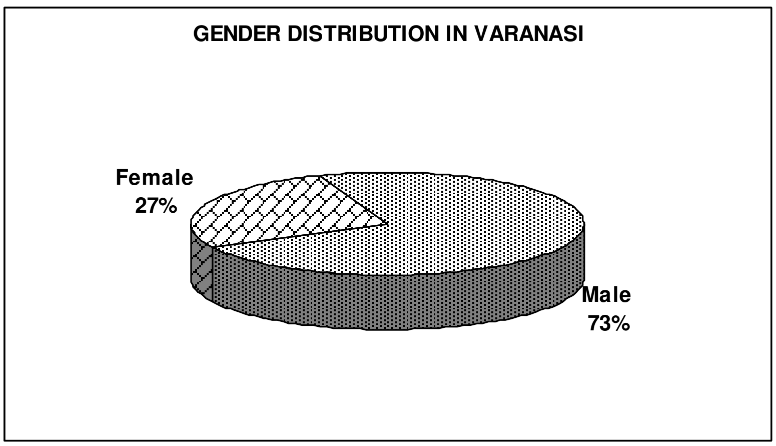


Table No. 5.3 Occupation distribution at selected sites

OCCUPATION	BLUE COLLAR	WHITE COLLAR	TOTAL
Aizawl	33	167	200
Varanasi	65	135	200

The occupation distribution ratio of white and blue collar individual in Aizawl was found high (5.06) in relation to Varanasi (2.07). The overall contribution of white collar individual was high (83% and 67%) as compare to blur collar (17% and 33%) at both site.

Fig 5.5

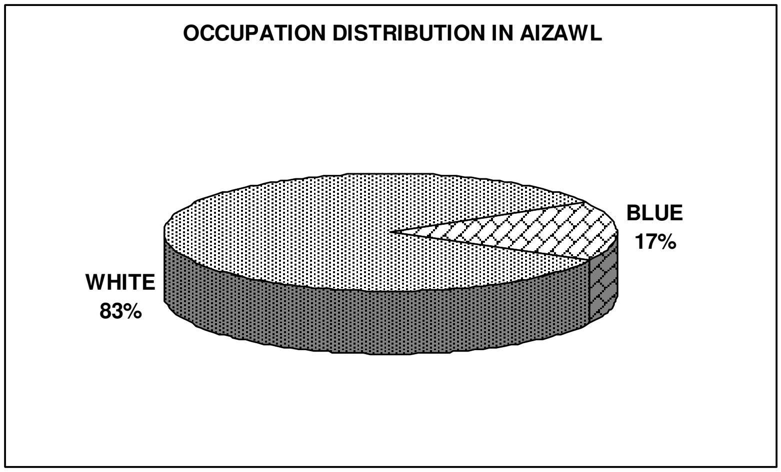


Fig 5.6

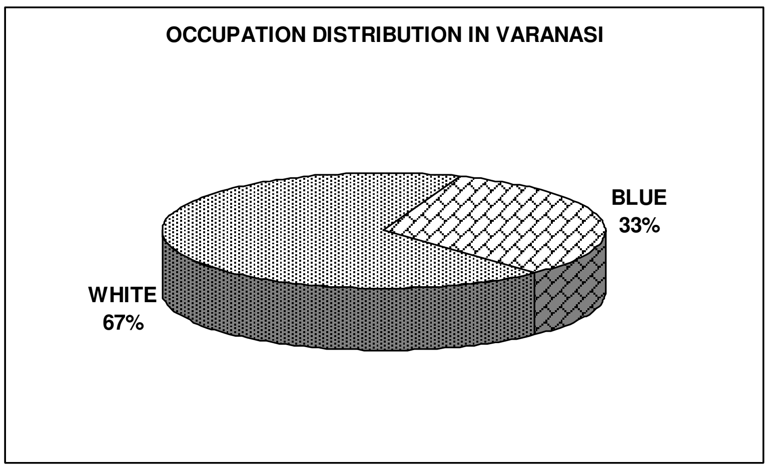


Table No.5.4 Dietary variation (Vegetarian and non-vegetarian)

DIET	VEGETARIAN	NON-VEGETARIAN	TOTAL
Aizawl	38	162	200
Varanasi	82	118	200

The ratio of dietary variation between non-vegetarian and vegetarian was observed high in Aizawl (4.26) than Varanasi (1.43). However the contribution of non-vegetarian individuals was higher (81% and 59%) in relation vegetarians (19% and 41%) at both sites.

Fig 5.7

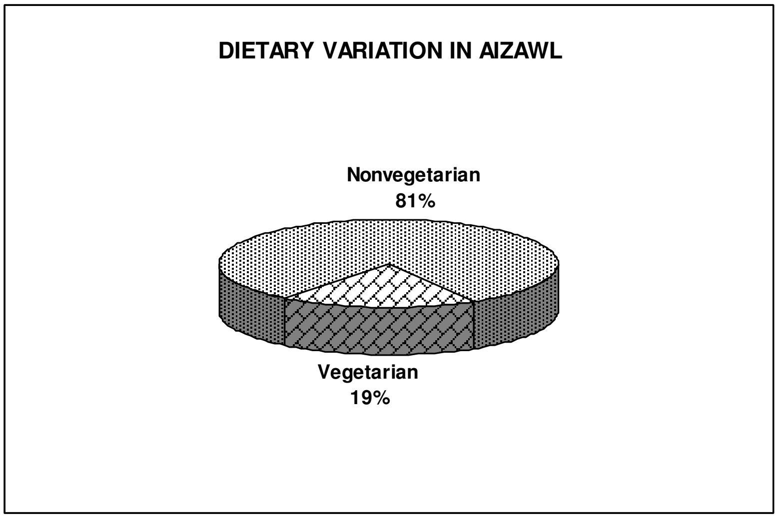


Fig 5.8

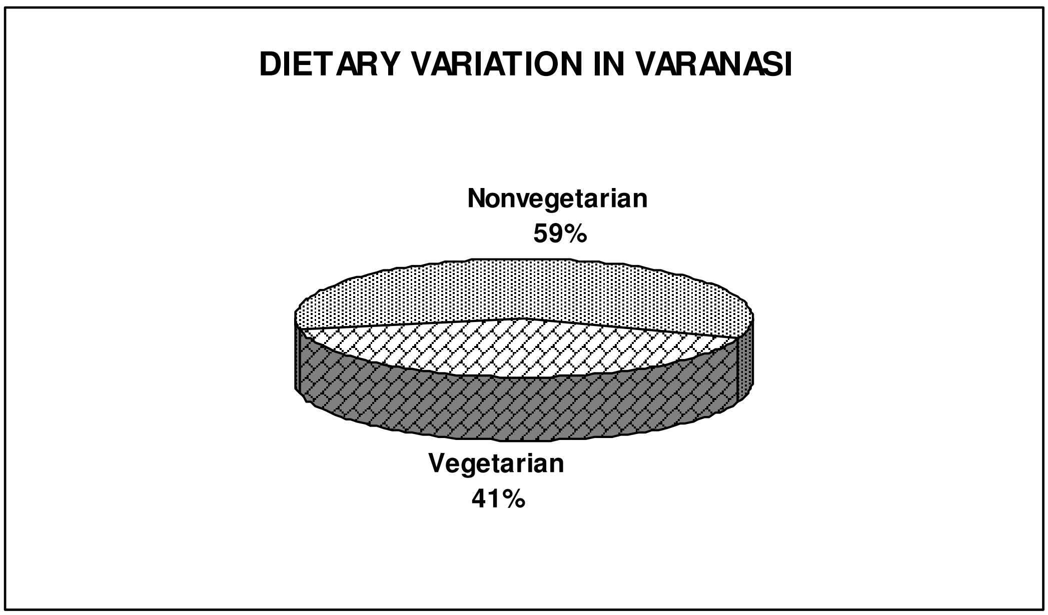


Table 5.5 Body mass index of different age group at selected sites

AGE GROUP	Below 20 (Mean ± SD)	Between 20 – 40 (Mean ± SD)	Above 40 (Mean ± SD)
Aizawl	20.73 ± 4.56	21.53 ± 3.55	23.47 ± 4.92

Varanasi	22.42 ± 4.51	23.75 ± 3.37	24.63 ± 3.56
***p* Value**	0.174	<0.001	0.167

The body mass index of individuals from Varanasi was found high (Varanasi 22.42 ± 4.51, 23.75 ± 3.37 and 24.63 ± 3.56) in all 3 age groups in relation to Aizawl (Aizawl 20.73 ± 4.56, 21.53 ± 3.55 and 23.47 ± 4.92). However this was statistically highly significant (<0.001) in the age group of 20-40 years.

Fig 5.9

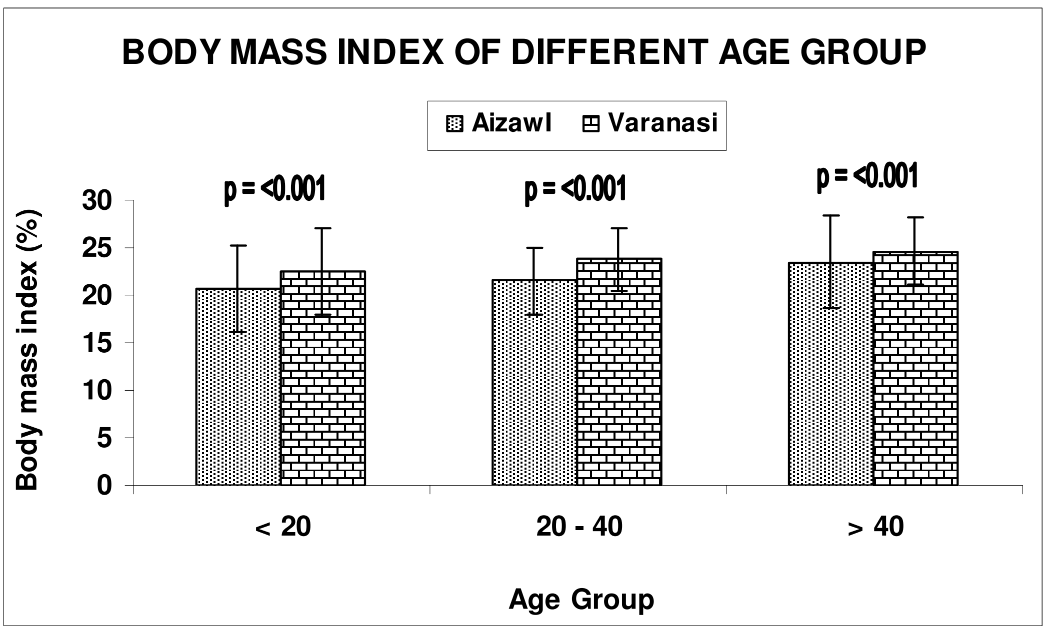


Table 5.6 Body mass index of male and female

GENDER	MALE (Mean ± SD)	FEMALE (Mean ± SD)

Aizawl	21.33 ± 2.99	22.31 ± 5.16
Varanasi	23.96 ± 3.61	24.00 ± 3.96
***p* Value**	<0.001	0.046

The body mass index of female at both sites were observed significantly high (Female 22.31 ± 5.16 and 24.00 ± 3.96) than male (Male 21.33 ± 2.99 and 23.96 ± 3.61). This difference was highly significant in male (<0.001) than female (0.046).

Fig 5.10

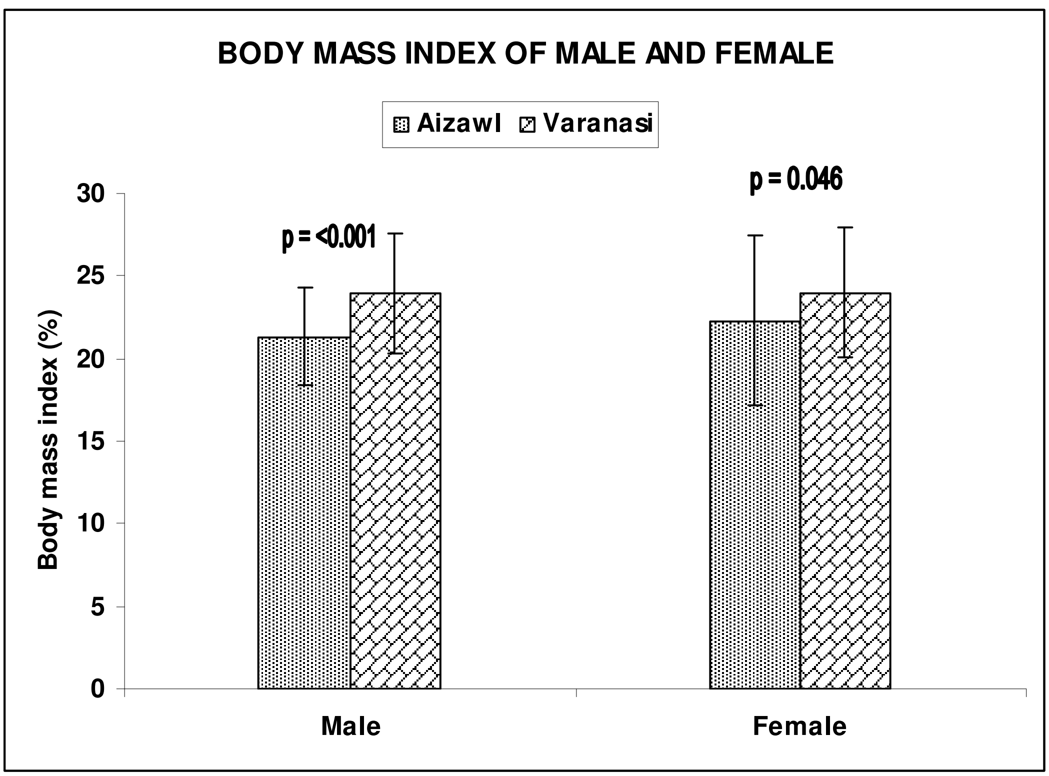


Table No.5.7 Body mass index of blue and white collar

OCCUPATION	BLUE COLLAR (Mean ± SD)	WHITE COLLAR (Mean ± SD)
Aizawl	20.75 ± 3.21	21.89 ± 4.09
Varanasi	23.22 ± 3.49	24.33 ± 3.75
***p* Value**	<0.001	<0.001

The body mass index of white collar subjects was observed significantly high (White collar 21.89 ± 4.09 and 24.33 ± 3.75) at both sites in relation to blue collar (Blue 20.75 ± 3.21 and 23.22 ± 3.49). However the body mass index of Varanasi individual was significantly higher than Aizawl.

Fig 5.11

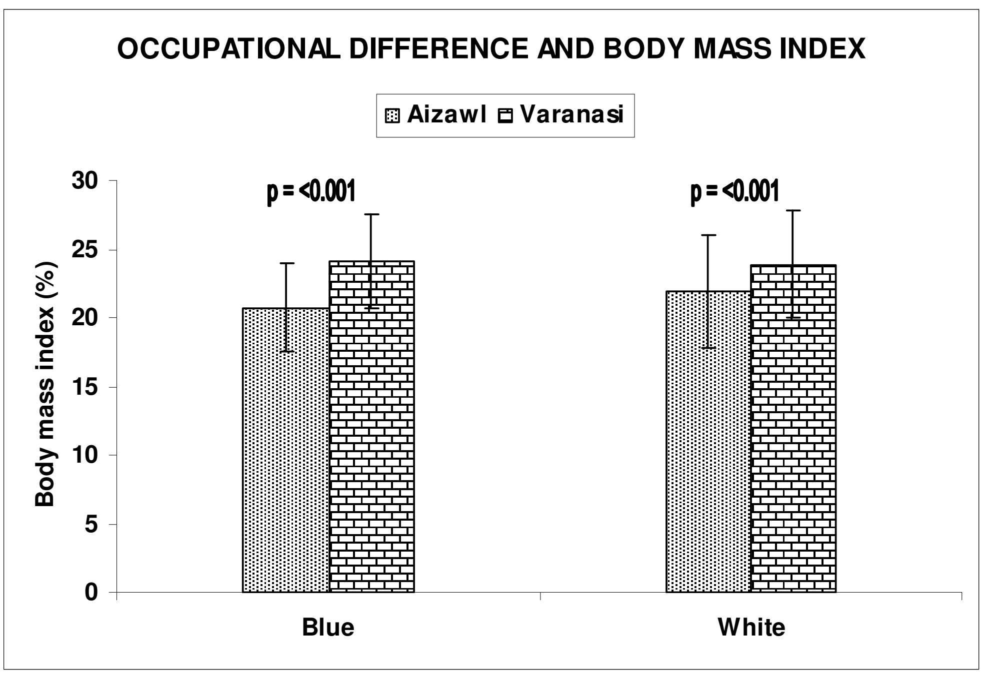


Table No.5.8 Body mass index of vegetarian and non-vegetarian

Body Mass Index	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	21.00 ± 2.83	21.86 ± 4.19
Varanasi	24.15 ± 3.43	23.84 ± 3.88
***p* Value**	<0.001	<0.001

No significant difference was observed between body mass index of vegetarian and non-vegetarian at Aizawl. However the vegetarian diet consumers of Varanasi had significantly higher body mass index (24.15 ± 3.43) than non-vegetarian (23.84 ± 3.88).

Fig 5.12

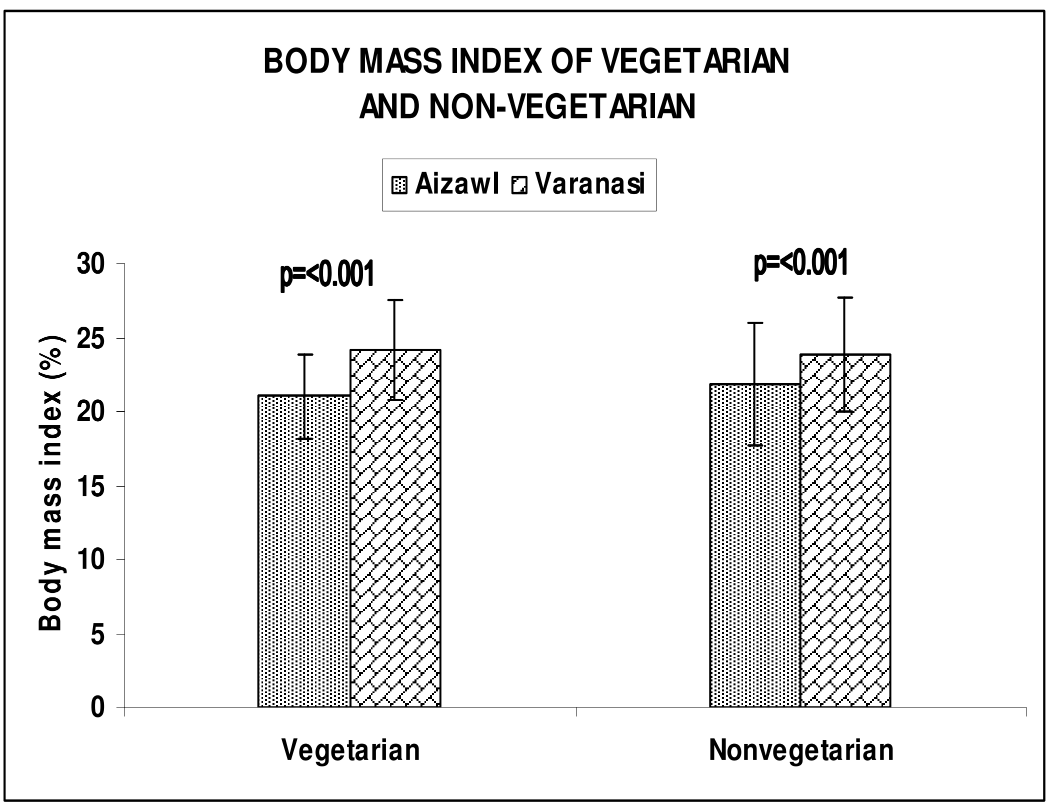


Table No.5.9 Correlation between body mass index and age group distribution

	AGE (Mean ± SD)	BMI (Mean ± SD)	p Value	Correlation Coefficient (r)
Aizawl	27.53 ± 9.40	21.70 ± 3.97	<0.001	0.254
Varanasi	44.22 ± 12.21	23.96 ± 3.69	0.004	0.202

The body mass index was found to have statistically significant positive correlation with all three age group both of the sites (Aizawl *p=<0.001 & r=0.254*) and (Varanasi *p=0.004 & r=0.202*).

Fig 5.13

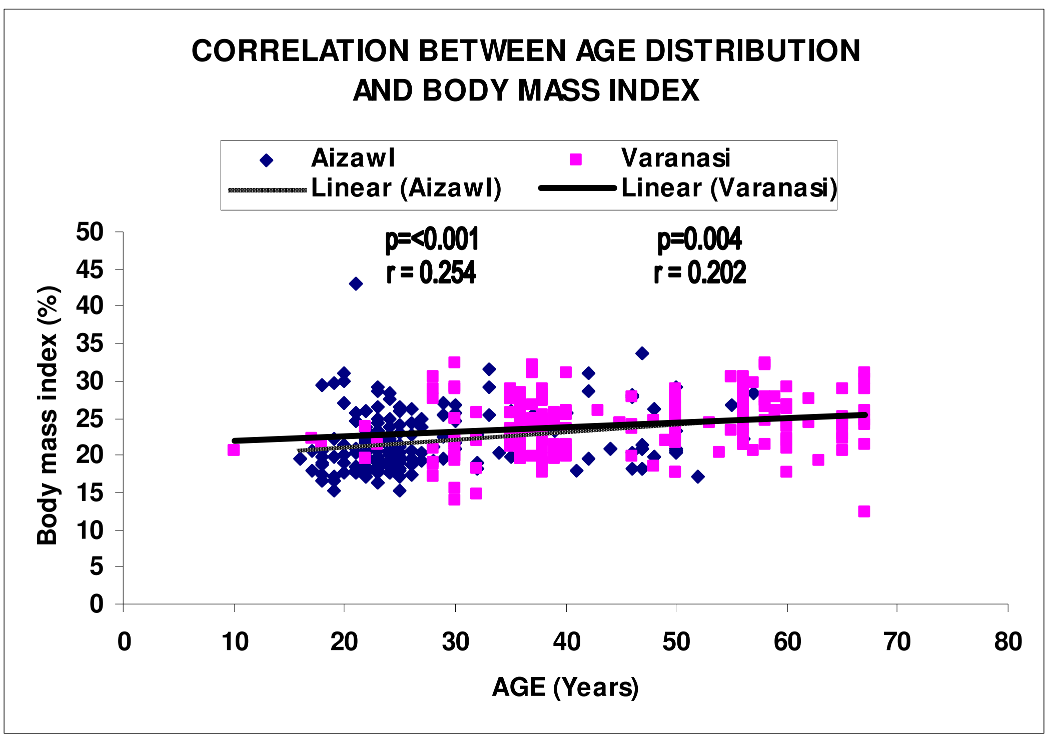


Table No. 5.10 Pattern of mean blood pressure of different age group

AGE GROUP	Below 20 (Mean ± SD)	Between 20 – 40 (Mean ± SD)	Above 40 (Mean ± SD)
Aizawl	83.81 ± 7.88	84.70 ± 8.44	95.34 ± 15.86
Varanasi	91.99 ± 9.38	95.63 ± 13.16	104.32 ± 13.79
***p* Value**	<0.001	<0.001	0.004

The mean blood pressure was significantly higher in upper age group above 40 years at both of the sites. However the residents of Varanasi had shown significantly higher blood pressure in all three age group (Varanasi 91.99 ± 9.38 mm Hg, 95.63 ± 13.16 mm Hg and 104.32 ± 13.79 mm Hg) than their Aizawl counterparts (Aizawl 83.81 ± 7.88 mm Hg, 84.70 ± 8.44 mm Hg and 95.34 ± 15.86 mm Hg).

Fig 5.14

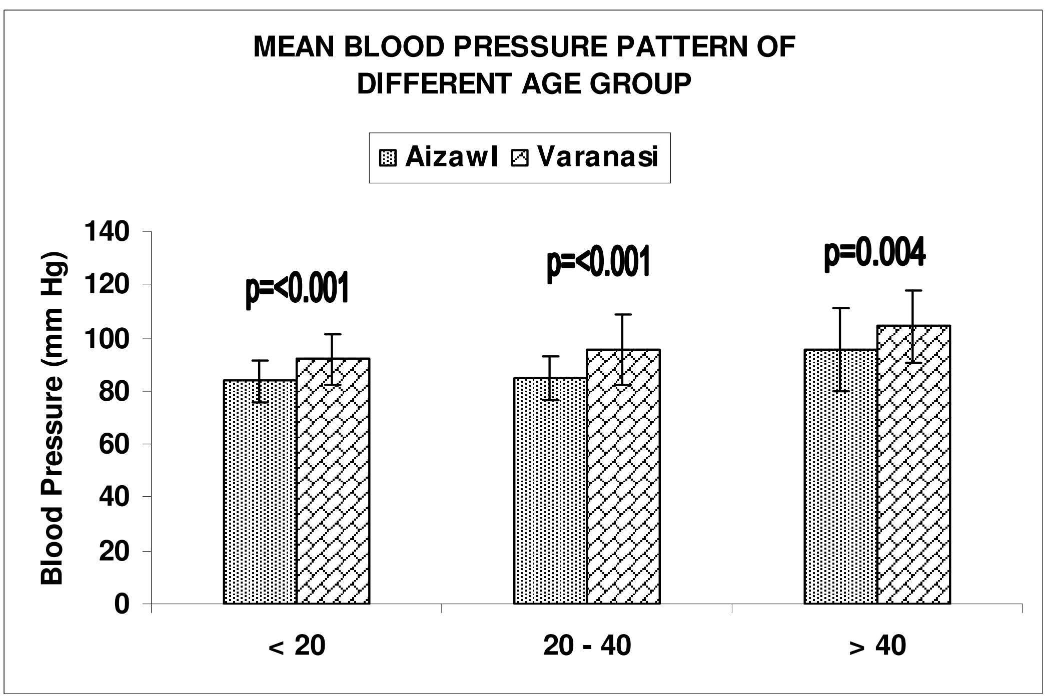


Table No. 5.11 Pattern of mean blood pressure in male and female

GENDER	MALE (Mean ± SD)	FEMALE (Mean ± SD)
Aizawl	86.64 ± 9.78	85.29 ± 11.48
Varanasi	99.14 ± 14.11	98.91 ± 13.28
***p* Value**	<0.001	<0.001

The mean blood pressure of female subjects was significantly lower (Female 85.29 ± 11.48 mm Hg and 98.91 ± 13.28 mm Hg) than their male counterparts (Male 86.64 ± 9.78 mm Hg and 99.14 ± 14.11 mm Hg) at both of the sites. However the blood pressure of Aizawl individuals was significantly lower than Varanasi individuals

Fig 5.15

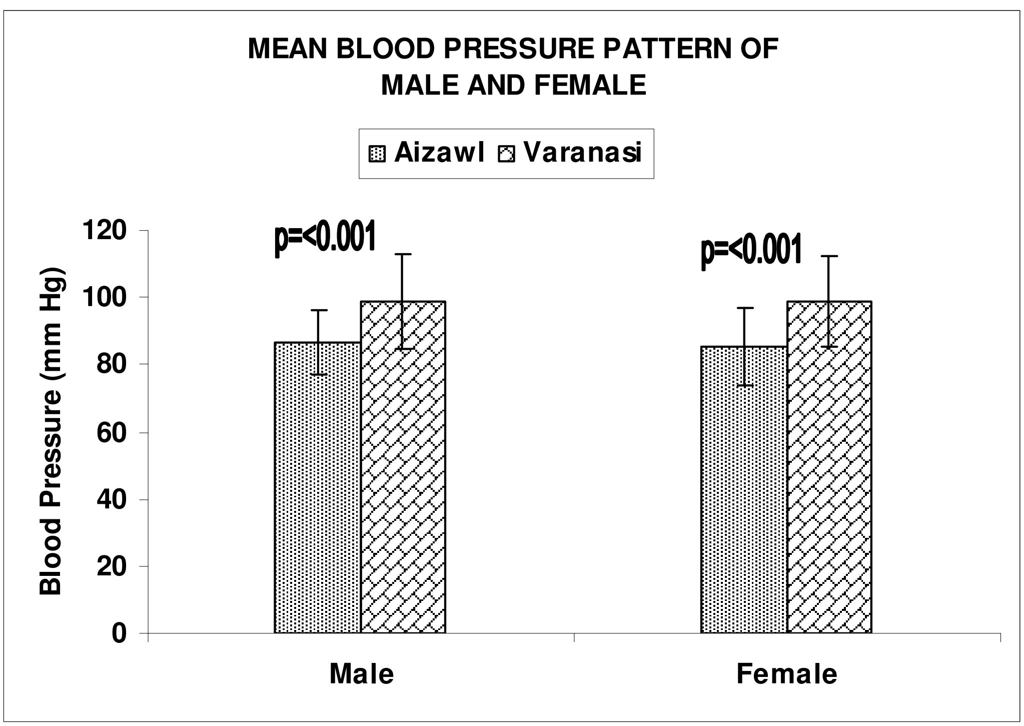


Table No. 5.12 Pattern of mean blood pressure in blue and white collar individual

OCCUPATION	BLUE COLLAR (Mean ± SD)	WHITE COLLAR (Mean ± SD)
Aizawl	91.78 ± 8.87	85.01 ± 10.40
Varanasi	95.18 ± 12.69	100.95 ± 14.05
***p* Value**	0.172	<0.001

The mean blood pressure of blue collar subjects was high (Blue 91.78 ± 8.87 mm Hg) than white collar (White 85.01 ± 10.40 mm Hg) in Aizawl, whereas the individuals from Varanasi had shown reverse pattern (White 100.95 ± 14.05 mm Hg and Blue 95.18 ± 12.69 mm Hg). However the observation was statistically highly significant only in white collar individuals (*p=<0.001*).

Fig 5.16

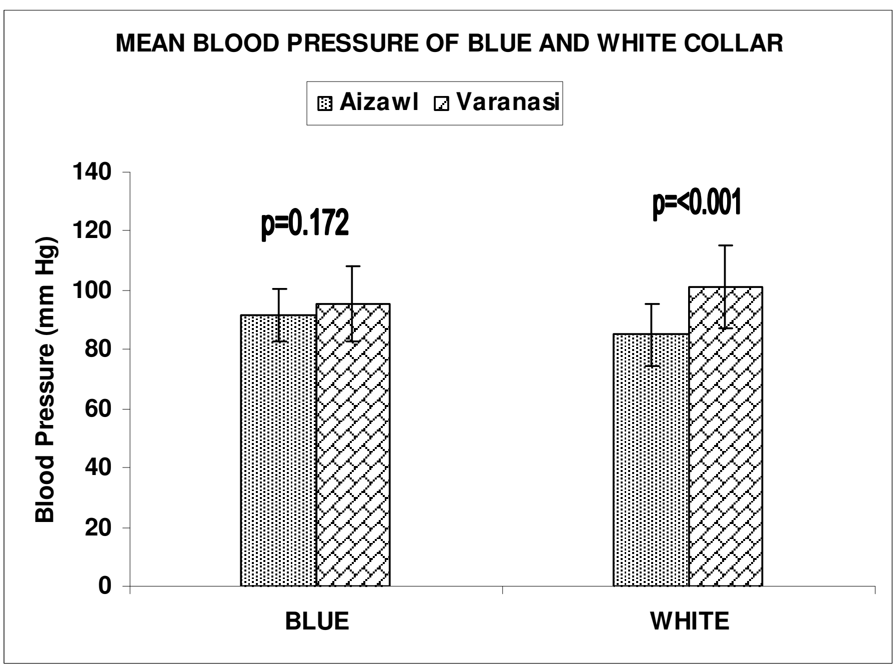


Table No. 5.13 Distribution of mean blood pressure in vegetarian and non-vegetarian

Mean blood pressure	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	86.32 ± 8.70	86.08 ± 10.85
Varanasi	96.93 ± 13.69	100.57 ± 13.84
***p* Value**	<0.001	<0.001

The non-vegetarian diet consumers had shown significantly (*p=<0.001*) higher mean blood pressure (100.57 ± 13.84 mm Hg) than vegetarian (96.93 ± 13.69 mm Hg) in Varanasi, whereas in Aizawl no significant difference was observed.

Fig 5.17

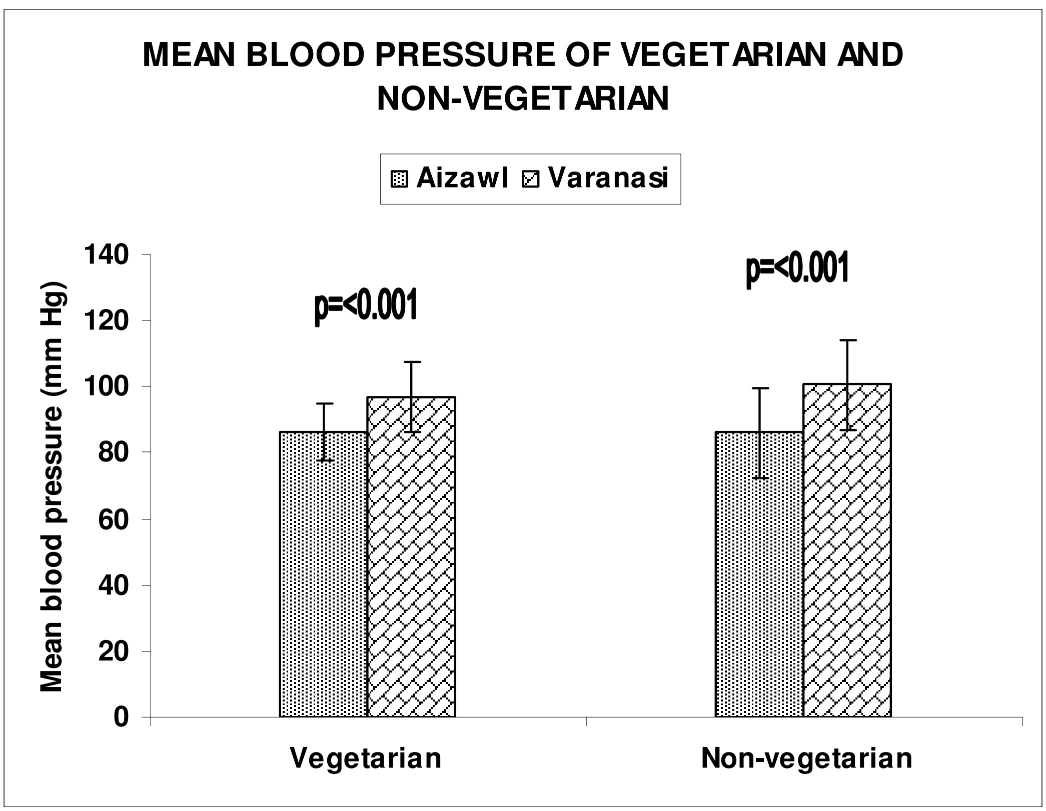


Table No. 5.14 Correlation between blood pressure and age group distribution

	AGE (Mean ± SD)	Mean Blood pressure (Mean ± SD)	p Value	Correlation Coefficient (r)
Aizawl	27.53 ± 9.40	86.13 ± 10.45	<0.001	0.381
Varanasi	44.22 ± 12.21	99.08 ± 13.86	<0.001	0.369

The statistically highly significant (Aizawl *p=<0.001& r=0.381*) positive correlation was observed between age distribution and mean blood pressure (Varanasi *p=0.369 & r=0.369*) at both site. The blood pressure was observed in increasing order with respect to age.

Fig 5.18

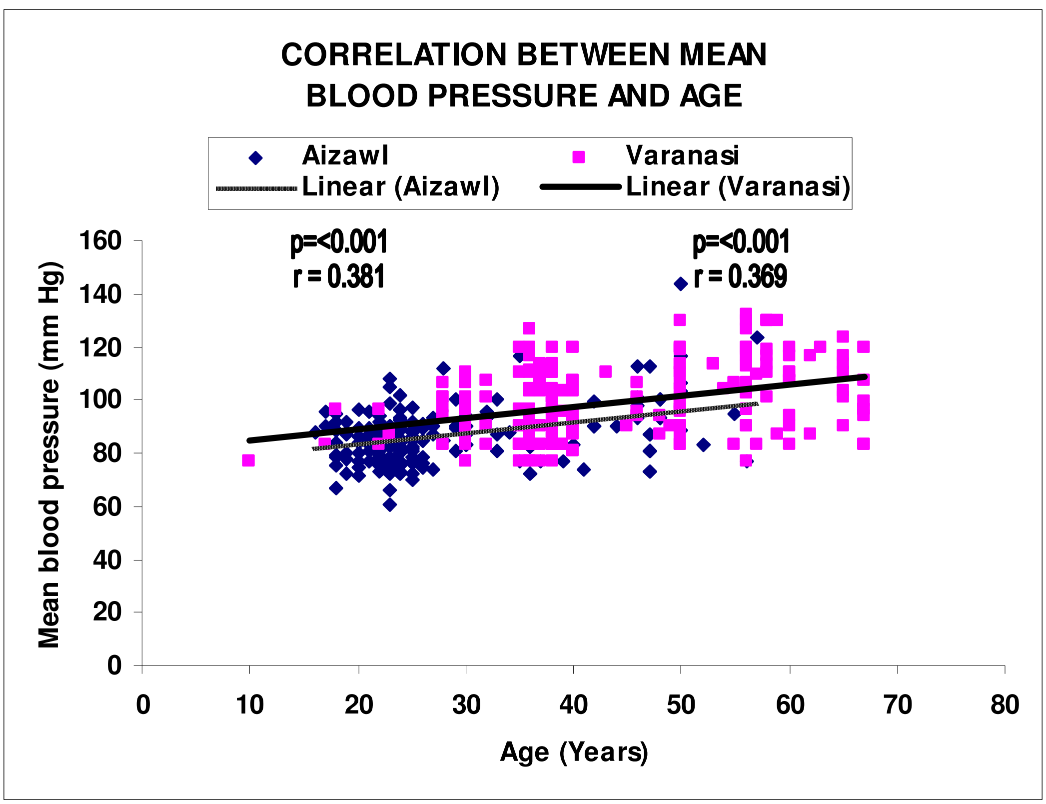


Table No. 5.15 Correlation between body mass index and blood pressure

	Body mass index (Mean ± SD)	Mean Blood pressure (Mean ± SD)	p Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	86.13 ± 10.45	<0.001	1.00
Varanasi	23.97 ± 3.69	99.08 ± 13.86	<0.001	0.942

The body mass index had shown statistically highly significant positive correlation with mean blood pressure in both sites (Aizawl *p=<0.001 & r=1.00*) and (Varanasi *p=<0.001 & r=0.942*).

Fig 5.19

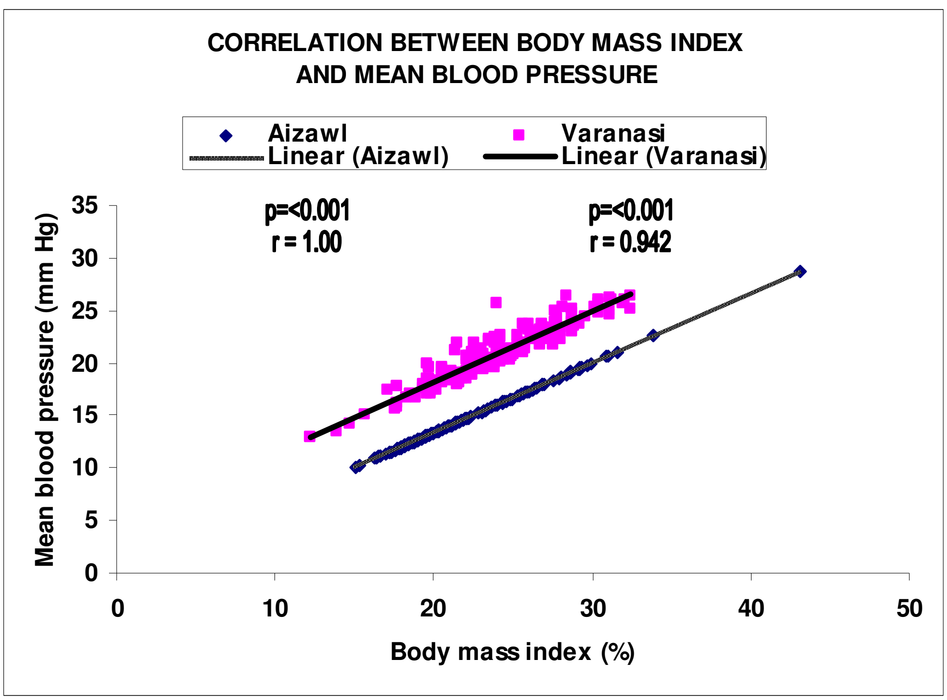


Table No. 5.16 Calorie intake of vegetarian and non-vegetarian

DIET	VEGETARIAN (Mean ± SD)	NONVEGETARIAN (Mean ± SD)
Aizawl	2262.98 ± 717.80	2328.91 ± 652.84
Varanasi	2643.07 ± 357.55	2721.06 ± 249.86
***p* Value**	<0.001	<0.001

The dietary calorie intake was found significantly higher in Varanasi (Vegetarian 2643.07 ± 357.55 & Non-vegetarian 2721.06 ± 249.86) than Aizawl (Vegetarian 2262.98 ± 717.80 & Non-vegetarian 2328.91 ± 652.84). However the calorie intake of non-vegetarians was observed higher than vegetarian individuals from both sites.

Fig 5.20

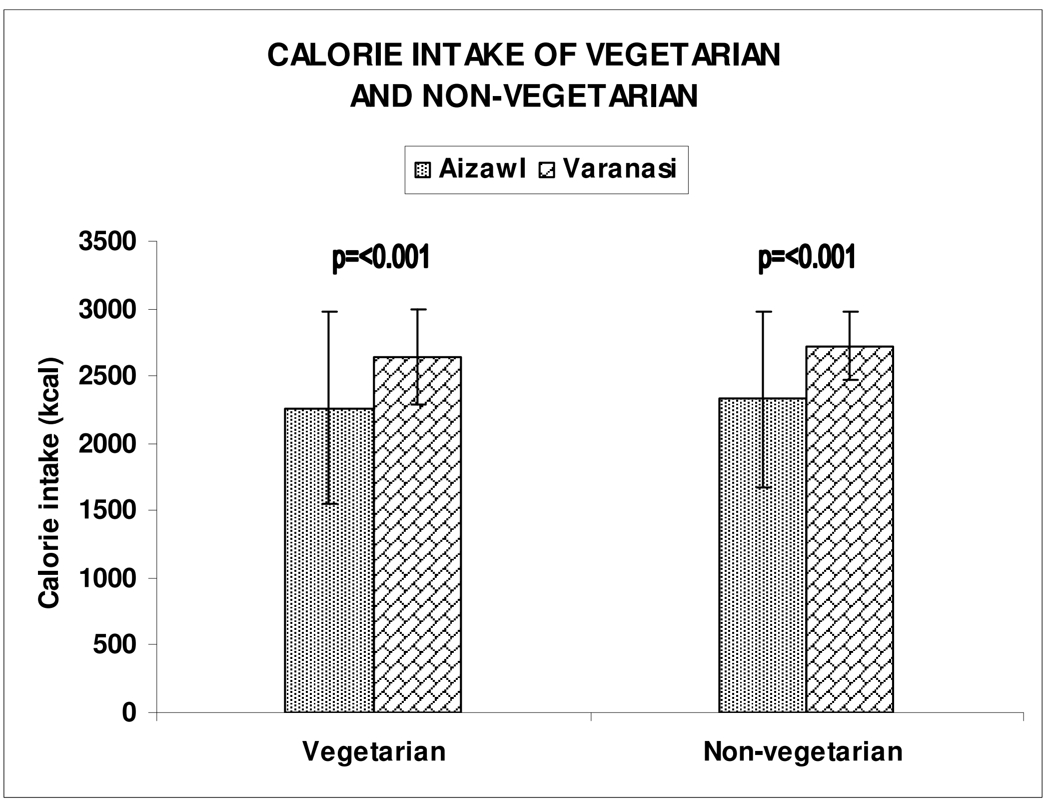


Table No. 5.17 Calorie intake of different age group

CALORIE INTAKE	Below 20 (Mean ± SD)	Between 20-40 (Mean ± SD)	Above 40 (Mean ± SD)
Aizawl	2592.74 ± 599.24	2246.05 ± 670.23	2408.31 ± 633.12
Varanasi	2705.47 ± 279.01	2681.67 ± 344.61	2690.64 ± 265.41
***p* Value**	0.372	<0.001	<0.001

Dietary calorie intake was observed significantly low in 20-40 age groups (Aizawl 2246.05 ± 670.23 & Varanasi 2681.67 ± 344.61) than other two groups at both sites. However the overall calorie intake was significantly higher in Varanasi amongst all age group than Aizawl.

Fig 5.21

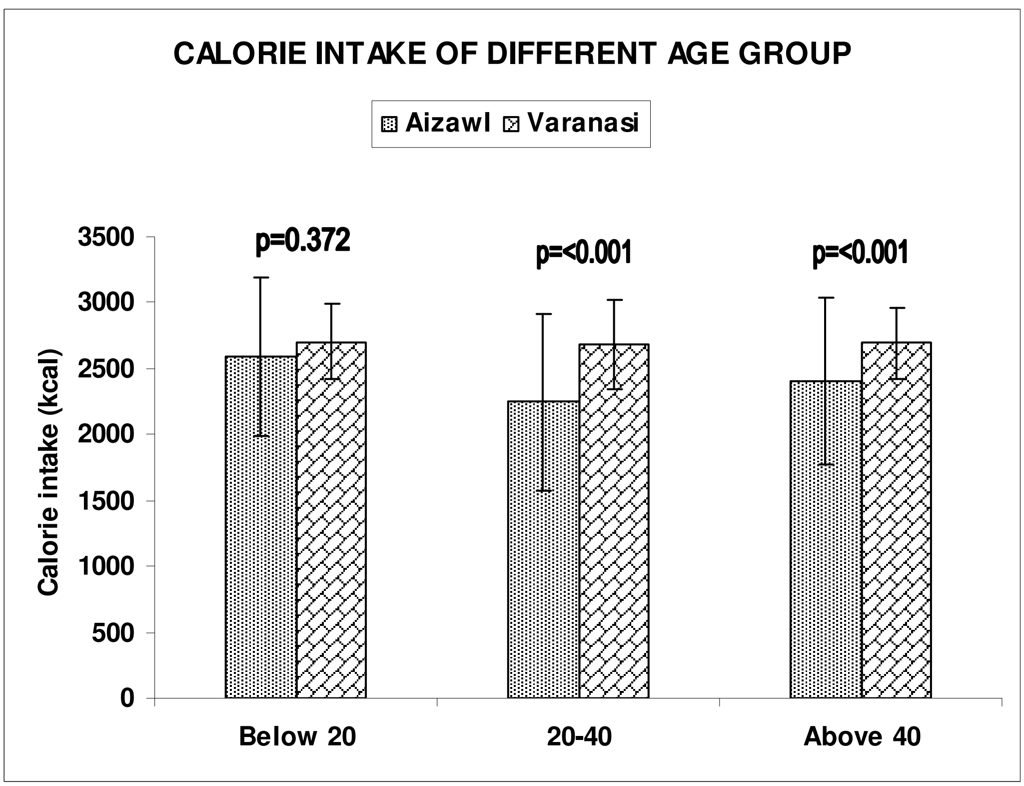


Table No. 5.18 Calorie intake of male and female

DIET	MALE (Mean ± SD)	FEMALE (Mean ± SD)
Aizawl	1980.02 ± 627.36	2865.18 ± 182.14
Varanasi	2730.87 ± 276.10	2576.10 ± 335.24
***p* Value**	<0.001	<0.001

The calorie intake in Varanasi was observed significantly high in both male and female than Aizawl subjects. The Female from Aizawl consumed significantly increased calorie than male (Male 1980.02 ± 627.36 and Female 2865.18 ± 182.14), whereas in Varanasi male individual's calorie intake was significantly higher than female (Male 2730.87 ± 276.10 and female 2576.10 ± 335.24).

Fig 5.22

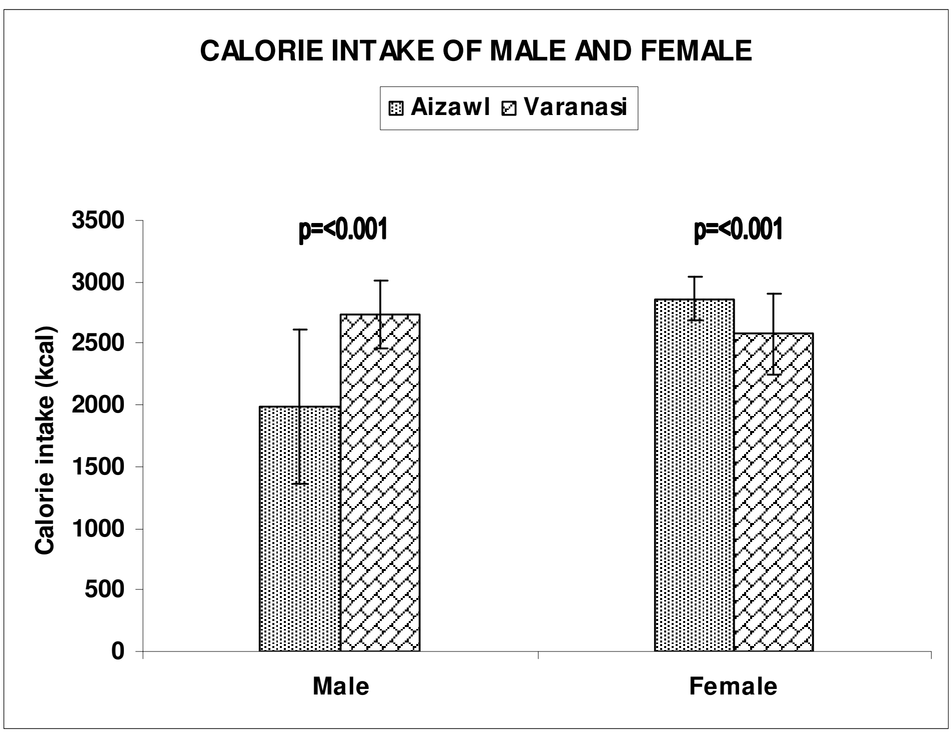


Table No. 5.19 Calorie intake of blue collar and white collar individuals

DIET	BLUE COLLAR (Mean ± SD)	WHITE COLLAR (Mean ± SD)
Aizawl	2211.38 ± 709.97	2337.13 ± 655.15
Varanasi	2738.50 ± 195.16	2665.29 ± 337.70
***p* Value**	<0.001	<0.001

The white collar subjects consumed significantly high calorie than blue collar (Blue 2211.38 ± 709.97 and White 2337.13 ± 655.15) in Aizawl. However in Varanasi a reverse pattern was observed where blue collar consumes significantly high calorie than white collar (Blue 2738.50 ± 195.16 and White 2665.29 ± 337.70).

Fig 5.23

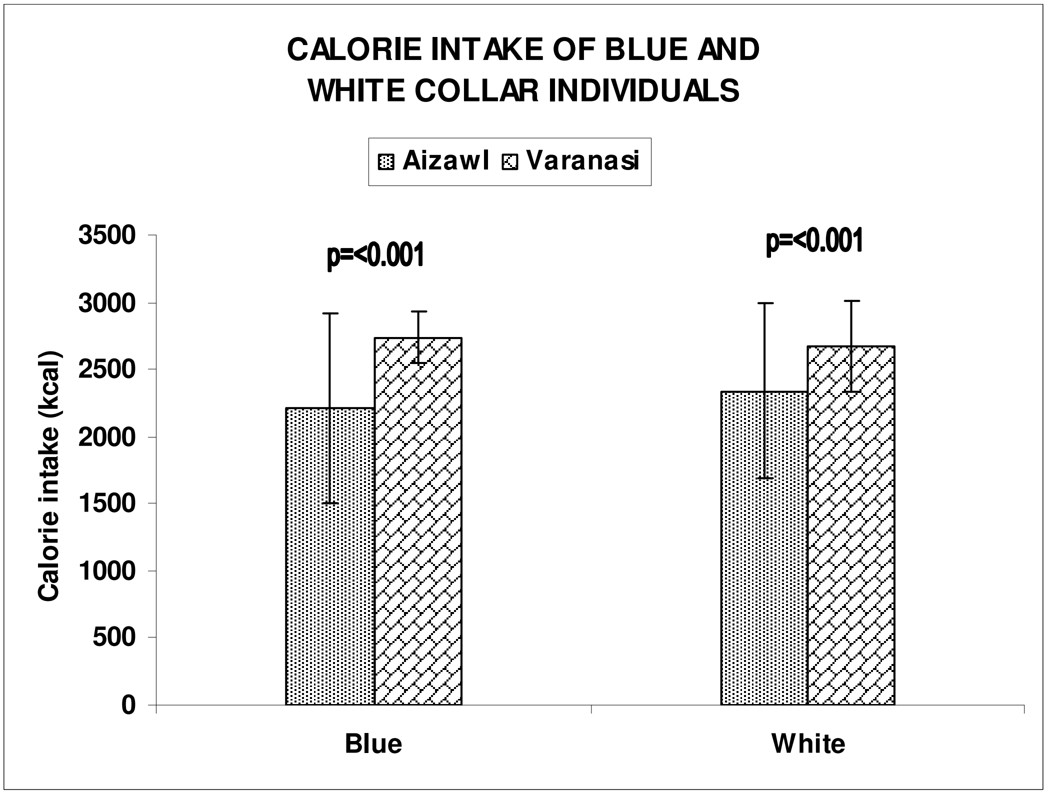


Table No. 5.20 **Carbohydrate and protein intake of vegetarian and non-vegetarian**

DIET	VEGETARIAN		NON-VEGETARIAN	
	Carbohydrate (Mean ± SD)	Protein (Mean ± SD)	Carbohydrate (Mean ± SD)	Protein (Mean ± SD)
Aizawl	570.13 ± 297.56	130.41 ± 78.98	542.69 ± 266.48	127.19 ± 68.03
Varanasi	558.70 ± 142.62	134.50 ± 38.78	608.33 ± 152.46	156.62 ± 43.03
***p* Value**	0.776	0.703	0.017	<0.001

The carbohydrate and protein consumption was observed significantly lower in non-vegetarian (Carbohydrate 542.69 ± 266.48 gm and Protein 127.19 ± 68.03 gm) than vegetarian (Carbohydrate 570.13 ± 297.56 gm and Protein 130.41 ± 78.98 gm) in Aizawl. However in Varanasi the reverse pattern was observed with significantly higher carbohydrate and protein consumption in non-vegetarian (Carbohydrate 608.33 ± 152.46 gm and Protein 156.62 ± 43.03 gm) than vegetarian (Carbohydrate 558.70 ± 142.62 gm and Protein 134.50 ± 38.78 gm). The difference in dietary intake was found significant in non-vegetarian only (*p=0.017, <0.001*).

Fig 5.24

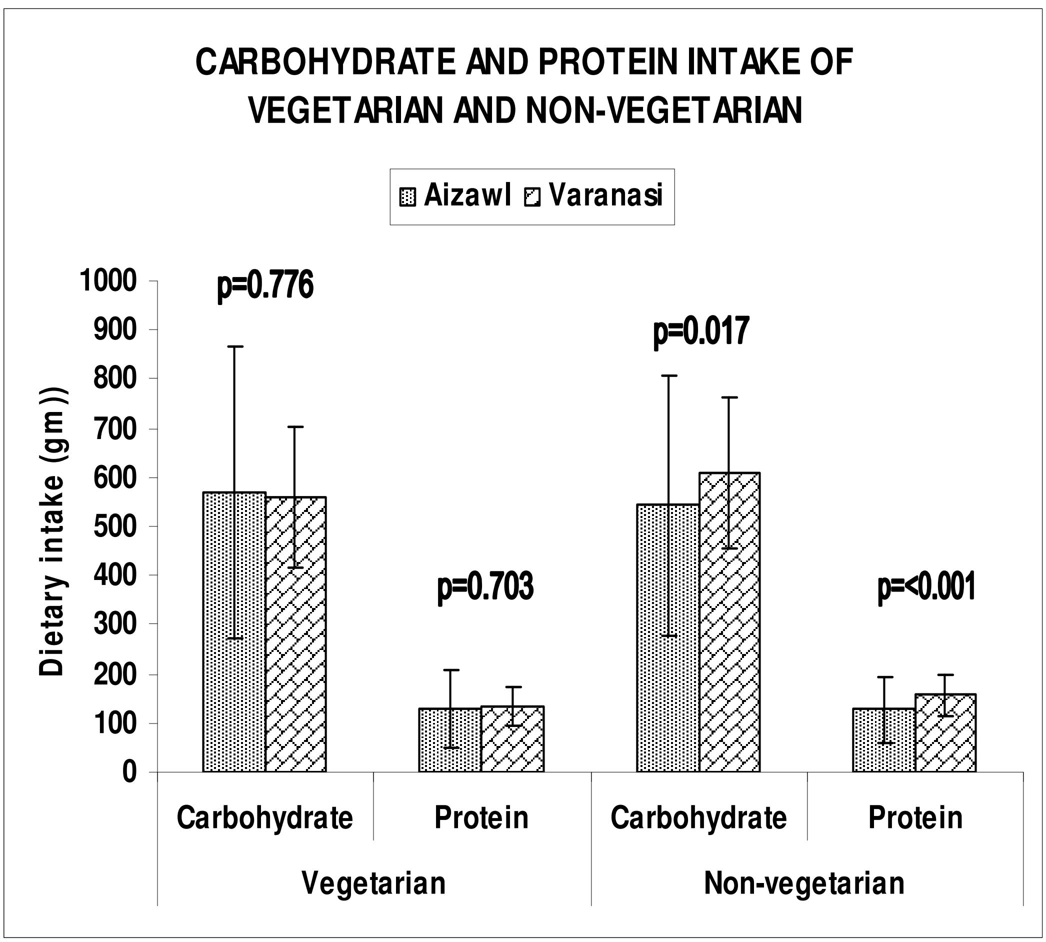


Table No. 5.21 Carbohydrate and protein intake of male and female

DIET	MALE		FEMALE	
	Carbohydrate (Mean ± SD)	**Protein (Mean ± SD)**	**Carbohydrate (Mean ± SD)**	**Protein (Mean ± SD)**
Aizawl	406.45 ± 165.71	90.07 ± 44.56	778.70 ± 253.65	189.36 ± 59.72
Varanasi	610.74 ± 151.21	154.06 ± 42.51	526.44 ± 129.64	129.96 ± 38.15
***p* Value**	<0.001	<0.001	<0.001	<0.001

The carbohydrate consumption was found significantly high in female than male (Male 406.45 ± 165.71 gm and Female 778.70 ± 253.65 gm) at Aizawl, whereas in Varanasi male subjects consumed significantly increased carbohydrate than female (Male 610.74 ± 151.21 gm and Female 526.44 ± 129.64 gm). The similar pattern was observed for protein intake with significantly increased value in female (Male 90.07 ± 44.56 gm and Female 189.36 ± 59.72 gm) at Aizawl and male (Male 154.06 ± 42.51 gm and Female 129.96 ± 38.15 gm) at Varanasi.

Fig 5.25

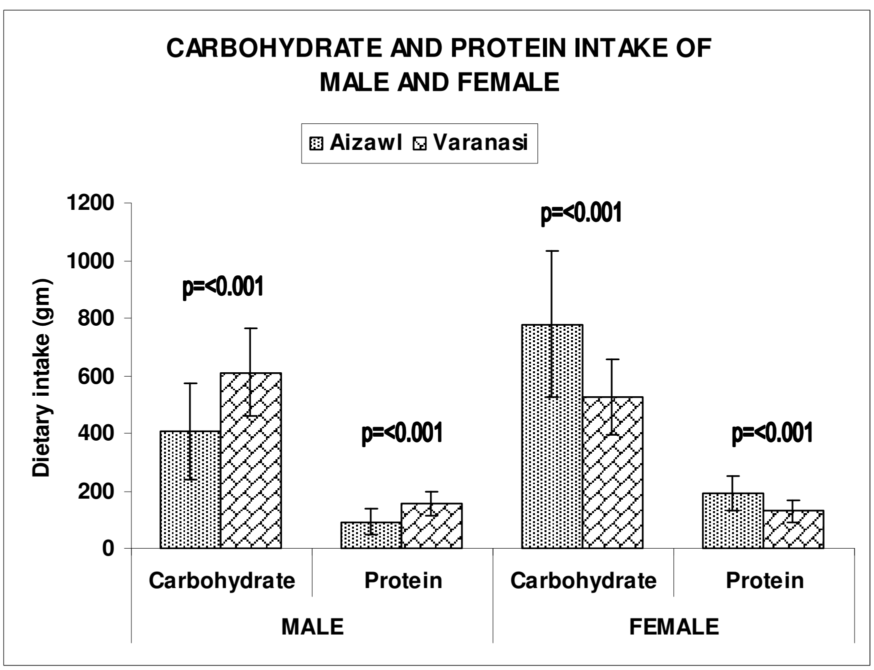


Table No. 5.22 Dietary sodium intake of vegetarian and non-vegetarian

Dietary sodium	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	183.39 ± 119.96	183.53 ± 102.90
Varanasi	306.36 ± 114.71	340.45 ± 118.74
***p* Value**	<0.001	<0.001

The sodium intake was significantly high (*p=<0.001*) in non-vegetarian subjects than vegetarian (Vegetarian 306.36 ± 114.71 gm and Non-vegetarian 340.45 ± 118.74 gm) in Varanasi, whereas in Aizawl no significant difference was observed. However the Varanasi residents had significantly higher dietary sodium than their Aizawl counterparts.

Fig 5.26

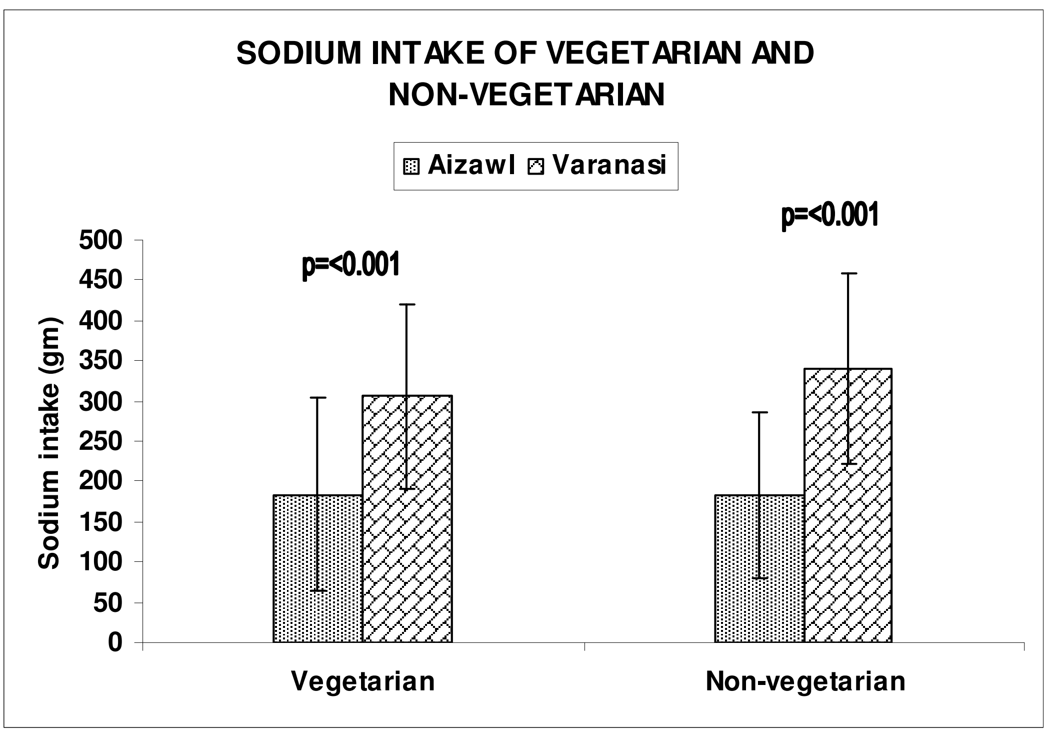


Table No. 5.23 Distribution of dietary potassium intake of vegetarian and non-vegetarian

Dietary potassium	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	2634.13 ± 1851.11	2579.14 ± 1561.30
Varanasi	3269.20 ± 1099.80	3618.34 ± 1153.00
***p* Value**	0.021	<0.001

The dietary potassium was observed significantly high in Varanasi than Aizawl individual. The potassium intake was significantly high in vegetarian at Aizawl than non-vegetarian (Vegetarian 2634.13 ± 1851.11 gm and Non-vegetarian 2579.14 ± 1561.30 gm), whereas in Varanasi non-vegetarian had shown increased potassium consumption than vegetarian (Vegetarian 3269.20 ± 1099.80 gm and Non-vegetarian 3618.34 ± 1153.00 gm).

Fig 5.27

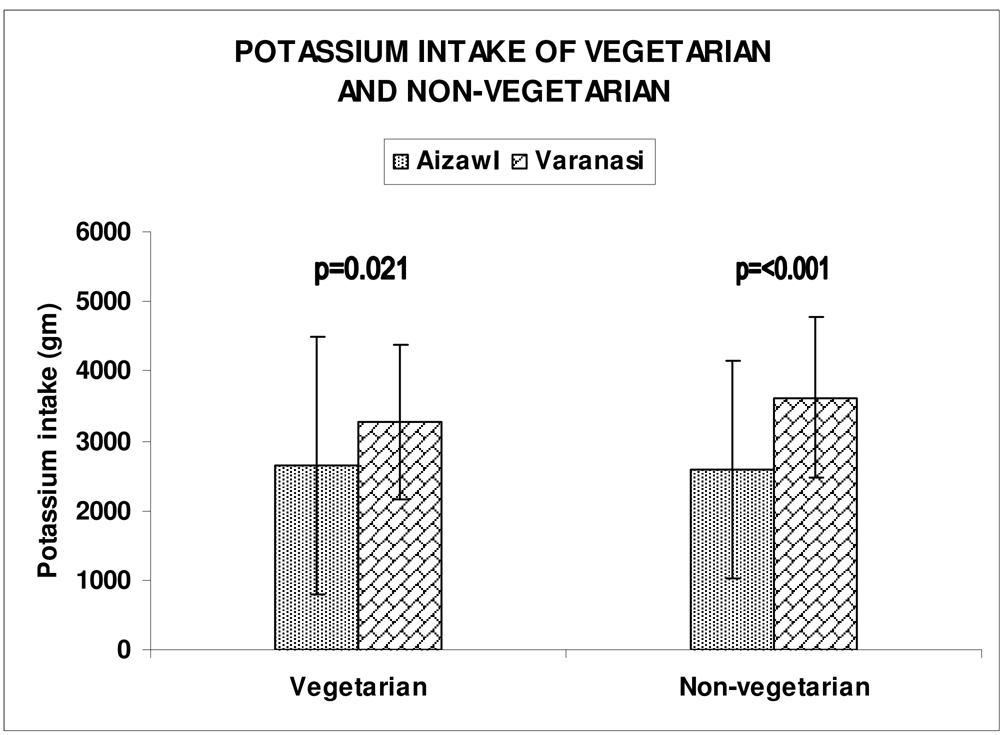


Table No. 5.24 Dietary sodium potassium ratio of vegetarian and non-vegetarian

Dietary sodium potassium ratio	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	0.08 ± 0.03	0.083 ± 0.05
Varanasi	0.095 ± 0.02	0.096 ± 0.02
***p* Value**	0.008	0.012

The dietary consumption ratio of sodium potassium was found significantly high in vegetarian and non-vegetarian subjects of Varanasi than Aizawl (Vegetarian Aizawl 0.08 ± 0.03 & Varanasi 0.095 ± 0.02 and Non-vegetarian Aizawl 0.083 ± 0.05 & Varanasi 0.096 ± 0.02). However no significant difference was observed in vegetarian and non-vegetarian individuals of both sites.

Fig 5.28

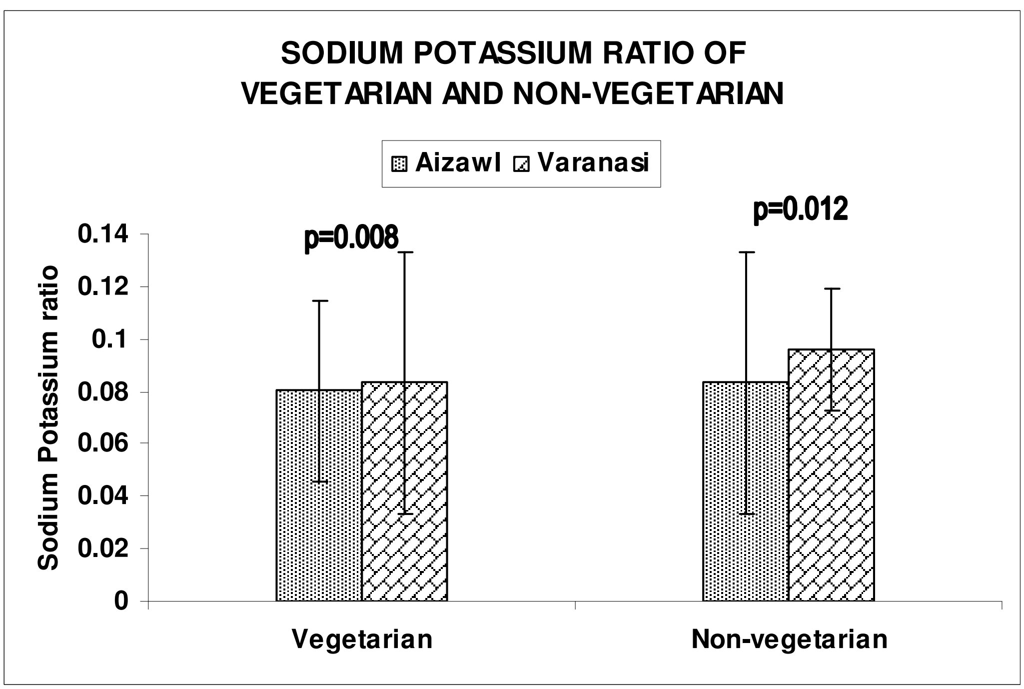


Table No. 5.25 Dietary calcium intake of vegetarian and non-vegetarian

Dietary calcium	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	404.84 ± 199.99	406.21 ± 234.11
Varanasi	1111.59 ± 606.91	1240.57 ± 634.72
***p* Value**	<0.001	<0.001

The dietary calcium was found significantly high in non-vegetarian (406.21 ± 234.11 gm and 1240.57 ± 634.72 gm) at both sites than vegetarian (404.84 ± 199.99 gm and 1111.59 ± 606.91 gm). However the overall calcium intake was significantly higher of Varanasi subjects than Aizawl.

Fig 5.29

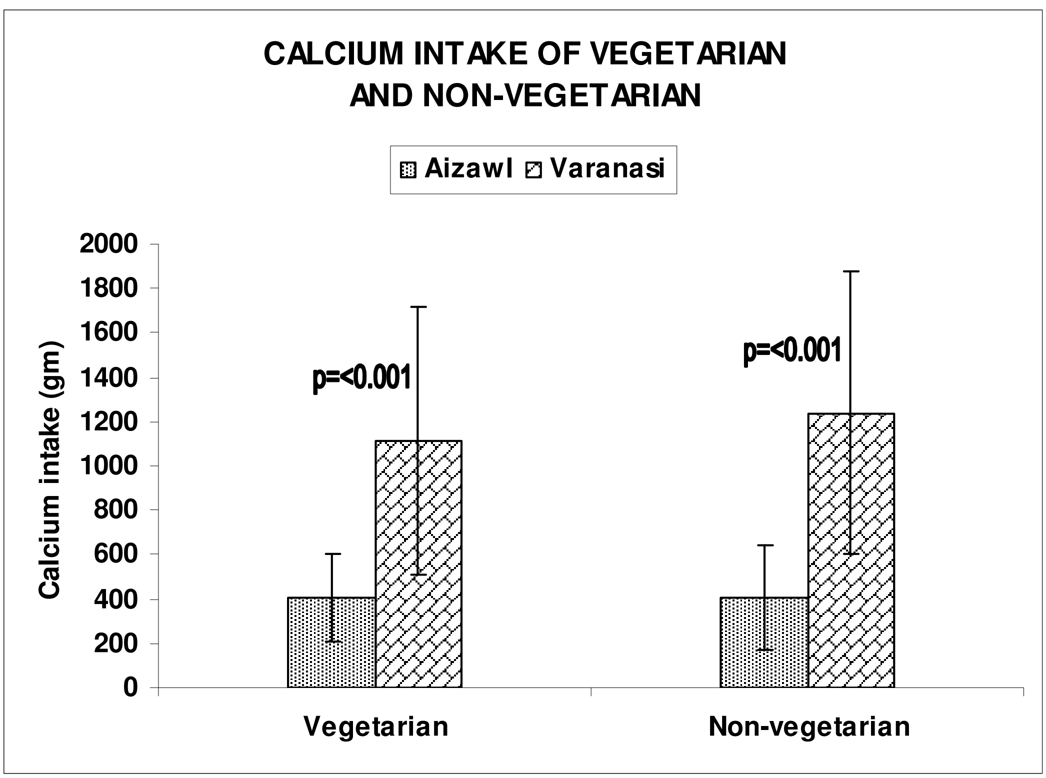


Table No. 5.26 Dietary chloride intake of vegetarian and non-vegetarian

Dietary chloride	VEGETARIAN (Mean ± SD)	NONVEGETARIAN (Mean ± SD)
Aizawl	119.03 ± 85.87	120.48 ± 69.51
Varanasi	204.09 ± 102.64	212.64 ± 99.15
***p* Value**	<0.001	<0.001

The daily dietary chloride consumption was found significantly high in non-vegetarian (Aizawl 120.48 ± 69.51 gm and Varanasi 212.64 ± 99.15 gm) at both sites than vegetarian (Aizawl 119.03 ± 85.87 gm and Varanasi 204.09 ± 102.64 gm). However the chloride intake was significantly higher of Varanasi subjects than Aizawl.

Fig 5.30

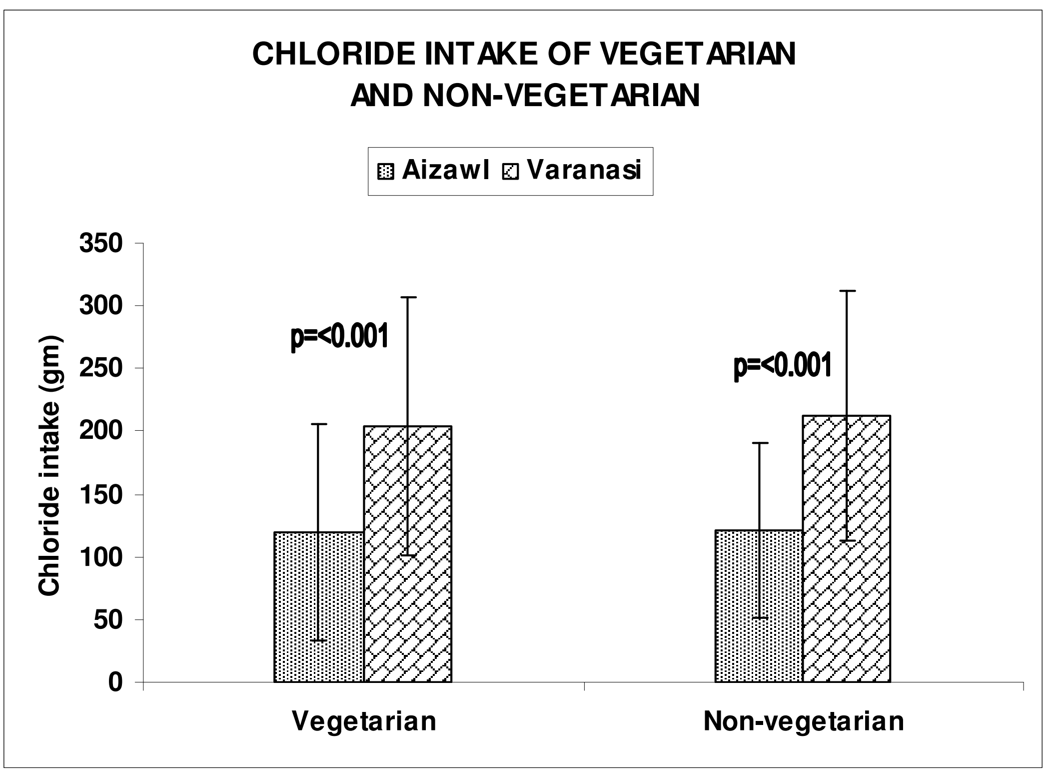


Table No. 5.27 Extra salt consumption of vegetarian and non-vegetarian

Extra salt consumption	VEGETARIAN (Mean ± SD)	NON-VEGETARIAN (Mean ± SD)
Aizawl	5.66±2.37	6.48±3.20
Varanasi	8.67±4.55	9.20±4.78
***p* Value**	<0.001	<0.001

The extra salt consumption was found significantly high in non-vegetarian (Aizawl 6.48 ± 3.20 gm and Varanasi 9.20 ± 4.78 gm) at both sites than vegetarian (Aizawl 5.66 ± 2.37 gm and Varanasi 8.67 ± 4.55 gm). However the consumption of extra salt was significantly higher in Varanasi subjects than Aizawl.

Fig 5.31

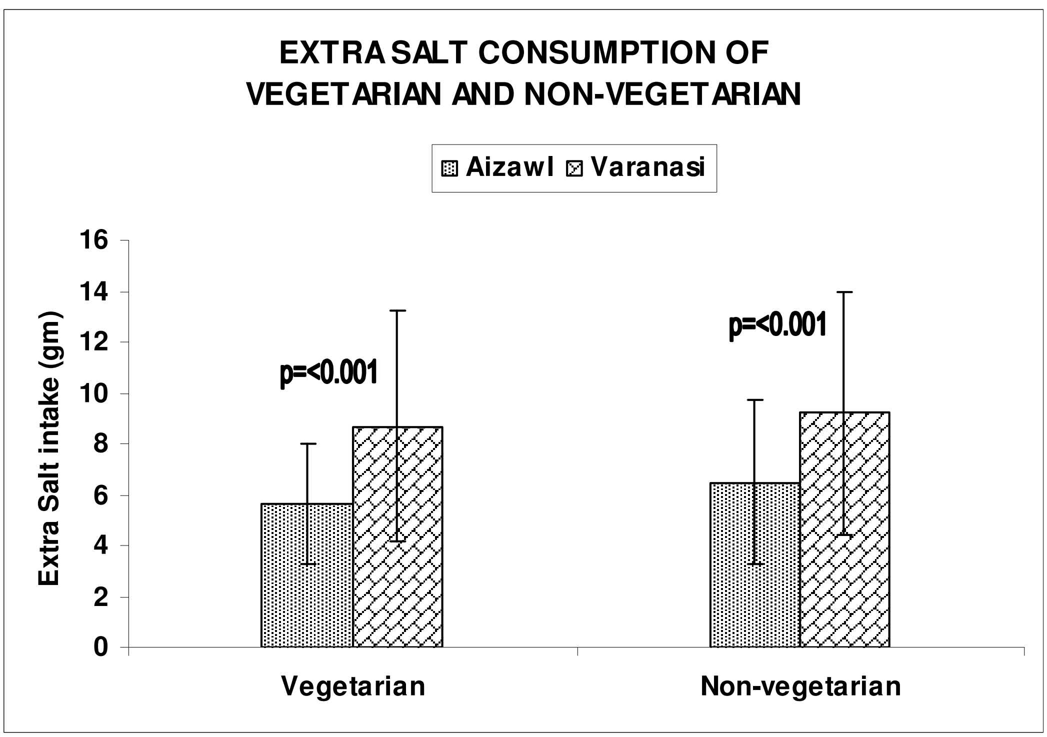


Table No. 5.28 Correlation between total calorie intake and carbohydrate intake

	Total Calorie (Mean ± SD)	Carbohydrate (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	2316.38 ± 664.30	547.91 ± 272.09	0.018	0.721
Varanasi	2689.09 ± 300.37	587.98 ± 150.15	0.016	0.659

The dietary calorie intake was found to be statistically significant positive correlation with carbohydrate consumption at both places (Aizawl *p=0.018 & r=0.721*) and (Varanasi *p=0.016 & r=0.659*).

Fig 5.32

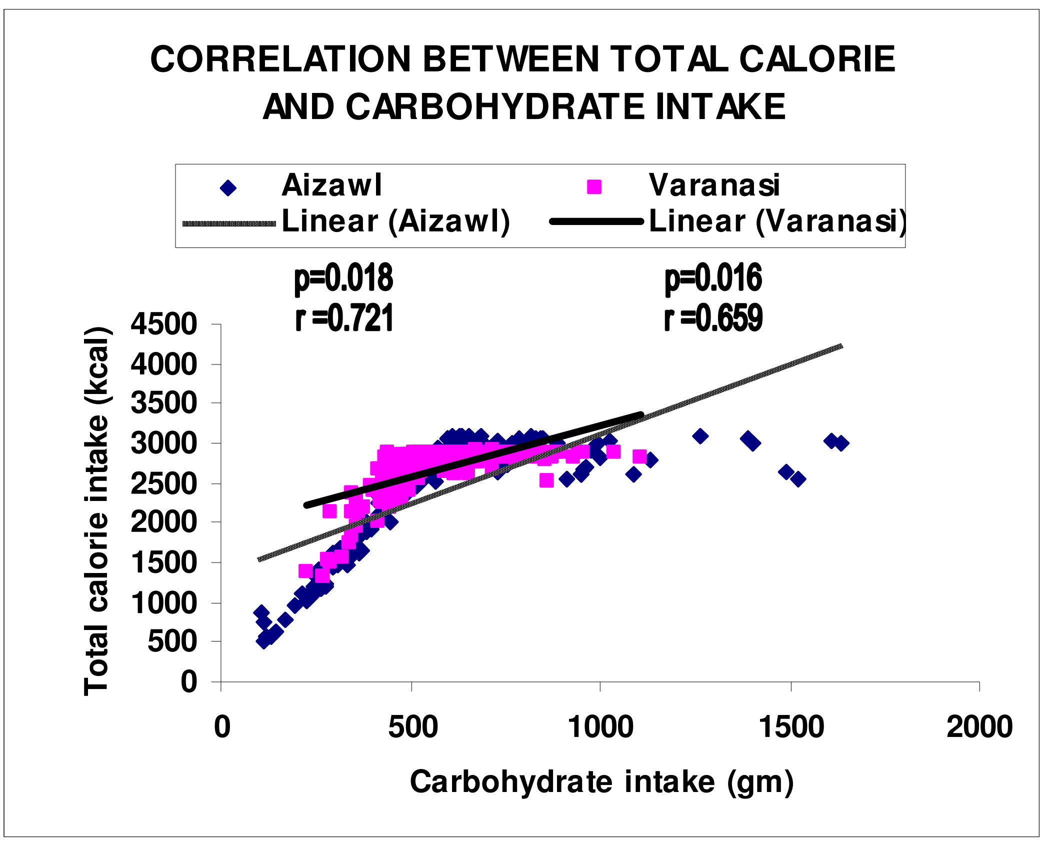


Table No. 5.29 Correlation between calorie intake and protein intake

	Calorie (Mean ± SD)	Protein (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	2316.38 ± 664.30	127.80 ± 70.04	0.012	0.745
Varanasi	2689.09 ± 300.37	147.55 ± 42.65	0.012	0.632

The dietary calorie consumption was found statistically significant positive correlation with protein (Aizawl *p=0.012 & r=0.745*) and (Varanasi *p=0.012 & r=0.632*) consumption at both site.

Fig 5.33

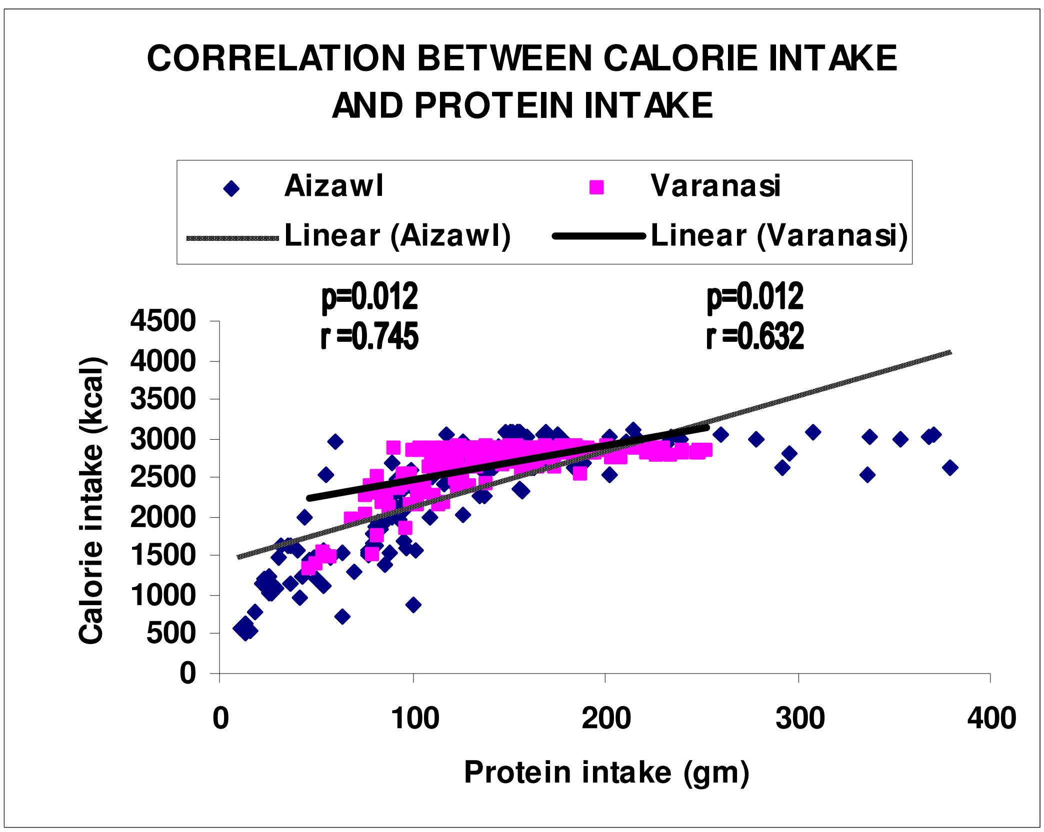


Table No. 5.30 Correlation between carbohydrate and protein intake

	Carbohydrate (Mean ± SD)	Protein (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	547.91 ± 272.09	127.80 ± 70.04	0.264	0.922
Varanasi	587.98 ± 150.15	147.55 ± 42.65	<0.001	0.251

The carbohydrate consumption was found statistically highly significant positive correlation with protein intake at Varanasi (*p=<0.001 & r=0.251*). However the Aizawl subjects had shown nonsignificant positive correlation between carbohydrate and protein intake (*p=0.264 & r=0.922*).

Fig 5.34

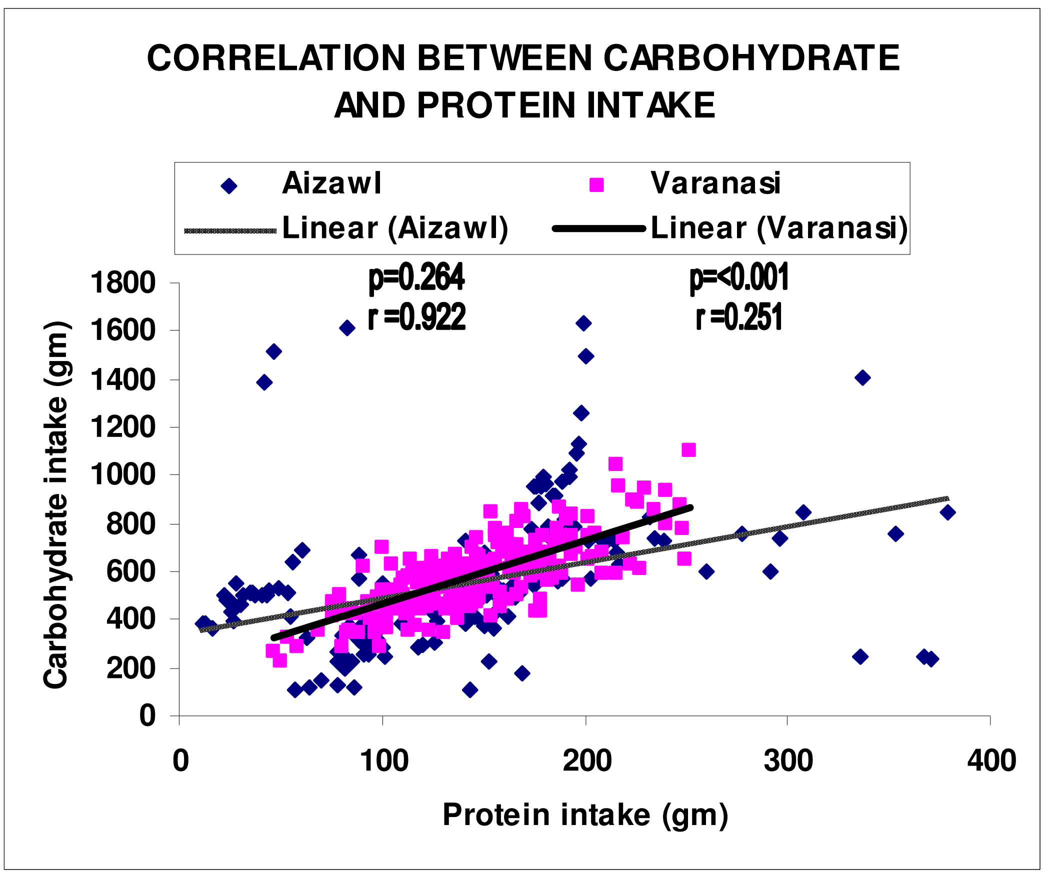


Table No. 5.31 Correlation between dietary sodium and potassium intake

Dietary Intake	Sodium (Mean ± SD)	Potassium (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	183.50 ± 106.03	2589.59 ± 1615.47	0.026	0.965
Varanasi	326.47 ± 118.02	3475.19 ± 1141.74	0.253	0.757

The sodium consumption was found statistically significant positive correlation with potassium intake at Aizawl (*p=0.026 & r=0.965*). However in Varanasi nonsignificant positive correlation was observed between sodium and potassium intake (*p=0.253 & r=0.757*).

Fig 5.35

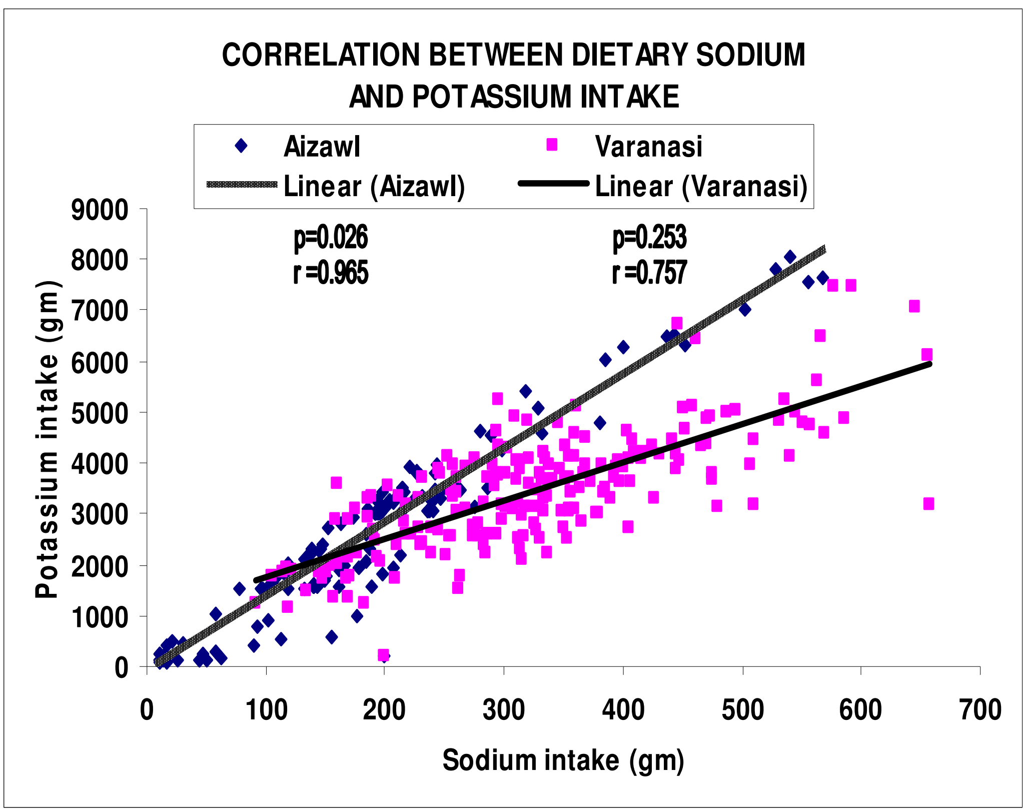


Table No. 5.32 Correlation between dietary sodium and chloride intake

Dietary Intake	Sodium (Mean ± SD)	Chloride (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	183.50 ± 106.03	120.20 ± 72.67	0.019	0.866
Varanasi	326.47 ± 118.02	209.14 ± 100.43	0.041	0.563

The dietary sodium consumption was found statistically significant positive correlation with chloride intake at both sites (Aizawl *p=0.019 & r=0.866* and Varanasi *p=0.041 & r=0.563*).

Fig 5.36

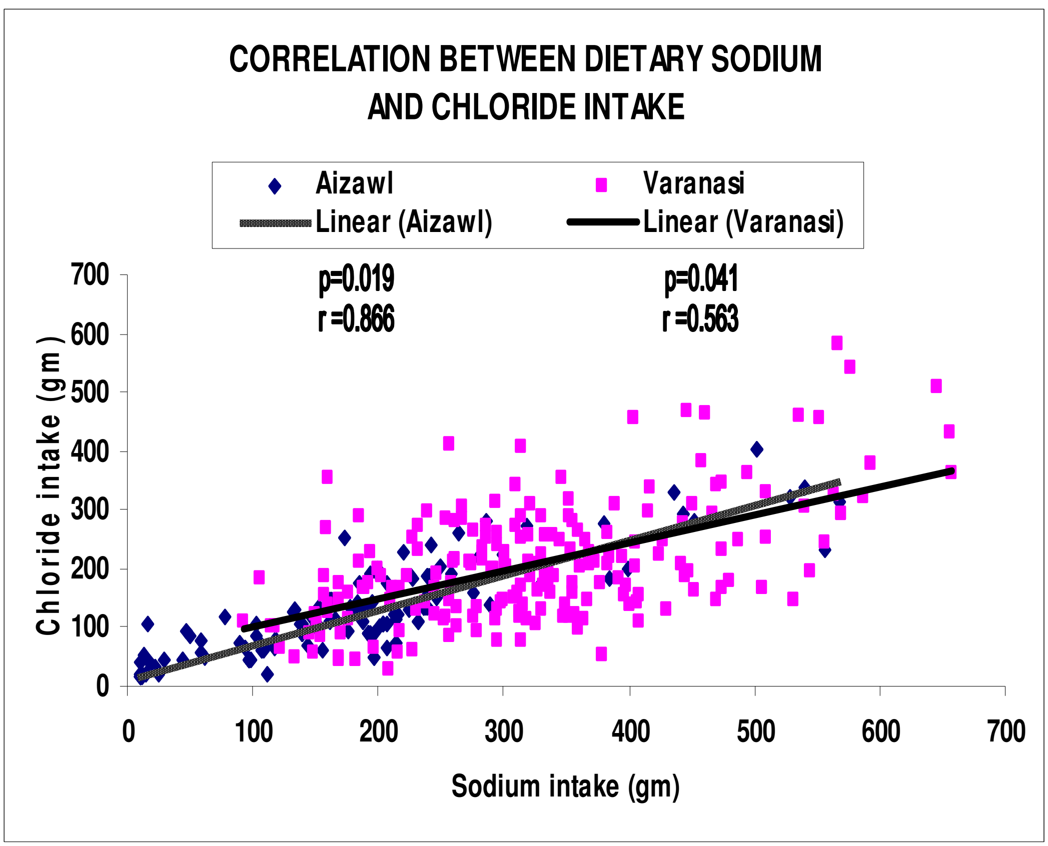


Table No. 5.33 Correlation between body mass index and calorie intake

Dietary Intake	Body mass index (Mean ± SD)	Calorie intake (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	2316.38 ± 664.30	0.043	0.143
Varanasi	23.97 ± 3.69	2689.09 ± 300.37	0.22	-0.086

The body mass index was found statistically significant positive correlation with total calorie intake at Aizawl (*p=0.043 & r=0.143*). However in Varanasi nonsignificant negative correlation was observed between body mass index and calorie consumption (*p=0.22 & r= - 0.086*).

Fig 5.37

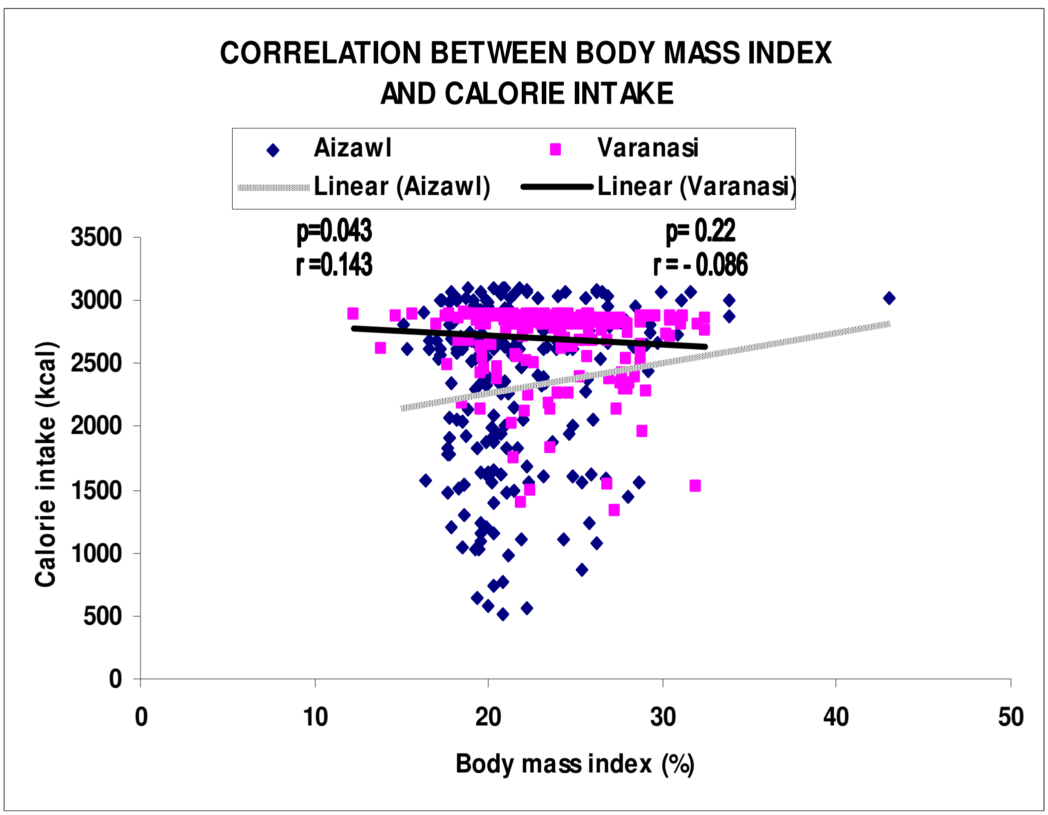


Table No. 5.34 Correlation between body mass index and carbohydrate intake

Dietary Intake	Body mass index (Mean ± SD)	Carbohydrate intake (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	547.91 ± 272.09	0.164	0.098
Varanasi	23.97 ± 3.69	587.98 ± 150.15	0.158	-0.10

The body mass index was found nonsignificant positive correlation with carbohydrate intake in Aizawl (*p=0.164 & r=0.098*). However nonsignificant negative correlation was observed at Varanasi (*p=0.158 & r= - 0.10*).

Fig 5.38

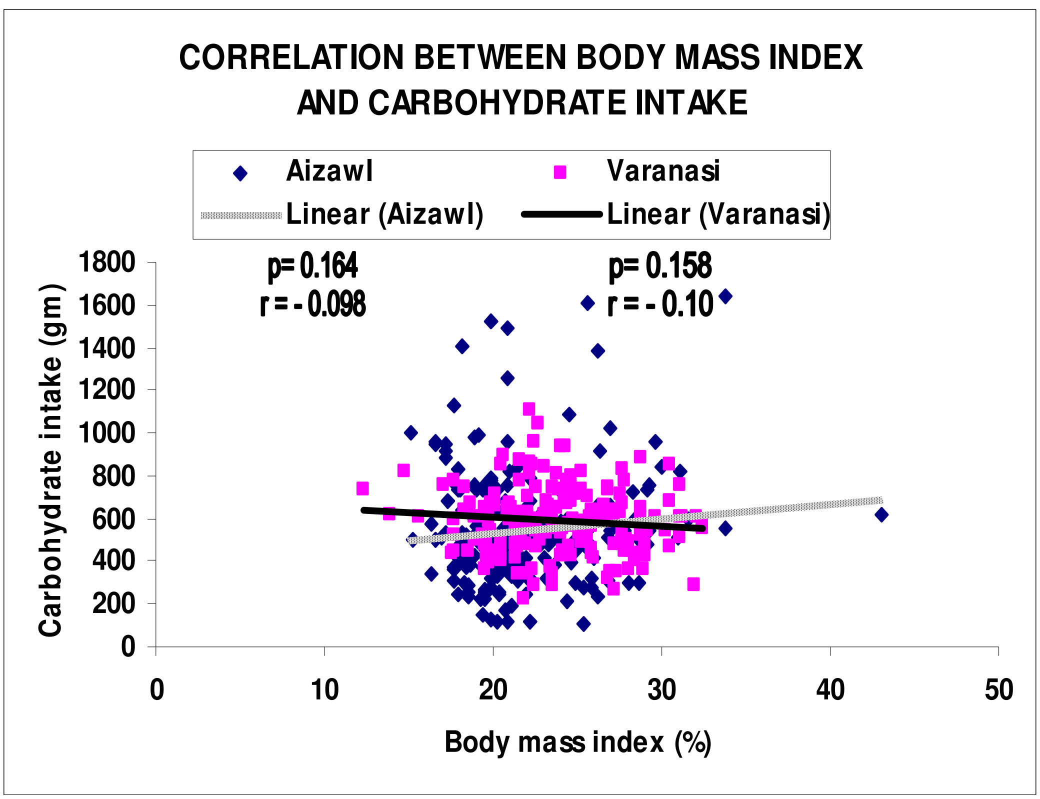


Table No. 5.35 Correlation between body mass index and protein intake

Dietary Intake	Body mass index (Mean ± SD)	Protein intake (Mean ± SD)	*P* Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	127.80 ± 70.04	0.116	0.112
Varanasi	23.97 ± 3.69	147.55 ± 42.65	0.07	-0.128

The body mass index was found nonsignificant positive correlation with protein intake in Aizawl (*p=0.116 & r=0.112*). However nonsignificant negative correlation was observed at Varanasi (*p=0.07 & r= - 0.128*).

Fig 5.39

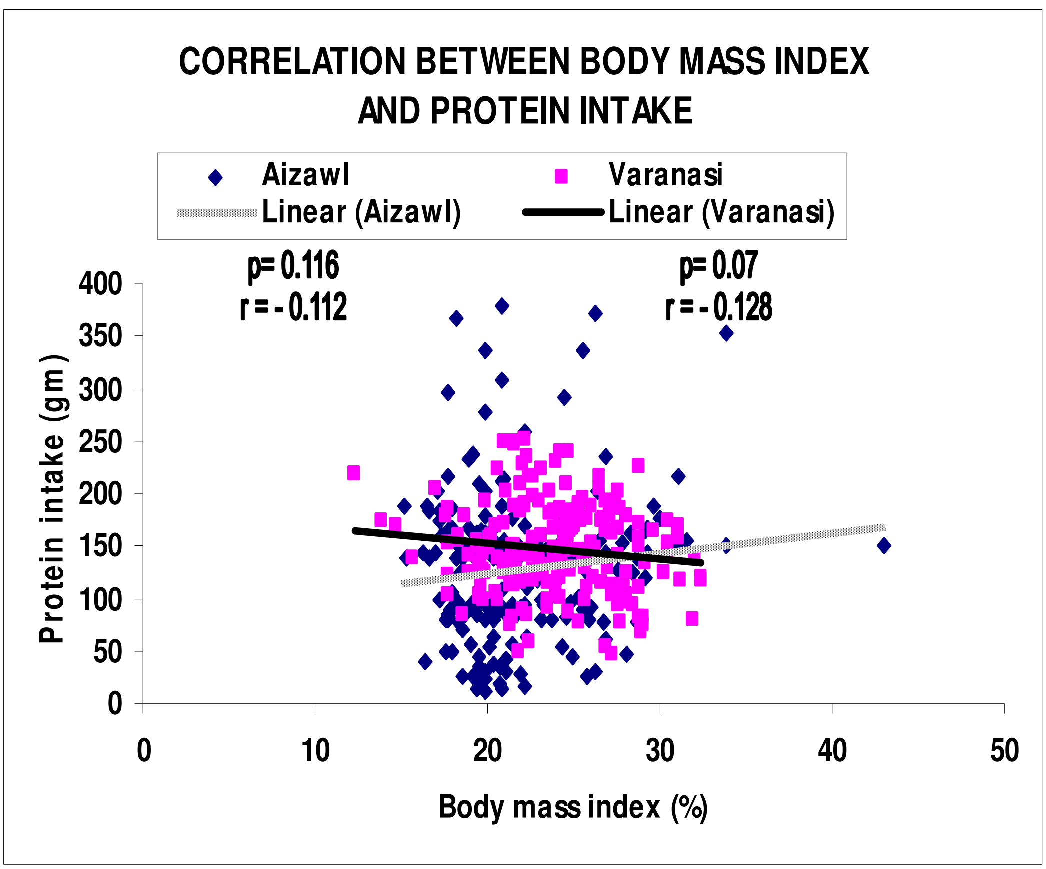


Table No. 5.36 Correlation between body mass index and dietary sodium intake

Dietary Intake	Body mass index (Mean ± SD)	Sodium intake (Mean ± SD)	*P* Value	Correlation Coefficient (r)
Aizawl	21.70±3.98	183.50±106.03	0.171	0.097
Varanasi	23.97±3.69	326.47±118.02	0.08	-0.124

The body mass index was found nonsignificant positive correlation with dietary sodium intake in Aizawl (*p=0.171& r=0.097*). However nonsignificant negative correlation was observed at Varanasi (*p=0.08 & r= - 0.124*).

Fig 5.40

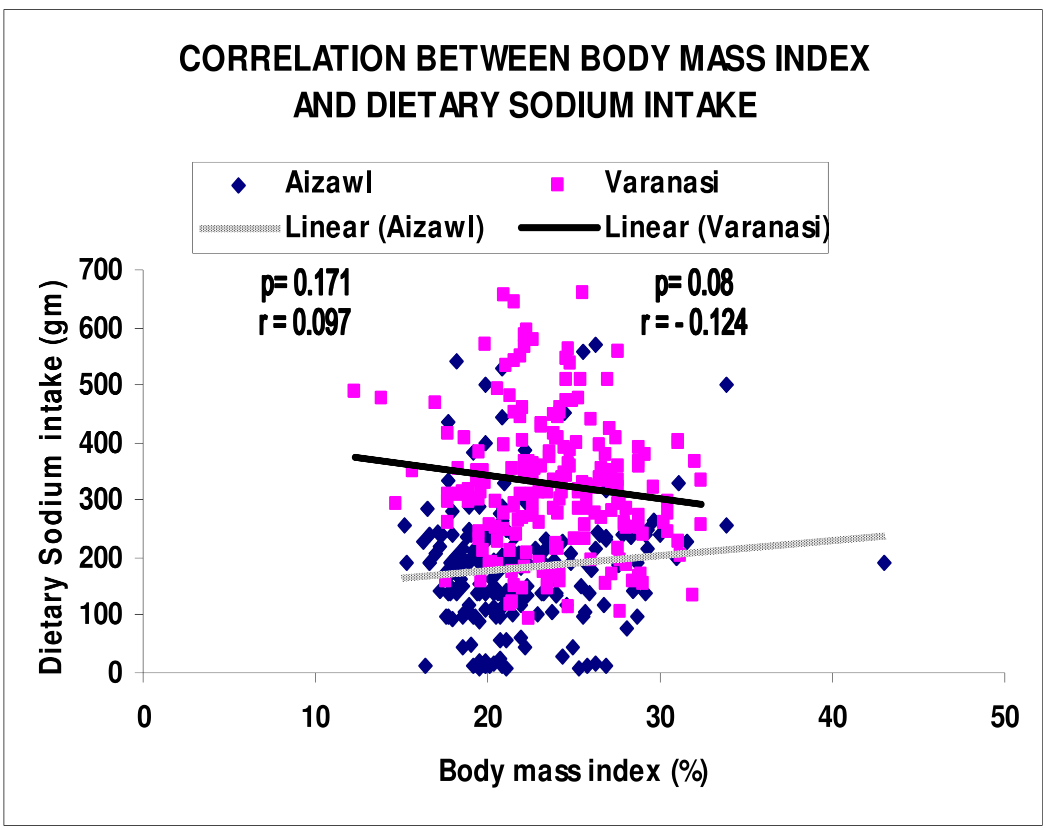


Table No. 5.37 Correlation between body mass index and dietary potassium intake

Dietary Intake	Body mass index (Mean ± SD)	Potassium intake (Mean ± SD)	*P* Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	2589.59 ± 1615.47	0.109	0.114
Varanasi	23.97 ± 3.69	3475.19 ± 1141.74	0.163	-0.10

The body mass index was found nonsignificant positive correlation with potassium intake in Aizawl (*p=0.109 & r=0.114*). However nonsignificant negative correlation was observed at Varanasi (*p=0.163 & r= - 0.10*).

Fig 5.41

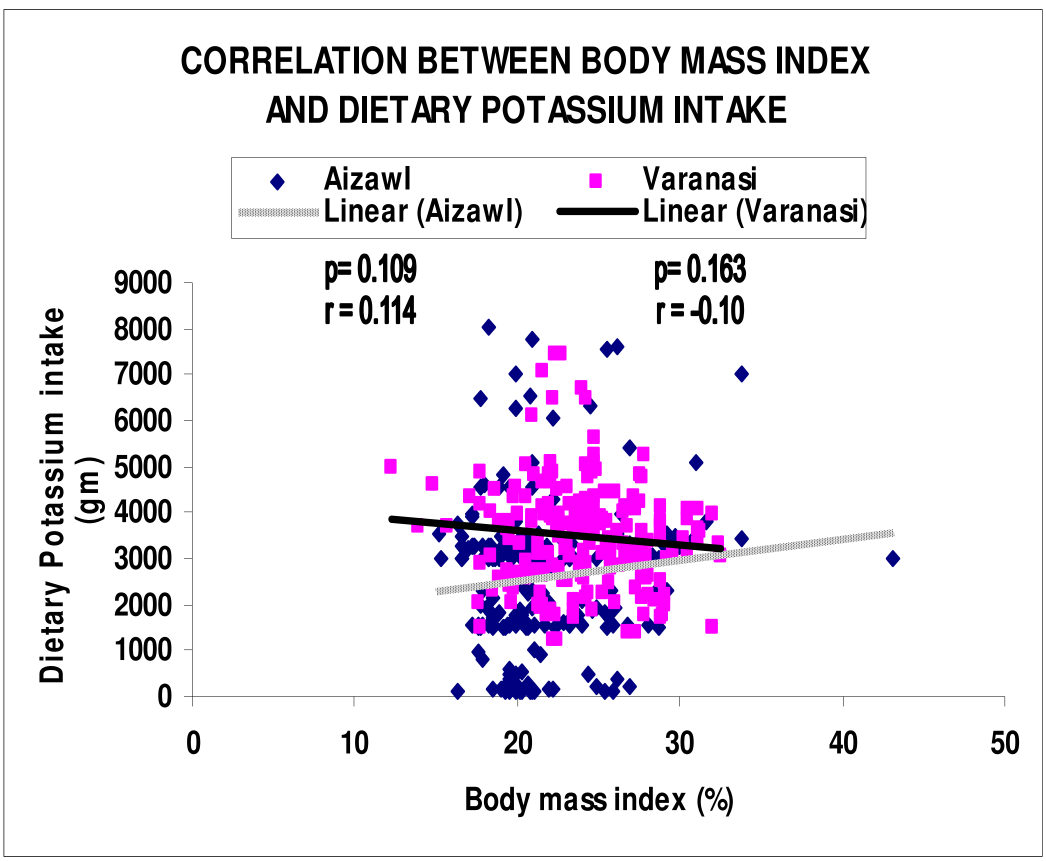


Table No. 5.38 Correlation between body mass index and dietary calcium intake

Dietary Intake	Body mass index (Mean ± SD)	Calcium intake (Mean ± SD)	*P* Value	Correlation coefficient (r)
Aizawl	21.70 ± 3.98	405.95 ± 227.55	0.08	0.124
Varanasi	23.97 ± 3.69	1187.69 ± 625.05	0.33	-0.07

The body mass index was found nonsignificant positive correlation with calcium intake in Aizawl (*p=0.08 & r=0.124*). However nonsignificant negative correlation was observed at Varanasi (*p=0.33 & r= - 0.07*).

Fig 5.42

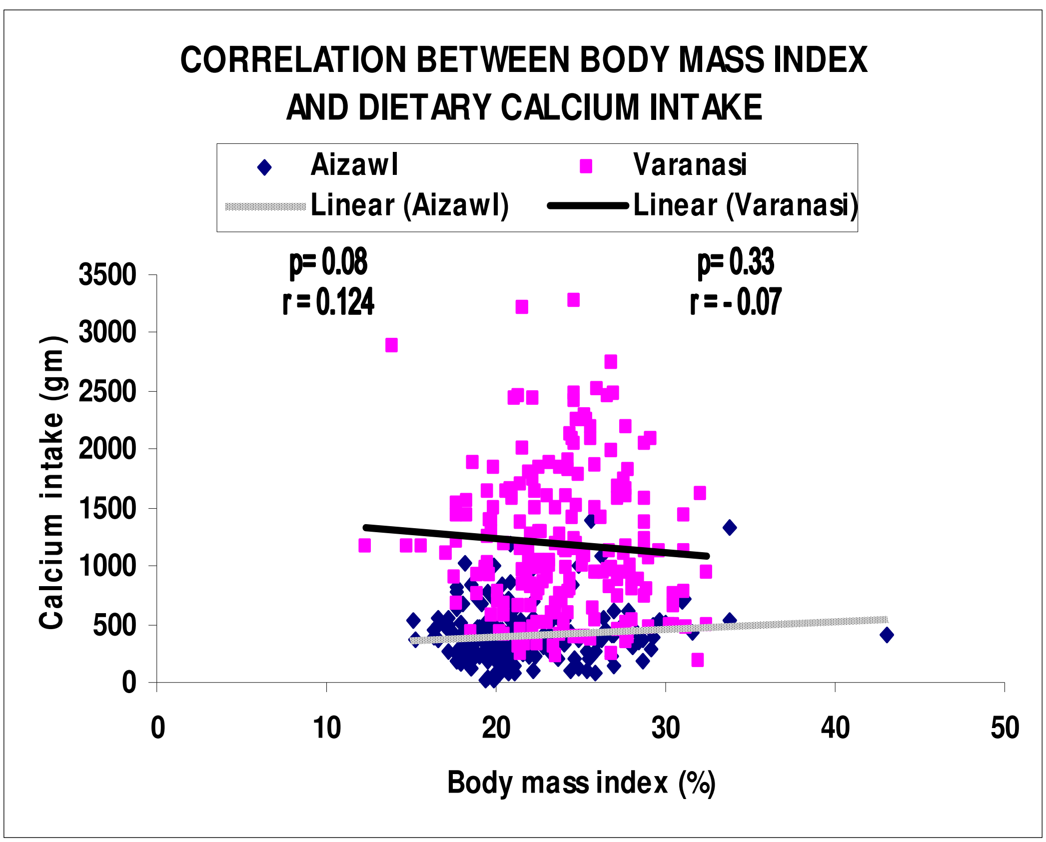


Table No. 5.39 Correlation between body mass index and dietary chloride intake

Dietary Intake	Body mass index (Mean ± SD)	Chloride intake (Mean ± SD)	*P* Value	Correlation Coefficient (r)
Aizawl	21.70 ± 3.98	120.20 ± 72.67	0.096	0.118
Varanasi	23.97 ± 3.69	209.14 ± 100.43	0.05	-0.133

The body mass index was found statistically significant negative correlation with chloride intake in Varanasi (*p=0.05 & r= -0.133*). However nonsignificant positive correlation was observed at Aizawl (*p=0.096 & r= 0.118*).

Fig 5.43

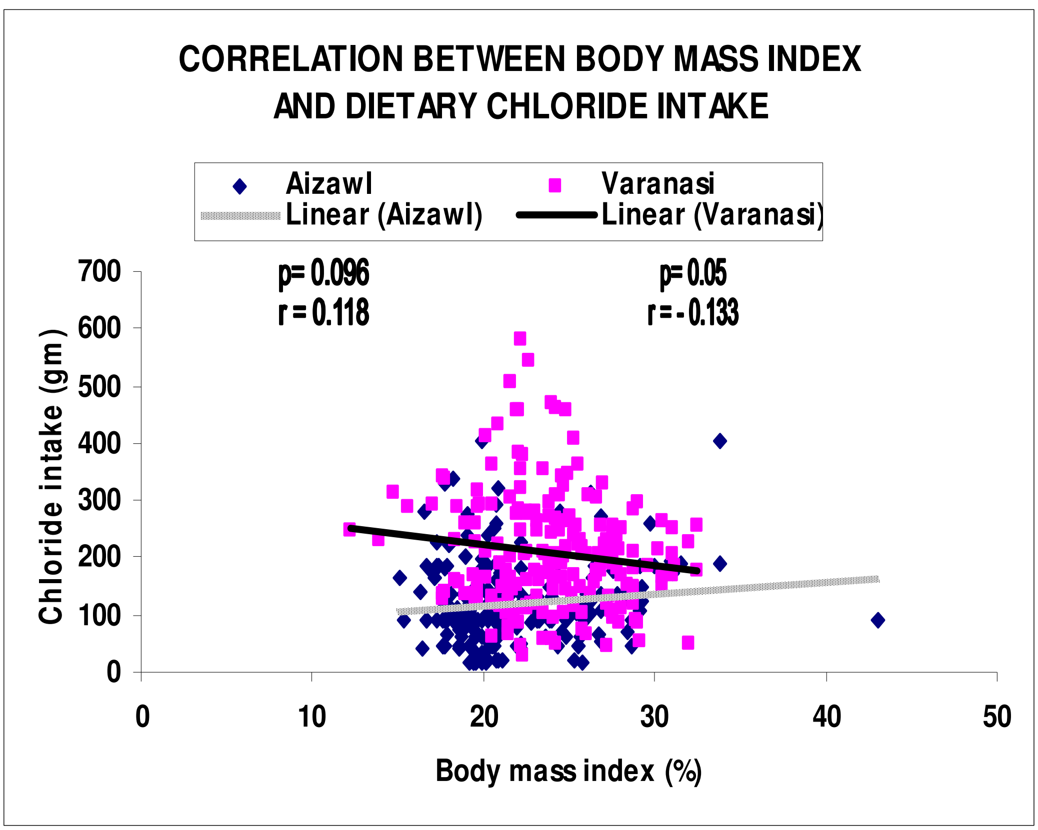


Table No. 5.40 Correlation between mean blood pressure and calorie intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Calorie intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	2316.38 ± 664.30	0.689	-0.0285
Varanasi	99.08 ± 13.86	2689.09 ± 300.37	0.671	-0.0302

The mean blood pressure was found statistically nonsignificant negative correlation with total calorie consumption at both of the sites.

Fig 5.44

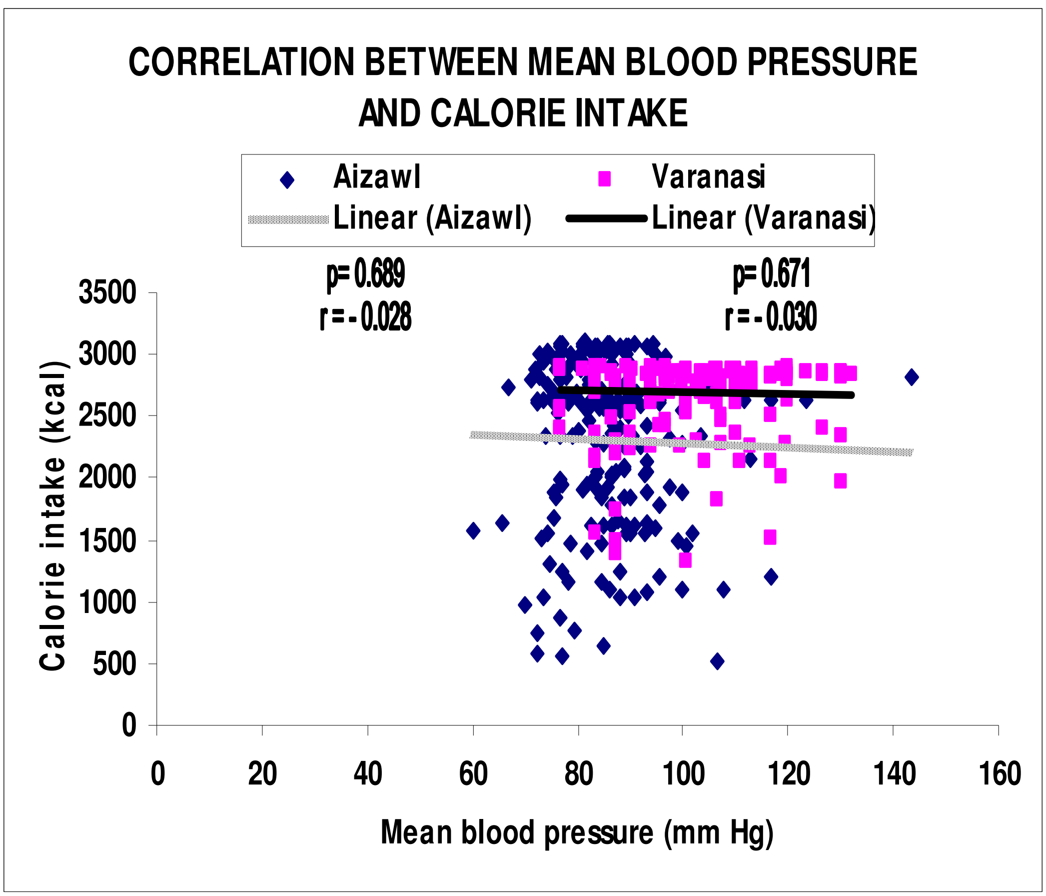


Table No. 5.41 Correlation between mean blood pressure and carbohydrate intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Carbohydrate intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	547.91 ± 272.09	0.243	-0.0829
Varanasi	99.08 ± 13.86	587.98 ± 150.15	0.262	-0.0797

The mean blood pressure was found statistically nonsignificant negative correlation with dietary carbohydrate intake at both of the sites.

Fig 5.45

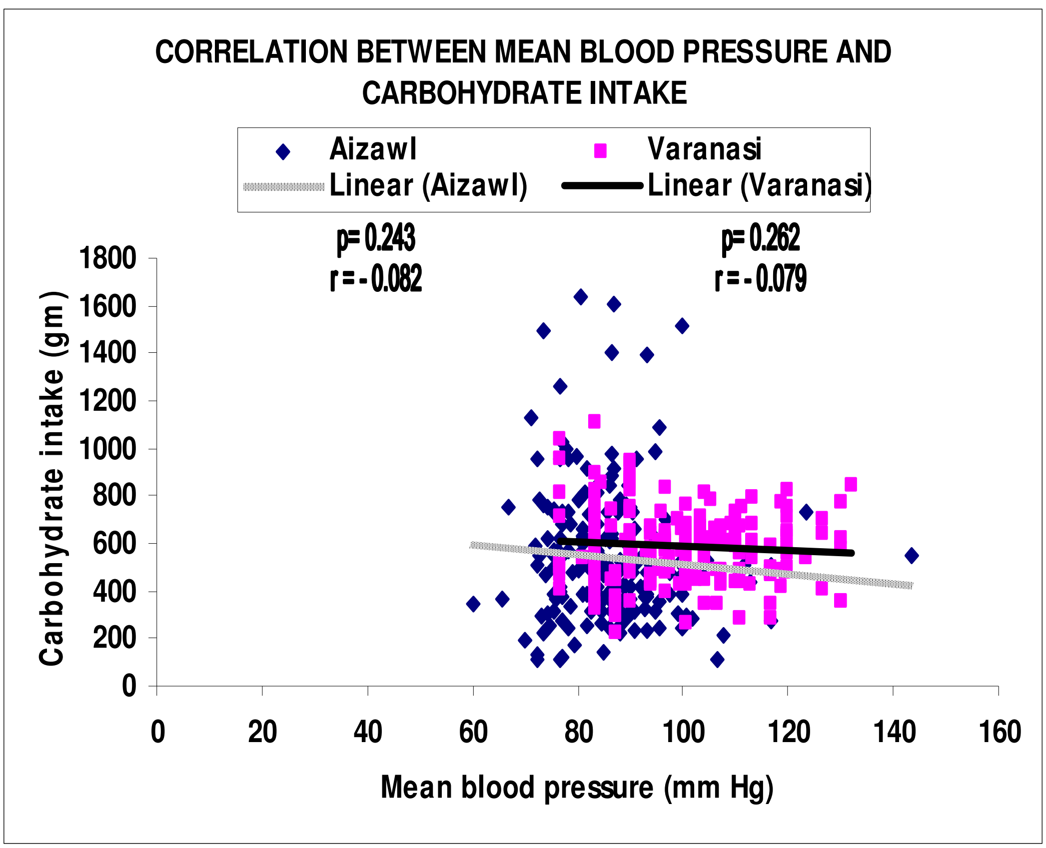


Table No. 5.42 Correlation between mean blood pressure and protein intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Protein intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	127.80 ± 70.04	0.572	-0.0402
Varanasi	99.08 ± 13.86	147.55 ± 42.65	0.806	-0.0175

The correlation between mean blood pressure and protein intake was found negative and statistically nonsignificant at both sites.

Fig 5.46

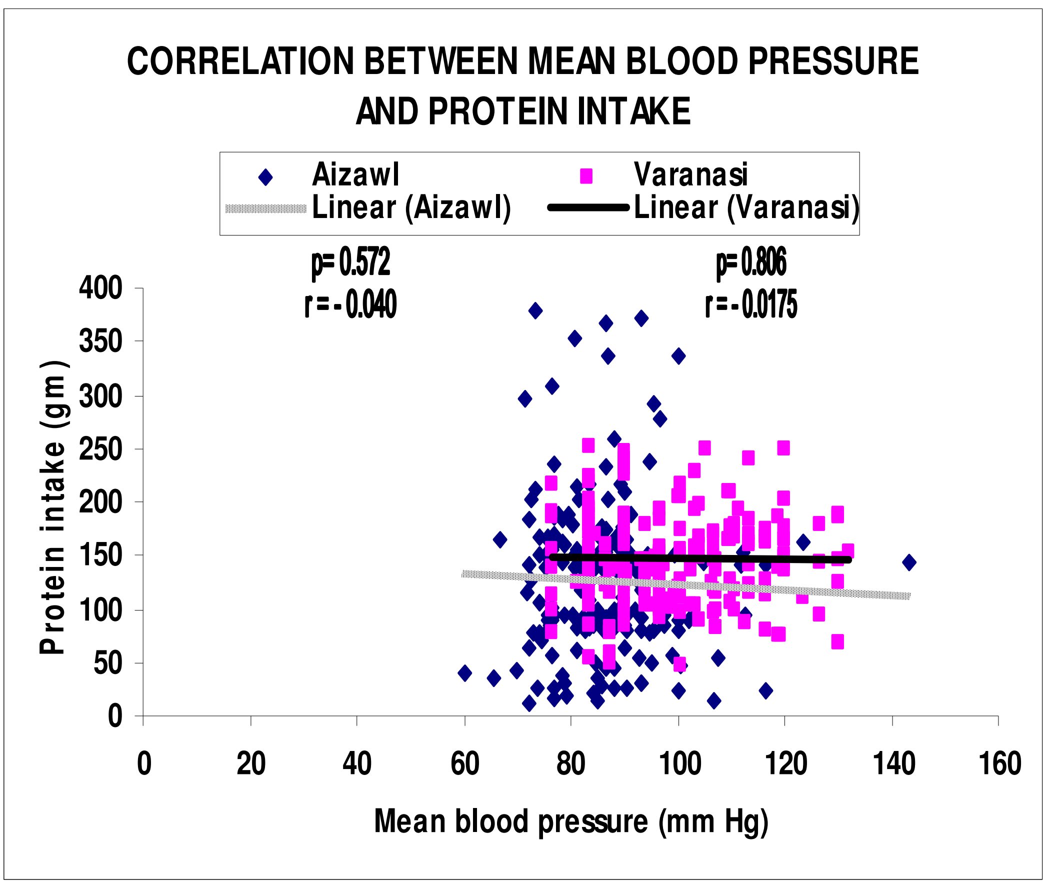


Table No. 5.43 Correlation between mean blood pressure and dietary sodium intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Sodium intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	183.50 ± 106.03	0.875	-0.0112
Varanasi	99.08 ± 13.86	326.47 ± 118.02	0.712	-0.0263

The correlation between mean blood pressure and dietary sodium intake was found negative and statistically nonsignificant at both sites.

Fig 5.47

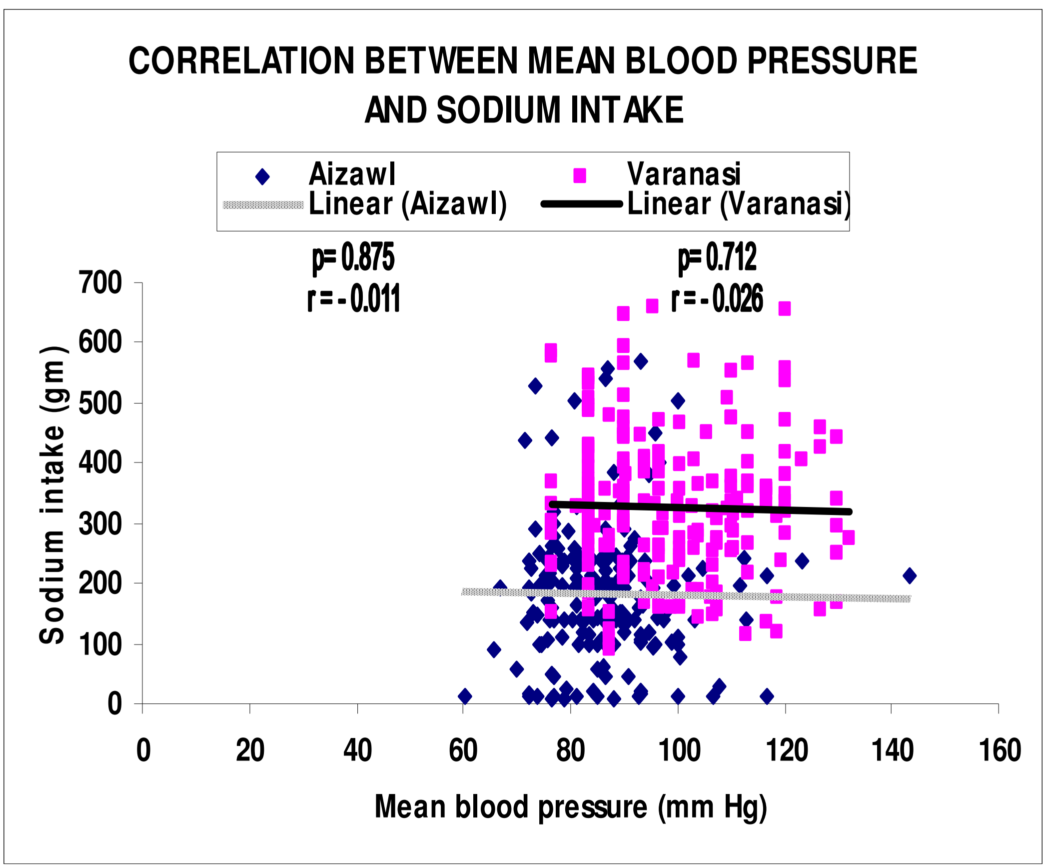


Table No. 5.44 Correlation between mean blood pressure and dietary potassium intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Potassium intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	2589.59 ± 1615.47	0.780	-0.0199
Varanasi	99.08 ± 13.86	3475.19 ± 1141.74	0.0293	0.680

The consumption of dietary potassium was found statistically significant positive correlation with mean blood pressure in Varanasi subjects (*p=0.0293 & r=0.680*). However in Aizawl nonsignificant negative correlation was observed (*p=0.78 & r= - 0.0199*).

Fig 5.48

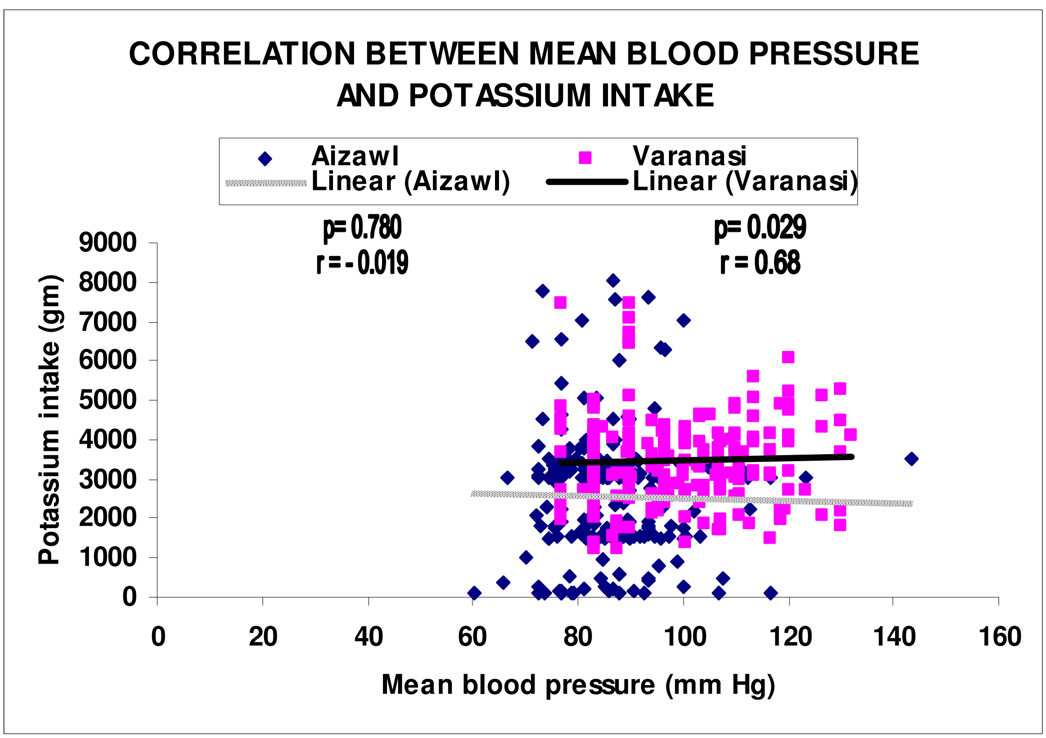


Table No. 5.45 Correlation between mean blood pressure and dietary calcium intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Calcium intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	405.95 ± 227.55	0.405	-0.0592
Varanasi	99.08 ± 13.86	1187.69 ± 625.05	0.883	-0.0105

The correlation between mean blood pressure and dietary calcium intake was found negative and statistically nonsignificant at both sites.

Fig 5.49

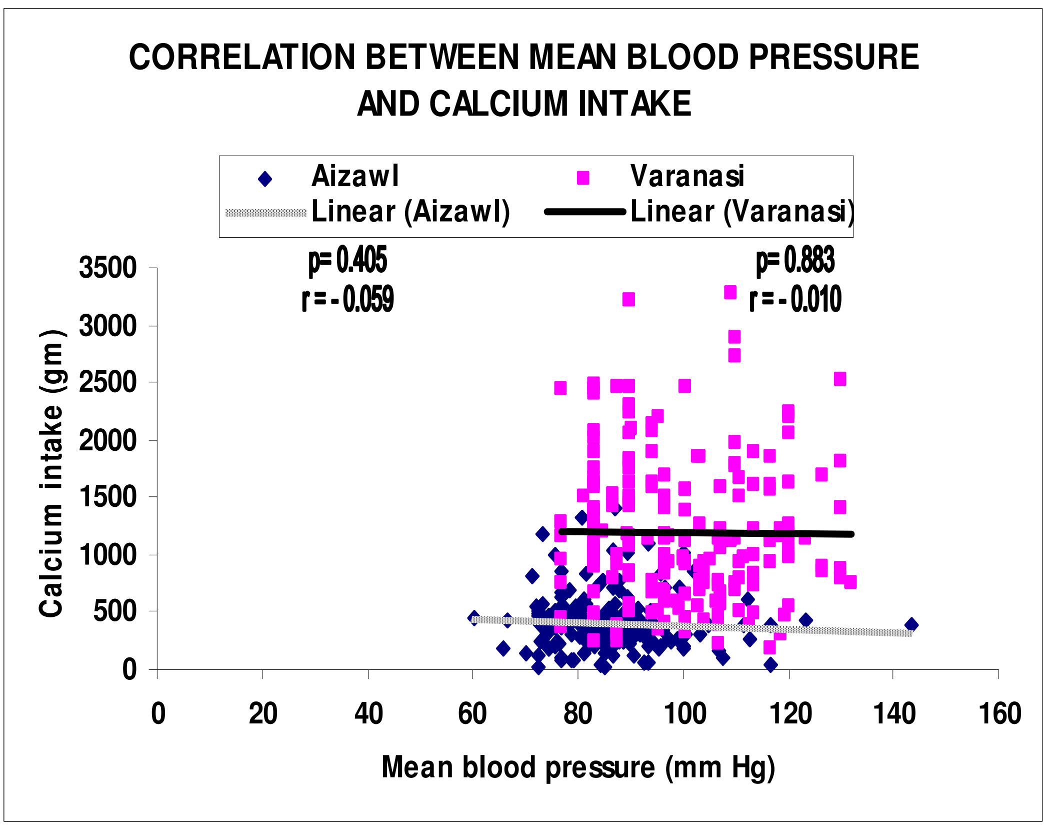


Table No. 5.46 Correlation between mean blood pressure and dietary chloride intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Chloride intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	120.20 ± 72.67	0.426	-0.0566
Varanasi	99.08 ± 13.86	209.14 ± 100.43	0.866	0.0120

The mean blood pressure and dietary chloride intake was found to have statistically nonsignificant negative correlation at Aizawl and positive at Varanasi.

Fig 5.50

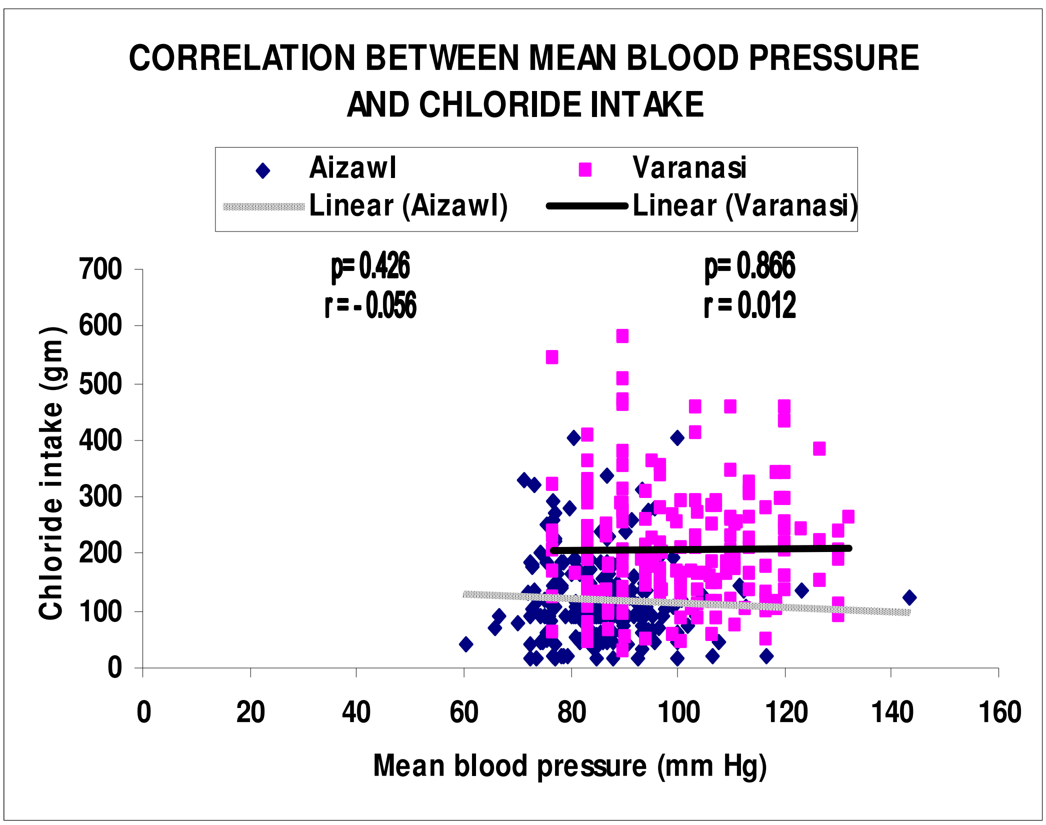


Table No. 5.47 Correlation between mean blood pressure and extra salt intake

Dietary Intake	Mean Blood pressure (Mean ± SD)	Extra salt intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	6.33 ± 3.07	0.210	0.0890
Varanasi	99.08 ± 13.86	8.99 ± 4.68	0.254	0.0810

The correlation between mean blood pressure and extra salt consumption was found positive but statistically nonsignificant at both sites.

Fig 5.51

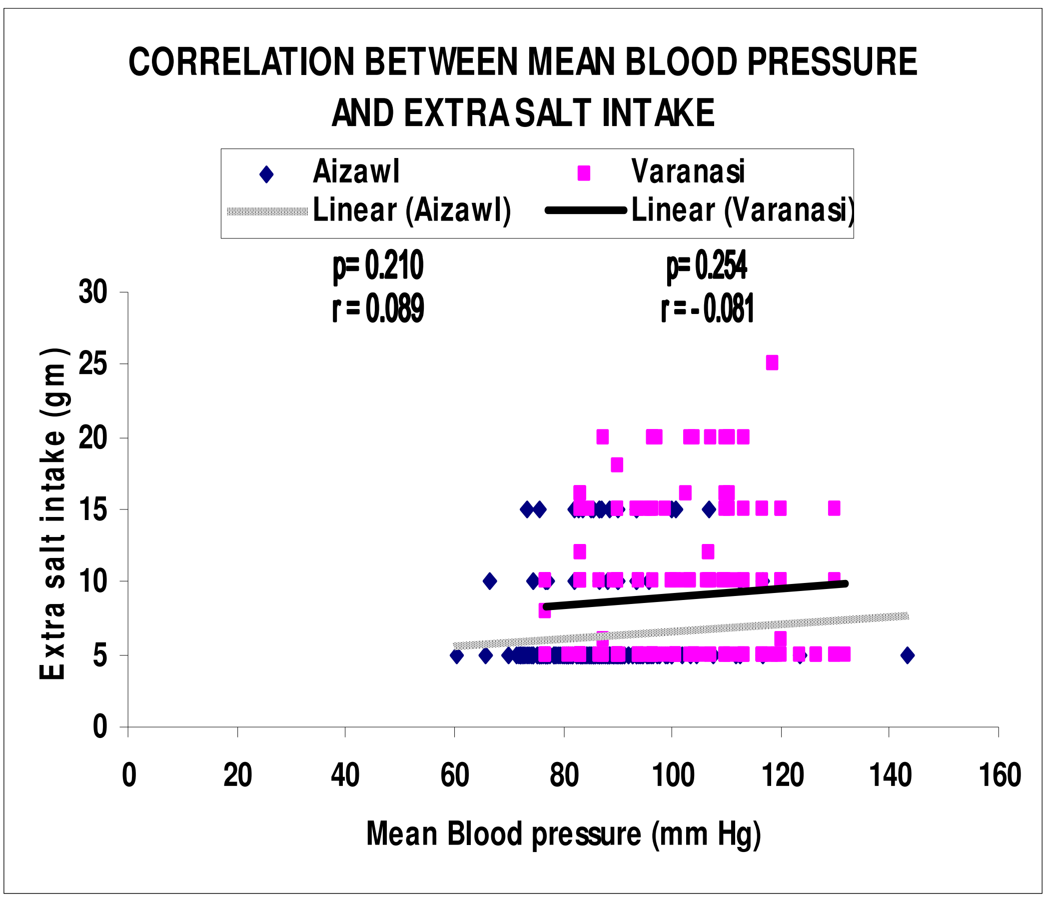


Table No. 5.48 Urinary and serum sodium of male and female

Electrolyte Sodium	MALE		FEMALE	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	132.34 ± 55.75	137.98 ± 12.60	129.01 ± 43.20	137.82 ± 15.68
Varanasi	119.53 ± 62.48	143.31 ± 29.67	176.77 ± 68.43	144.32 ± 13.39
***p* Value**	0.079	0.063	<0.001	0.015

The serum sodium and urinary sodium excretion in female from Aizawl was observed significantly lower (Female Serum 137.82 ± 15.68 meq/l and Urinary 129.01 ± 43.20 meq/l) than their male counterparts (Male Serum 137.98 ± 12.60 meq/l and Urinary 132.34 ± 55.75 meq/l). However in Varanasi a reversal pattern was observed in female with significantly higher value of electrolyte sodium (Female Serum 144.32 ± 13.39 meq/l and Urinary 176.77 ± 68.43 meq/l) than male (Male Serum 143.31 ± 29.67 meq/l and Urinary 119.53 ± 62.48 meq/l).

Fig 5.52

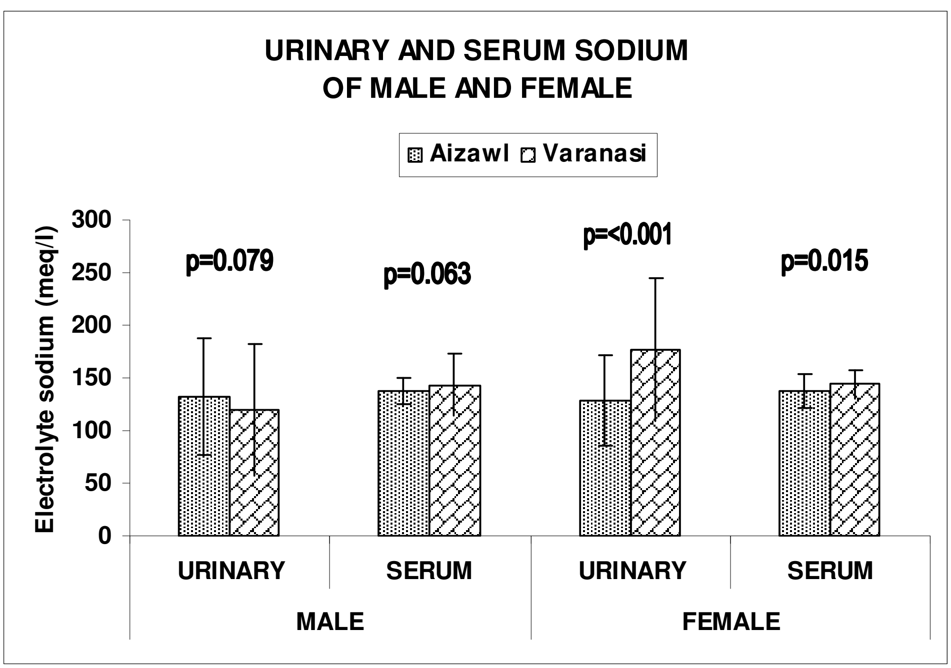


Table No. 5.49 Urinary and serum sodium of white and blue collar subjects

Electrolyte Sodium	BLUE COLLAR		WHITE COLLAR	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	123.95 ± 34.24	134.94 ± 29.48	132.48 ± 53.96	138.50 ± 7.70
Varanasi	152.31 ± 65.98	142.92 ± 28.85	126.64 ± 68.89	143.90 ± 25.02
***p* Value**	0.023	0.202	0.409	0.761

The electrolyte sodium in serum and urine of white collar subjects from Aizawl was found higher (Serum 138.50 ± 7.70 meq/l and Urinary 132.48 ± 53.96 meq/l) than blue collar subjects (Serum 134.94 ± 29.48 meq/l and Urinary 123.95 ± 34.24 meq/l). However in Varanasi reverse pattern was observed only of urinary sodium excretion (Blue 152.31 ± 65.98 meq/l and White 126.64 ± 68.89 meq/l), whereas for serum sodium similar pattern like Aizawl was followed (Blue 142.92 ± 28.85 meq/l and White 143.90 ± 25.02 meq/l).

Fig 5.53

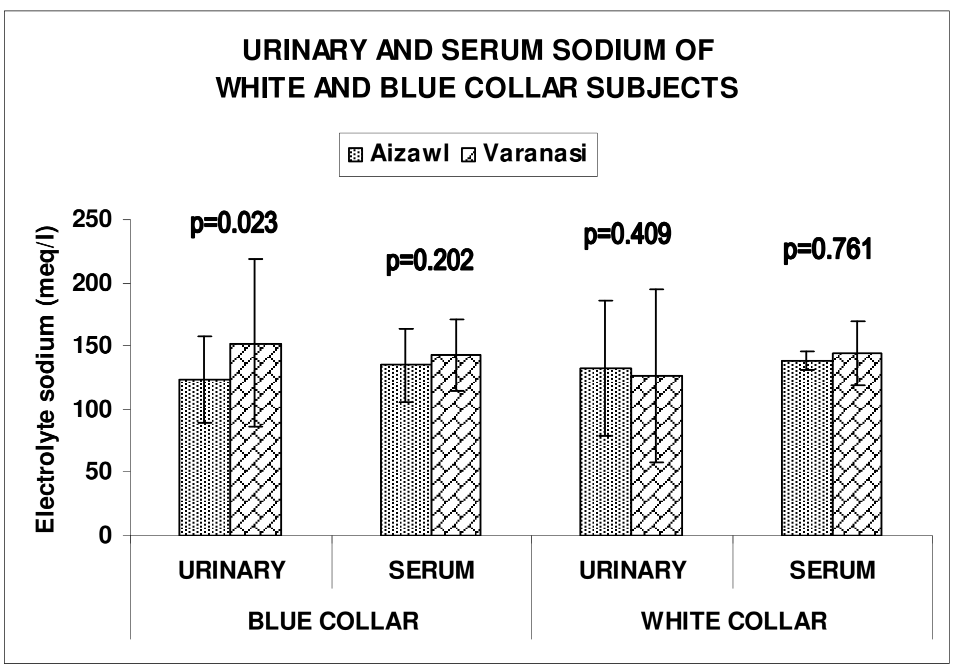


Table No. 5.50 Urinary and serum sodium of vegetarian and non-vegetarian subjects

Electrolyte Sodium	VEGETARIAN		NON-VEGETARIAN	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	137.18 ± 39.60	141.45 ± 7.80	129.64 ± 53.63	137.09 ± 14.78
Varanasi	103.66 ± 47.91	136.15 ± 25.29	156.75 ± 72.86	148.75 ± 25.77
***p* Value**	<0.001	0.21	<0.001	0.677

The non-vegetarian from Aizawl was observed low serum and urinary sodium excretion (Serum 137.09 ± 14.78 meq/l and Urinary 129.64 ± 53.63 meq/l) than vegetarian subjects (Serum 141.45 ± 7.80 meq/l and Urinary 137.18 ± 39.60 meq/l). However in Varanasi reverse pattern was observed where serum and urinary sodium in vegetarian was found lower (Serum 136.15 ± 25.29 meq/l and Urinary 103.66 ± 47.91 meq/l) than non-vegetarian (Serum 148.75 ± 25.77 meq/l and Urinary 156.75 ± 72.86 meq/l). However the value of urinary sodium was statistically highly significant (<0.001) at both of the sites.

Fig 5.54

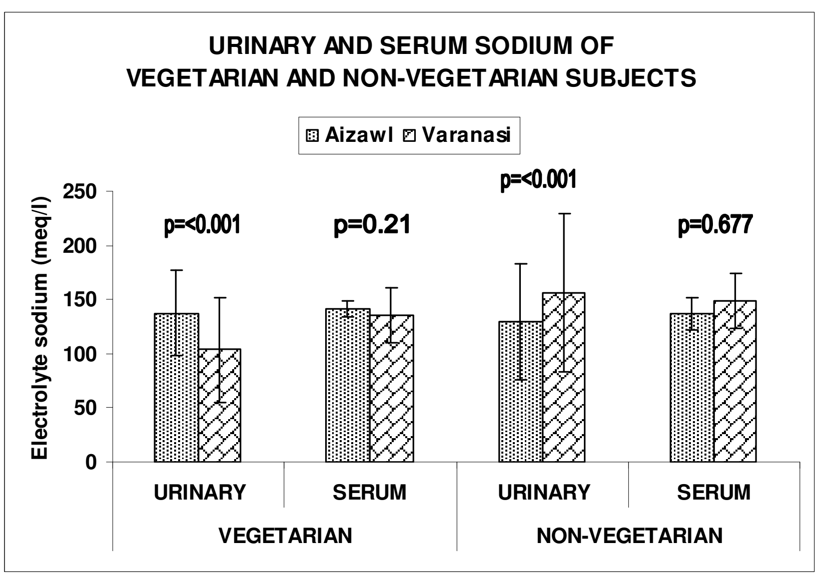


Table No. 5.51 Urinary and serum potassium of male and female

Electrolyte Potassium	MALE		FEMALE	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	31.74 ± 16.83	3.81 ± 0.84	32.96 ± 15.86	3.84 ± 1.03
Varanasi	27.08 ± 14.50	4.20 ± 1.11	34.72 ± 20.80	4.15 ± 0.71
***p* Value**	0.88	0.876	0.584	0.765

The urinary potassium excretion was found lower in male subjects (Aizawl 31.74 ± 16.83 meq/l and Varanasi 27.08 ± 14.50 meq/l) than their female counterparts (Aizawl 32.96 ± 15.86 meq/l and Varanasi 34.72 ± 20.80 meq/l) at both Aizawl and Varanasi. The serum potassium value in Varanasi was observed higher in male than female (Varanasi Male 4.20 ± 1.11 meq/l and Female 4.15 ± 0.71 meq/l), whereas in Aizawl no significant difference was noticed.

Fig 5.55

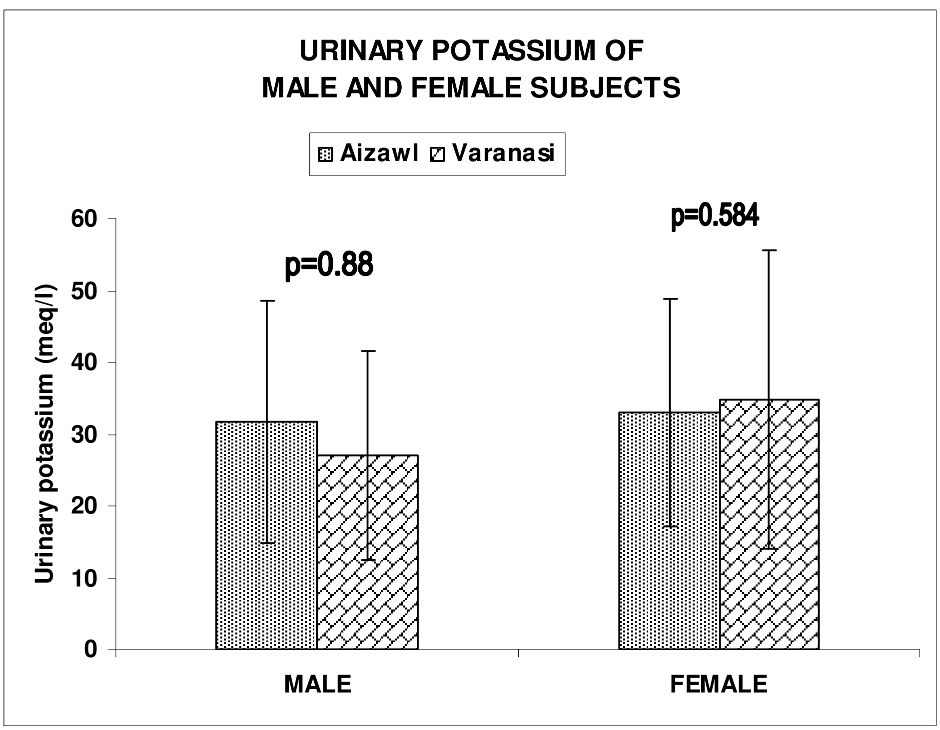


Fig 5.56

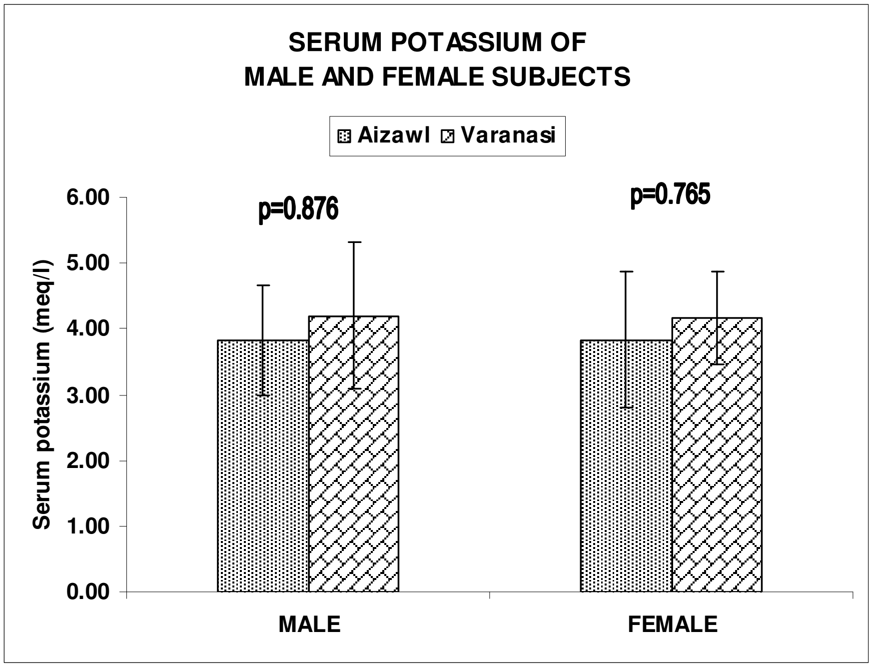


Table No. 5.52 Urinary and serum potassium of white and blue collar subjects

Electrolyte Potassium	BLUE COLLAR		WHITE COLLAR	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	34.03 ± 16.69	3.55 ± 0.93	31.84 ± 16.42	3.88 ± 0.90
Varanasi	46.28 ± 33.46	4.14 ± 1.05	40.89 ± 28.84	4.21 ± 1.00
***p* Value**	0.801	0.716	0.775	0.804

The urinary potassium excretion was found high in white collar subjects (Aizawl 31.84 ± 16.42 meq/l and Varanasi 40.89 ± 28.84 meq/l) than blue collar subjects (Aizawl 34.03 ± 16.69 meq/l and Varanasi 46.28 ± 33.46 meq/l) at both sites. However it was nonsignificant. The serum potassium was observed in reverse pattern with lower value in blue collar subject (Aizawl 3.55 ± 0.93 meq/l and Varanasi 4.14 ± 1.05 meq/l) than blue collar (Aizawl 3.88 ± 0.90 meq/l and Varanasi 4.21 ± 1.00 meq/l) at both Aizawl and Varanasi with a nonsignificant difference.

Fig 5.57

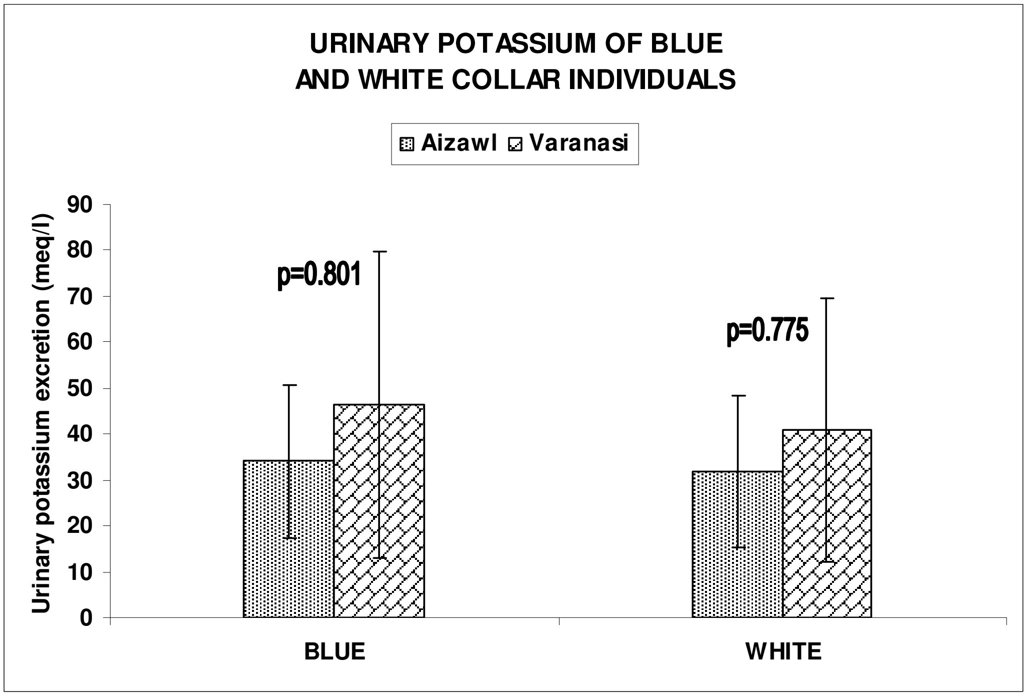


Fig 5.58

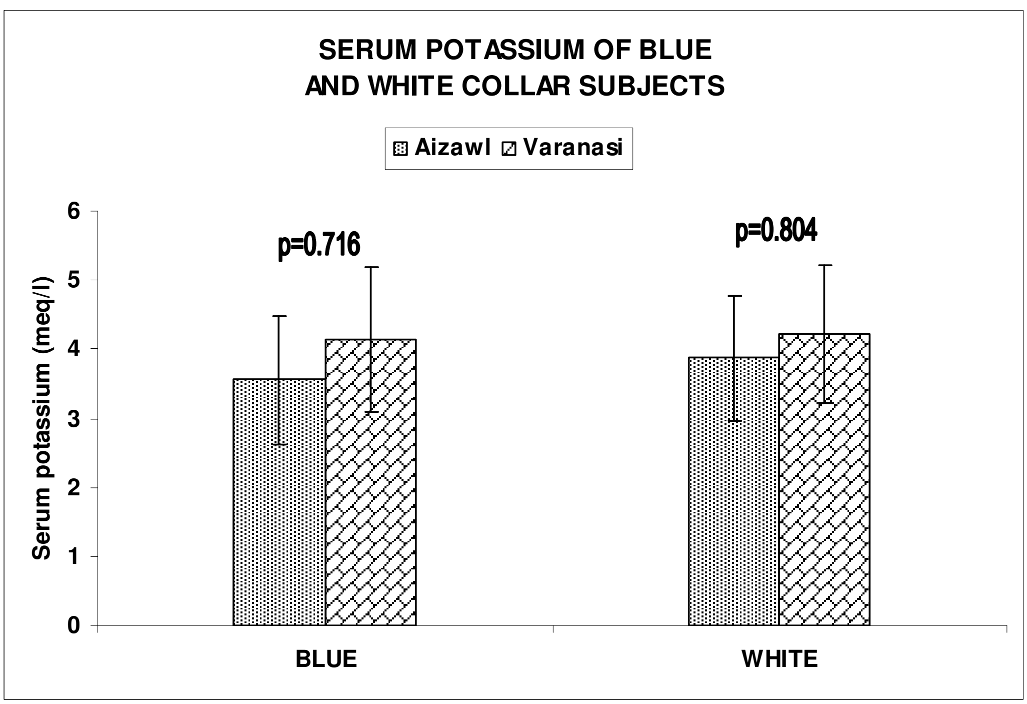


Table No. 5.53 Urinary and serum potassium of vegetarian and non-vegetarian subjects

Electrolyte Potassium	VEGETARIAN		NON-VEGETARIAN	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	39.07 ± 14.44	3.57 ± 0.69	30.59 ± 16.50	3.88 ± 0.95
Varanasi	33.89 ± 20.96	4.00 ± 1.03	48.73 ± 14.36	4.32 ± 0.98
***p* Value**	0.873	0.784	0.429	0.756

The urinary potassium in vegetarian was observed higher (Vegetarian 39.07 ± 14.44 meq/l and Non-vegetarian 30.59 ± 16.50 meq/l) than non-vegetarian subjects from Aizawl, whereas reverse pattern was noted in Varanasi (Vegetarian 33.89 ± 20.96 meq/l and non-vegetarian 48.73 ± 14.36 meq/l). However non-vegetarians had shown higher value of serum potassium (Aizawl 3.88 ± 0.95 meq/l and Varanasi 4.32 ± 0.98 meq/l) than vegetarians (Aizawl 3.57 ± 0.69 meq/l and 4.00 ± 1.03 meq/l). Overall serum and urinary potassium value was nonsignificant at both sites.

Fig 5.59

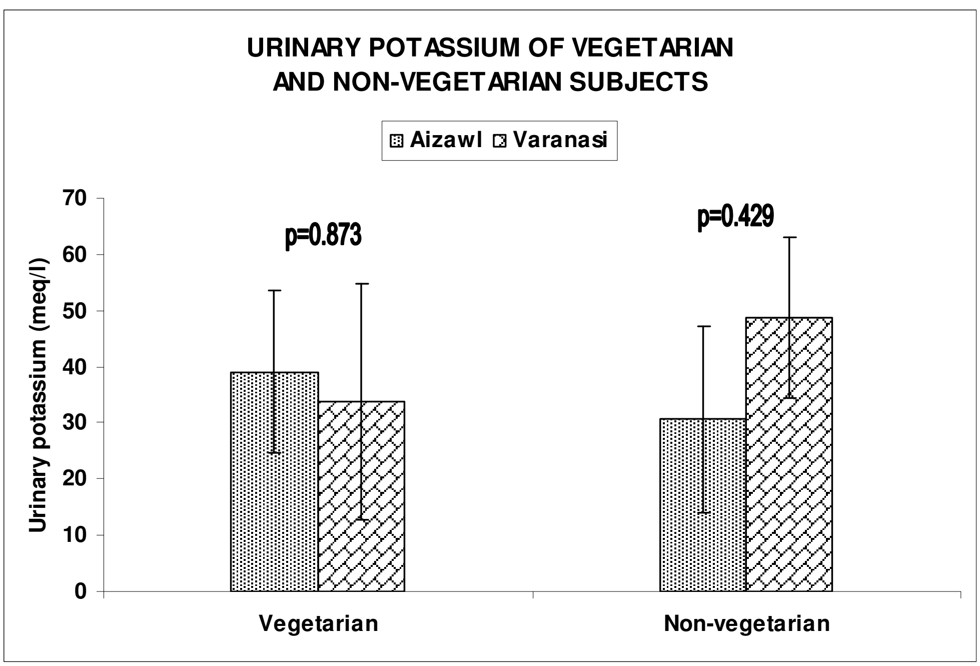


Fig 5.60

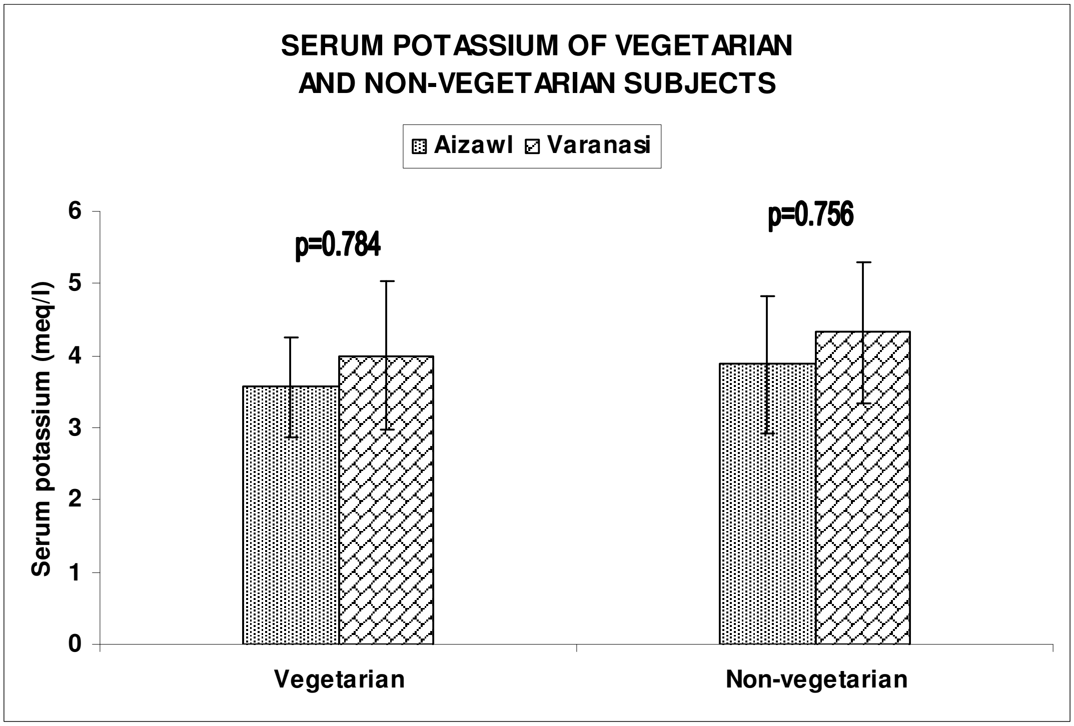


Table No. 5.54 Urinary and serum calcium of male and female

Electrolyte Calcium	MALE		FEMALE	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	2.52 ± 0.88	8.42 ± 1.26	2.54 ± 0.88	8.55 ± 1.53
Varanasi	2.96 ± 0.83	7.93 ± 1.58	2.97 ± 0.88	7.85 ± 1.64
***p* Value**	0.717	0.810	0.743	0.761

The male subjects from both Aizawl and Varanasi had shown lower urinary calcium excretion (Male Aizawl 2.52 ± 0.88 meq/l and Varanasi 2.96 ± 0.83 meq/l) then their female counterparts (Female Aizawl 2.54 ± 0.88 meq/l and Varanasi 2.97 ± 0.88 meq/l). The serum calcium had also followed the similar trend in Aizawl but a reversal pattern was observed in Varanasi (Male 7.93 ± 1.58 meq/l and Female 7.85 ± 1.64). Statistically none of the values were found significant.

Fig 5.61

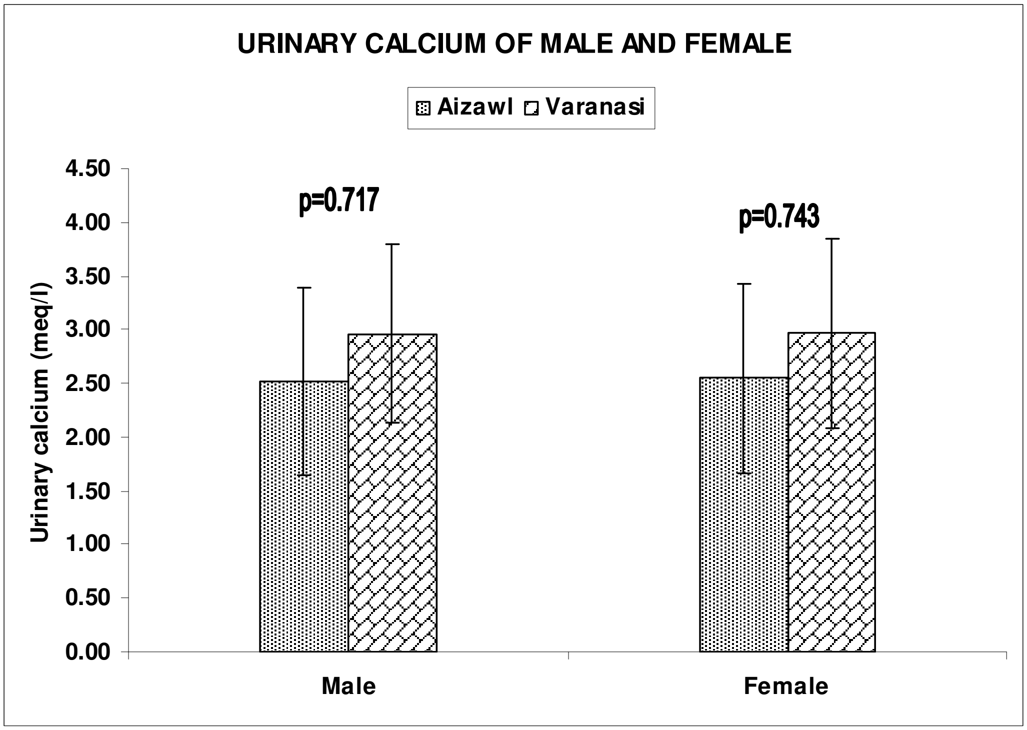


Fig 5.62

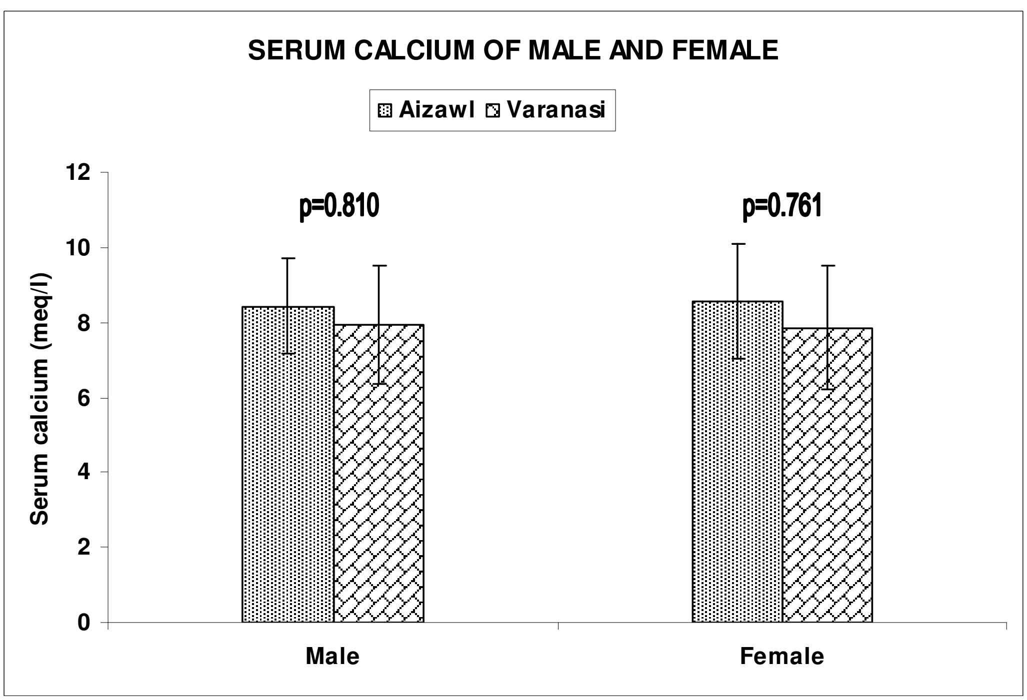


Table No. 5.55 Urinary and serum calcium of white and blue collar subjects

Electrolyte Calcium	BLUE COLLAR		WHITE COLLAR	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	2.79 ± 0.91	8.62 ± 1.22	2.48 ± 0.86	8.44 ± 1.40
Varanasi	3.00 ± 0.83	7.84 ± 1.55	2.94 ± 0.85	7.94 ± 1.63
***p* Value**	0.871	0.741	0.707	0.813

The blue collar subjects were observed higher value of serum and urinary calcium excretion (Serum 8.62 ± 1.22 meq/l and Urinary 2.79 ± 0.91 meq/l) than white collar (Serum 8.44 ± 1.40 meq/l and Urinary 2.48 ± 0.86 meq/l) at Aizawl. In Gangetic plain at Varanasi no significant difference was observed in urinary calcium and reverse pattern of serum calcium was observed (Blue collar 7.84 ± 1.55 meq/l and white collar 7.94 ± 1.63 meq/l). The all values at both sites were statistically non significant.

Fig 5.63

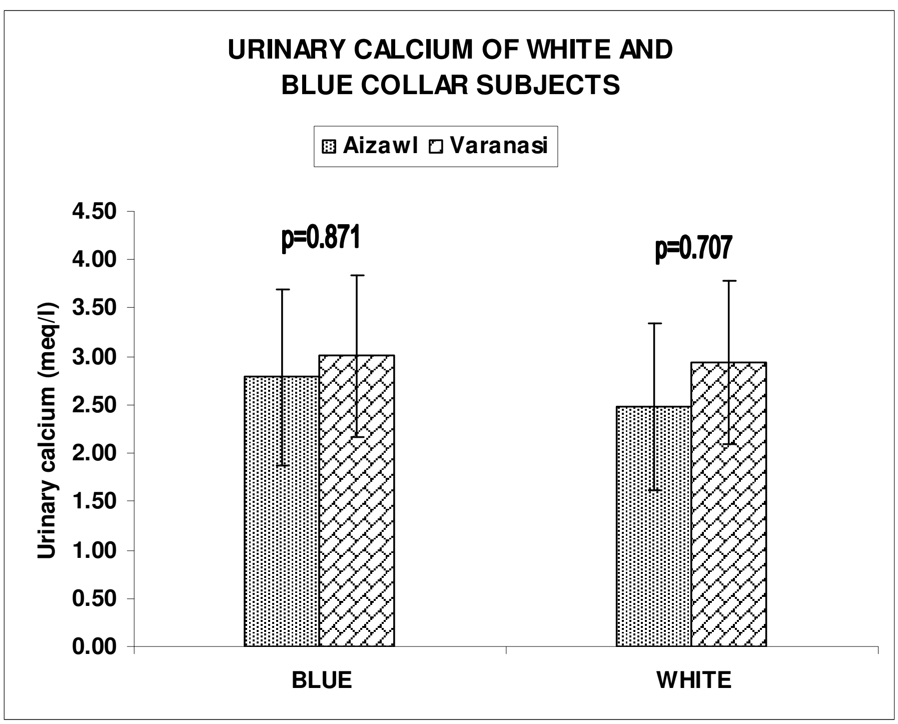


Fig 5.64

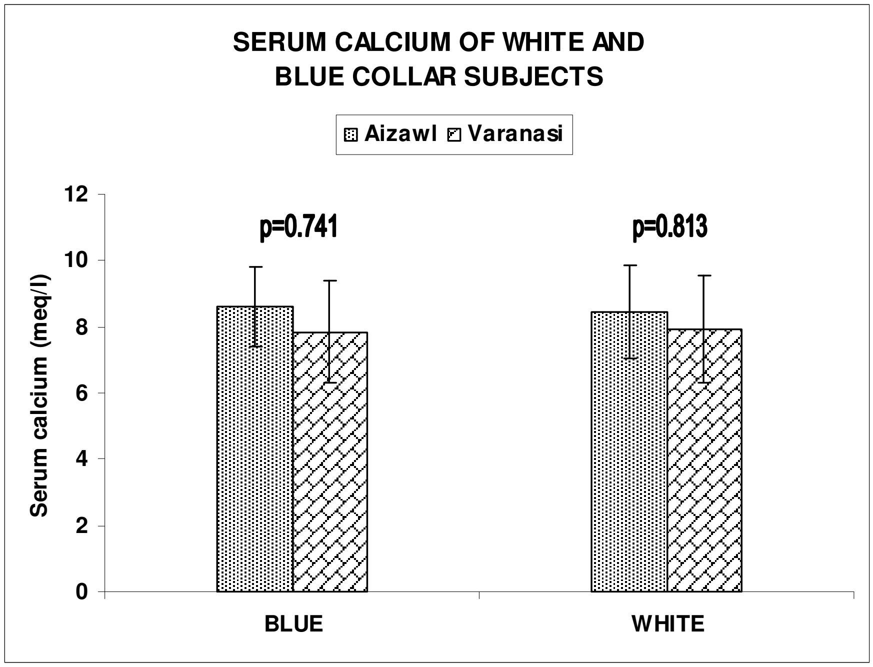


Table No. 5.56 Urinary and serum calcium of vegetarian and non-vegetarian subjects

Electrolyte Calcium	VEGETARIAN		NON-VEGETARIAN	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	2.67 ± 0.84	8.49 ± 1.51	2.50 ± 0.88	8.47 ± 1.34
Varanasi	2.82 ± 0.82	7.89 ± 1.61	3.06 ± 0.85	7.92 ± 1.60
***p* Value**	0.910	0.816	0.656	0.791

The vegetarian subjects from Aizawl had shown higher electrolyte calcium in serum and urine (Urinary 2.67 ± 0.84 meq/l and Serum 8.49 ± 1.51 meq/l) than non-vegetarian (Urinary 2.50 ± 0.88 meq/l and & Serum 8.47 ± 1.34 meq/l), whereas in Varanasi the observation was in reversal order where vegetarian showed lower value (Urinary 2.82 ± 0.82 meq/l and Serum 7.89 ± 1.61 meq/l) than non-vegetarian (Urinary 3.06 ± 0.85 meq/l and Serum 7.92 ± 1.60 meq/l). However no significant difference was observed in the value of serum and urinary calcium at both of the sites Aizawl and Varanasi.

Fig 5.65

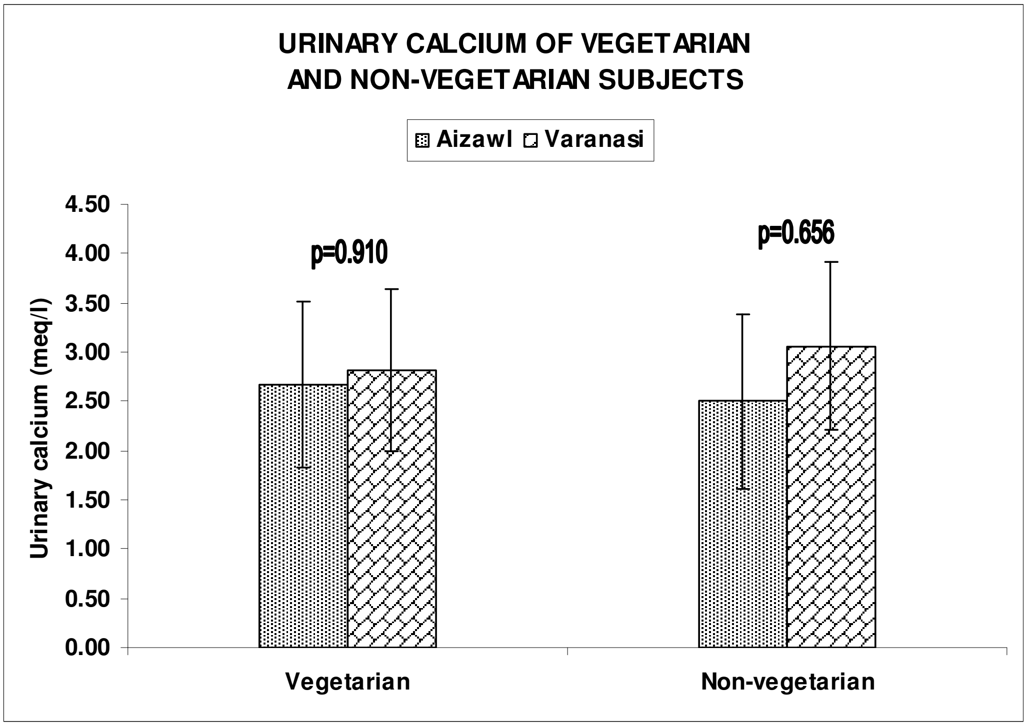


Fig 5.66

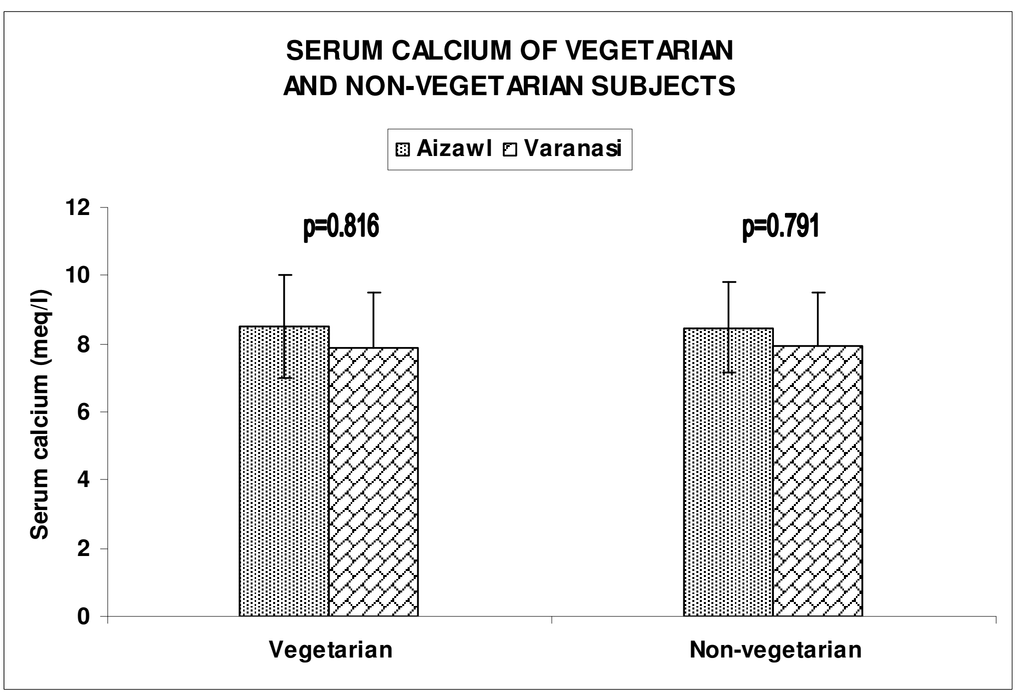


Table No. 5.57 Urinary and serum chloride of male and female

Electrolyte chloride	MALE		FEMALE	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	78.65 ± 32.93	77.35 ± 20.14	84.54 ± 33.76	87.86 ± 13.49
Varanasi	70.32 ± 31.41	99.73 ± 16.36	71.87 ± 33.19	100.14 ± 16.92
***p* Value**	0.855	0.384	0.796	0.568

The serum and urinary chloride excretion in female subjects from both Aizawl and Varanasi was found to be higher (Aizawl Serum 77.35 ± 20.14 meq/l & Urinary 78.65 ± 32.93 meq/l and Varanasi Serum 99.73 ± 16.36 meq/l & Urinary 70.32 ± 31.41 meq/l) than their male counterparts (Aizawl Serum 87.86 ± 13.49 meq/l & Urinary 84.54 ± 33.76 meq/l and Varanasi Serum 100.14 ± 16.92 meq/l & Urinary 71.87 ± 33.19 meq/l). However none of the observation was statistically significant.

Fig 5.67

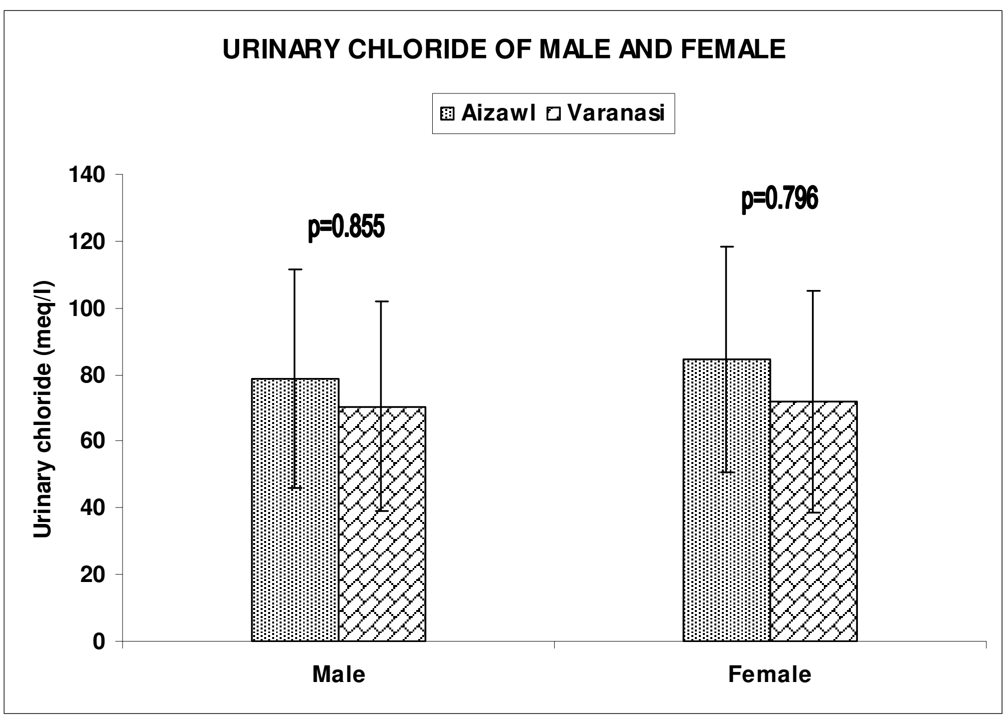


Fig 5.68

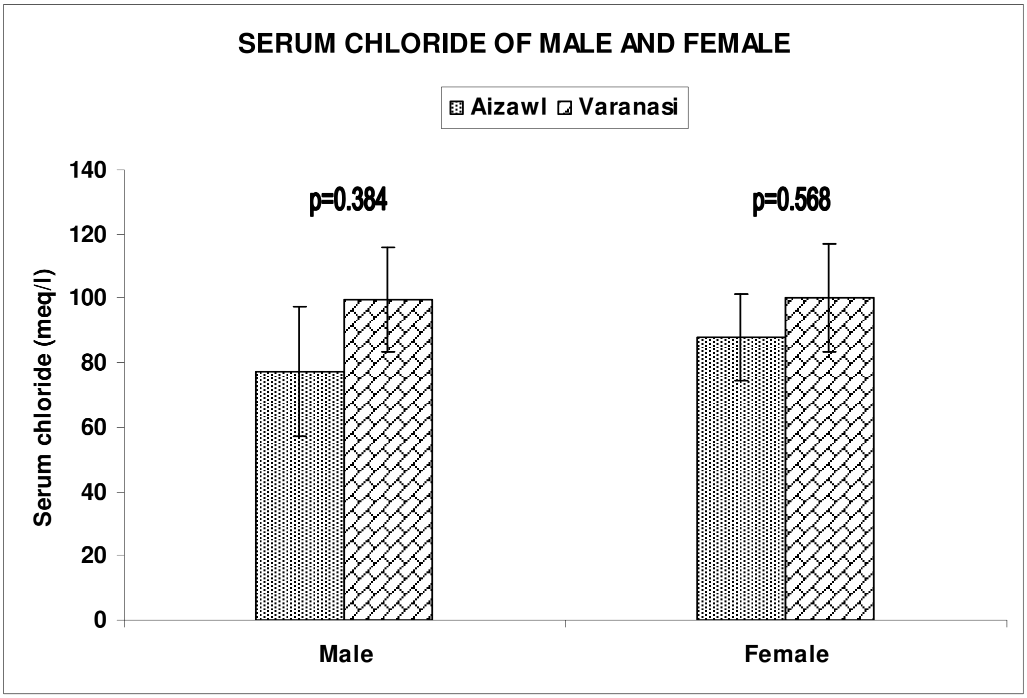


Table No. 5.58 Urinary and serum chloride of white and blue collar subjects

Electrolyte chloride	BLUE COLLAR		WHITE COLLAR	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	71.06 ± 21.26	74.55 ± 19.69	82.83 ± 34.90	82.68 ± 18.12
Varanasi	65.45 ± 30.88	97.99 ± 15.38	73.29 ± 32.07	100.73 ± 16.96
***p* Value**	0.903	0.365	0.844	0.476

The pattern of serum and urinary chloride excretion was observed on lower side in blue collar subjects (Aizawl Serum 74.55 ± 19.69 meq/l & Urinary 71.06 ± 21.26 meq/l) and (Varanasi Serum 97.99 ± 15.38 meq/l & Urinary 65.45 ± 30.88 meq/l) than their white collar counterparts (Aizawl Serum 82.68 ± 18.12 meq/l & Urinary 82.83 ± 34.90 meq/l) and Varanasi Serum 100.73 ± 16.96 meq/l & Urinary 73.29 ± 32.07 meq/l) at both sites with no statistical significance.

Fig 5.69

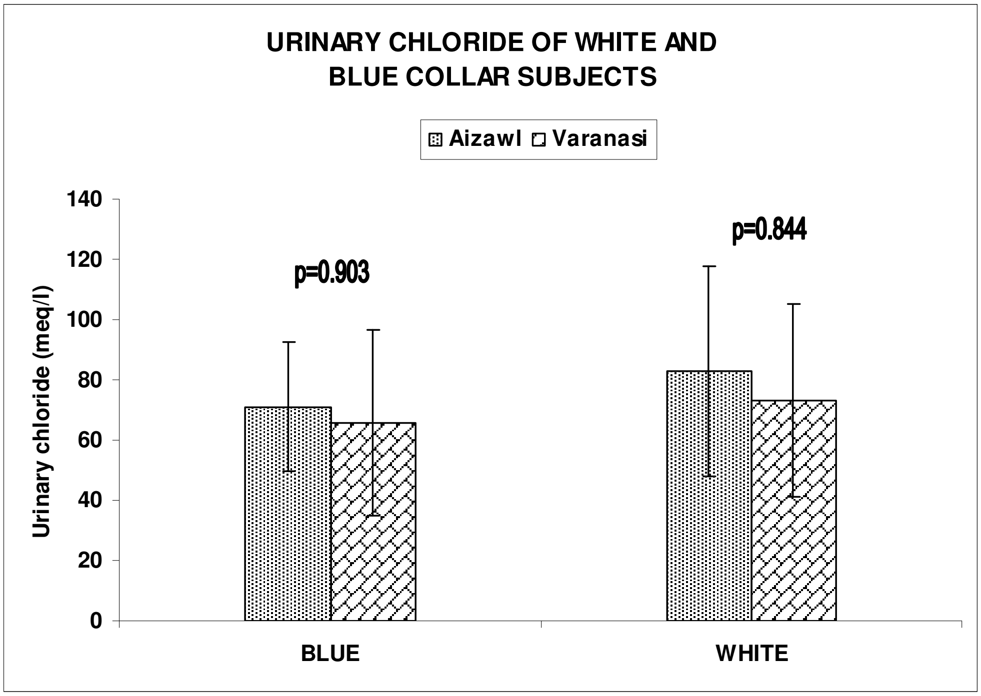


Fig 5.70

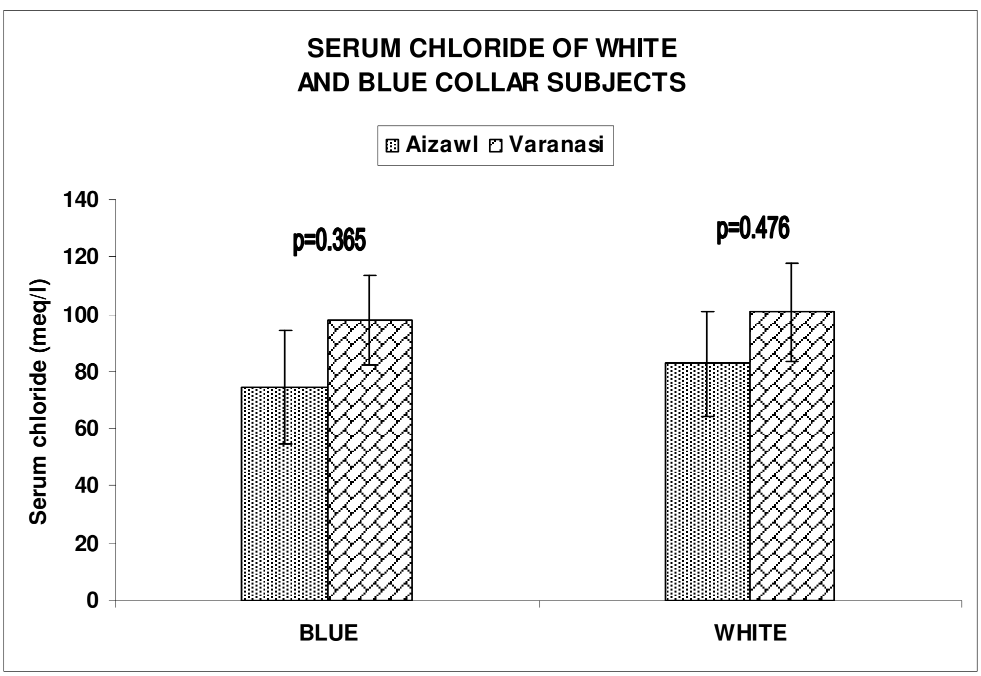


Table No. 5.59 Urinary and serum chloride of vegetarian and non-vegetarian subjects

Electrolyte chloride	VEGETARIAN		NON-VEGETARIAN	
	URINARY (Mean ± SD)	SERUM (Mean ± SD)	URINARY (Mean ± SD)	SERUM (Mean ± SD)
Aizawl	84.05 ± 27.34	81.32 ± 18.18	80.15 ± 34.56	81.35 ± 18.73
Varanasi	75.68 ± 33.31	100.18 ± 17.75	67.31 ± 30.41	99.61 ± 15.60
***p* Value**	0.873	0.515	0.790	0.478

The urinary chloride excretion was observed high in vegetarian subjects (Aizawl 84.05 ± 27.34 meq/l and Varanasi 75.68 ± 33.31) than non-vegetarian (Aizawl 80.15 ± 34.56 meq/l and Varanasi 67.31 ± 30.41 meq/l) at both sites. The serum sodium followed the similar pattern in subjects from Gangetic plain (Vegetarian 100.18 ± 17.75 meq/l and Non-vegetarian 99.61 ± 15.60 meq/l), whereas hill subjects have showed no difference. However none of the results were statistically significant.

Fig 5.71

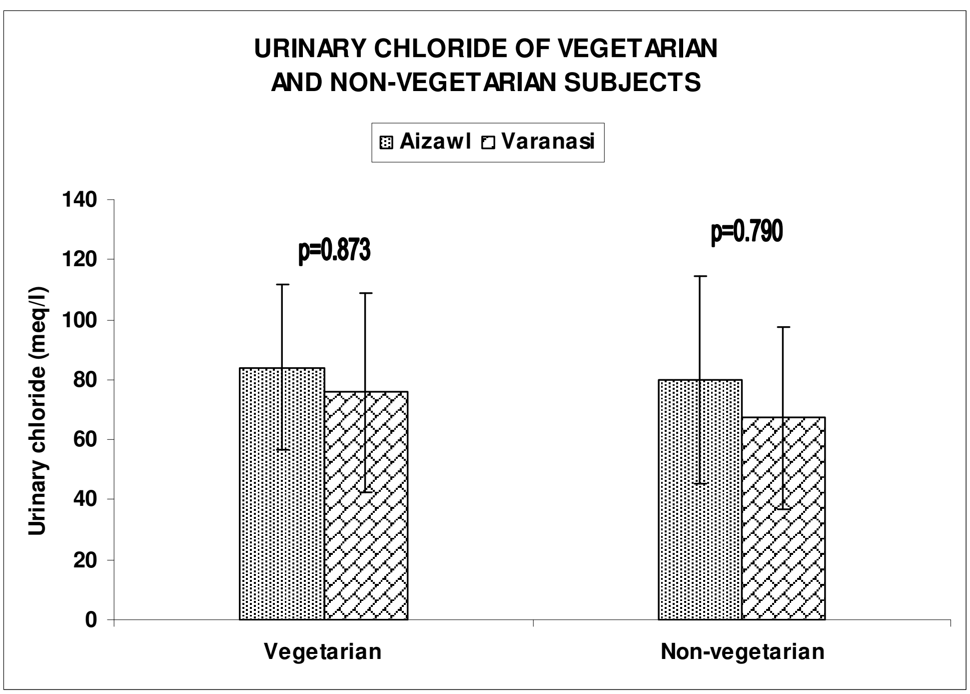


Fig 5.72

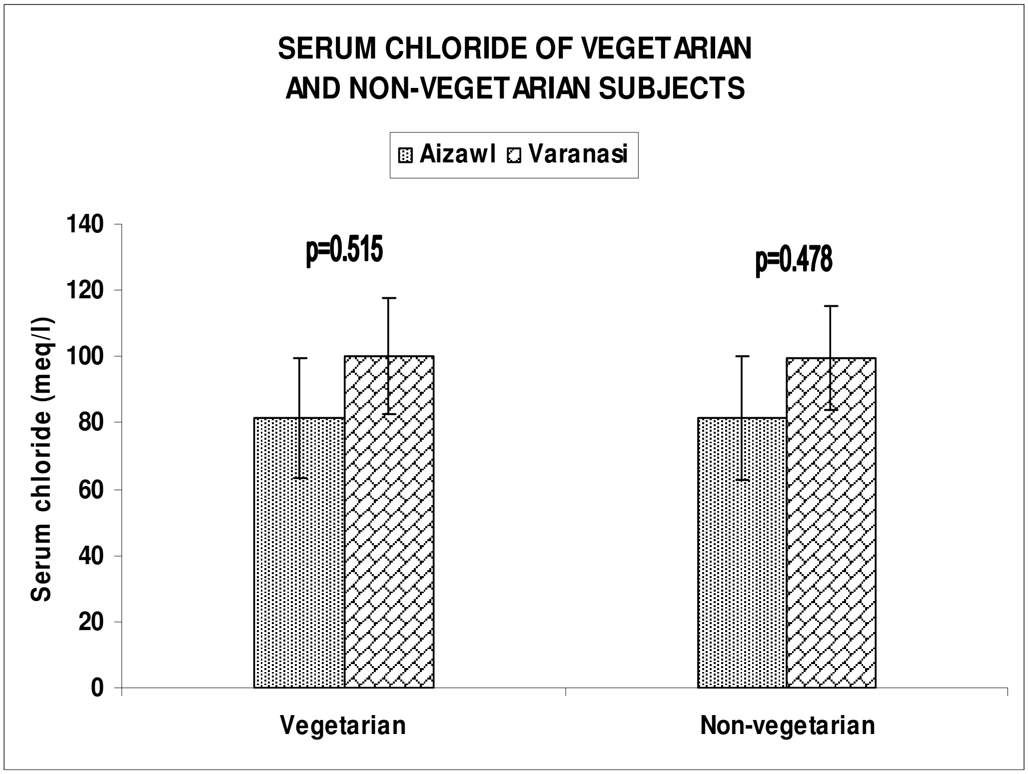


Table No. 5.60 Correlation between mean blood pressure and urinary sodium excretion

	Mean Blood pressure (Mean ± SD)	Urinary sodium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	131.07 ± 51.25	0.0266	-0.157
Varanasi	99.08 ± 13.86	134.98 ± 68.85	0.218	0.0874

The mean blood pressure was observed to have a statistically significant negative correlation with urinary sodium excretion in Aizawl subjects (Aizawl *p= 0.0266 & r= -0.157*), in Varanasi subjects nonsignificant positive correlation was found.

Fig 5.73

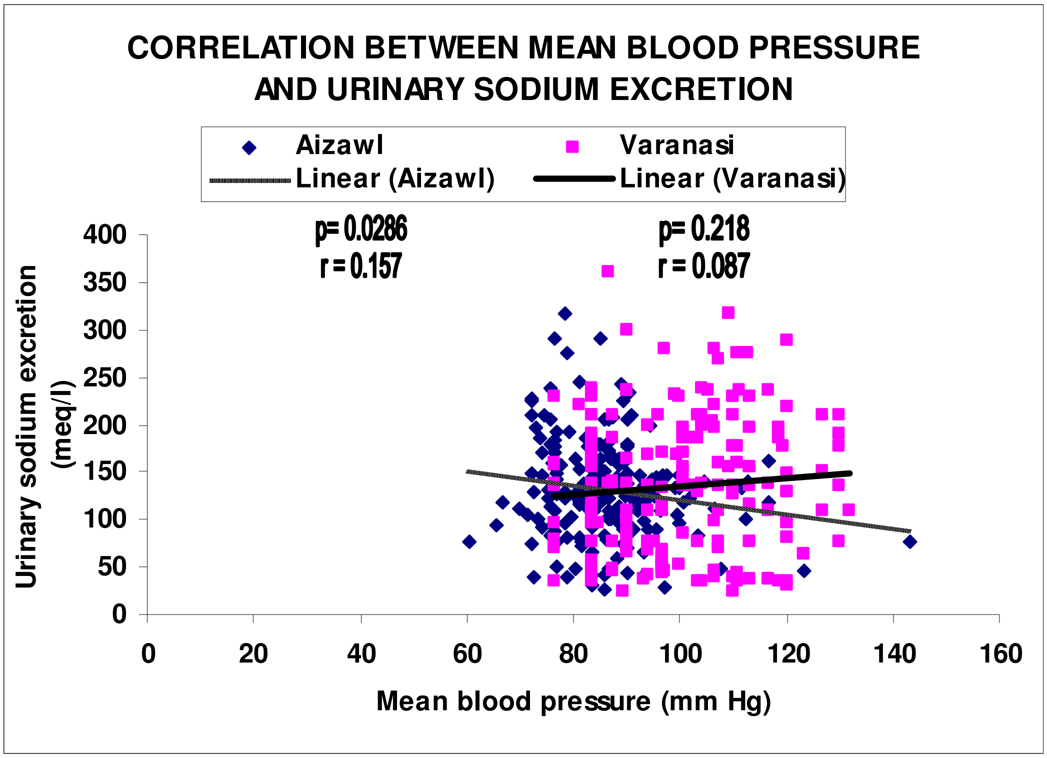


Table No. 5.61 Correlation between mean blood pressure and serum sodium

	Mean Blood pressure (Mean ± SD)	Serum sodium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	137.92 ± 13.82	0.772	- 0.0206
Varanasi	99.08 ± 13.86	143.58 ± 26.26	<0.001	0.381

The mean blood pressure was found to have statistically highly significant positive correlation (Aizawl *p =<0.001 & r =0.381*) with serum sodium in Varanasi subjects, whereas in Aizawl subjects nonsignificant linear negative correlation was observed.

Fig 5.74

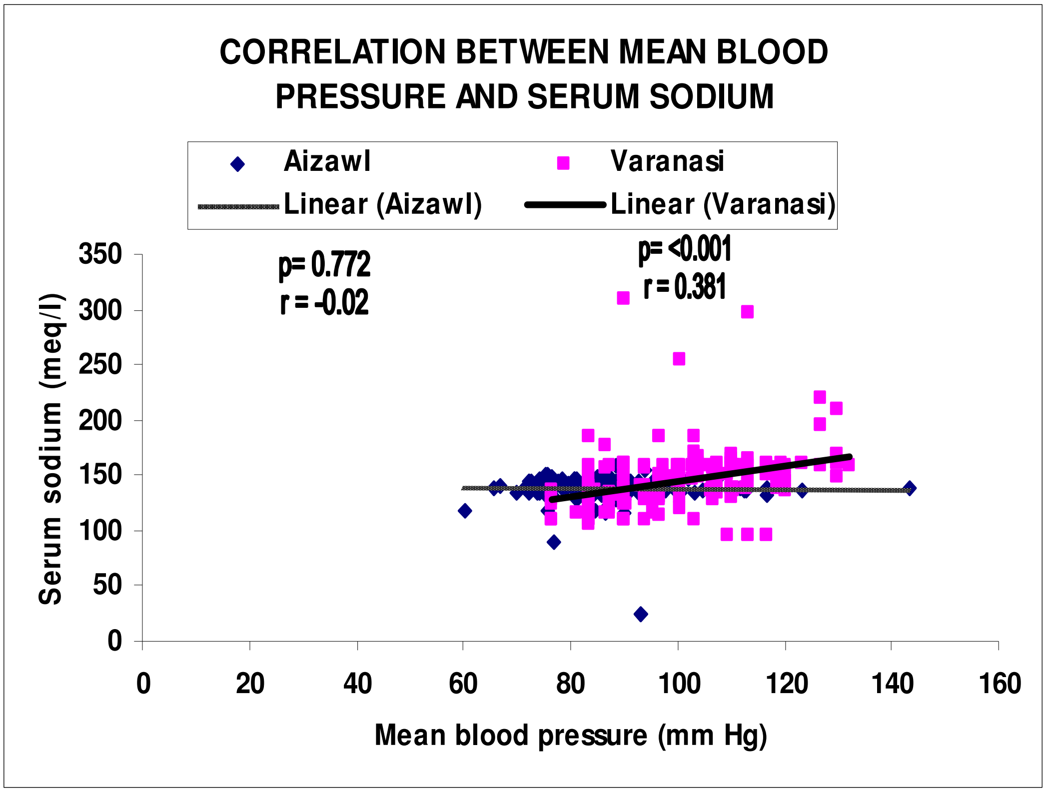


Table No. 5.62 **Correlation between mean blood pressure and urinary potassium excretion**

	Mean Blood pressure (Mean ± SD)	Urinary potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	32.20 ± 16.44	0.291	- 0.075
Varanasi	99.08 ± 13.86	42.64 ± 30.44	0.855	0.013

The mean blood pressure and urinary sodium excretion was found to have a nonsignificant negative correlation in Aizawl subjects and linear positive correlation in Varanasi individuals.

Fig 5.75

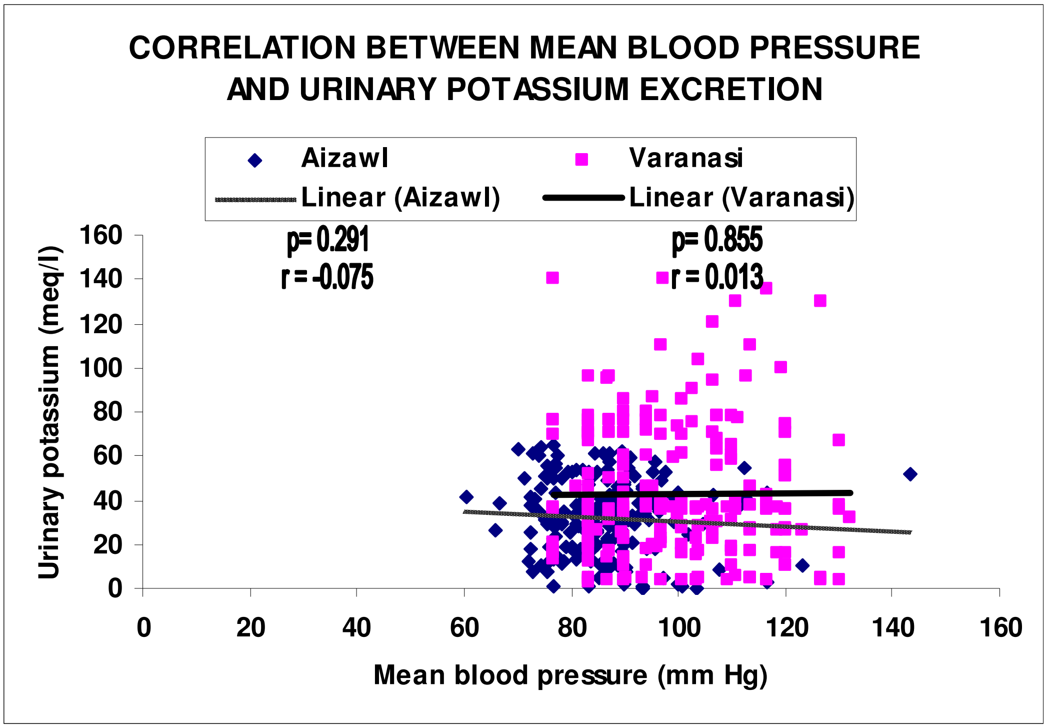


Table No. 5.63: Correlation between mean blood pressure and serum potassium

	Mean Blood pressure (Mean ± SD)	Serum potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	3.82 ± 0.91	0.419	- 0.0575
Varanasi	99.08 ± 13.86	4.19 ± 1.01	<0.001	0.370

The mean blood pressure and serum potassium was found to have a statistically highly significant positive correlation (Varanasi *p=<0.001 & r=0.370*) in subjects from Gangetic plain of Varanasi. However in Aizawl nonsignificant negative correlation was observed.

Fig 5.76

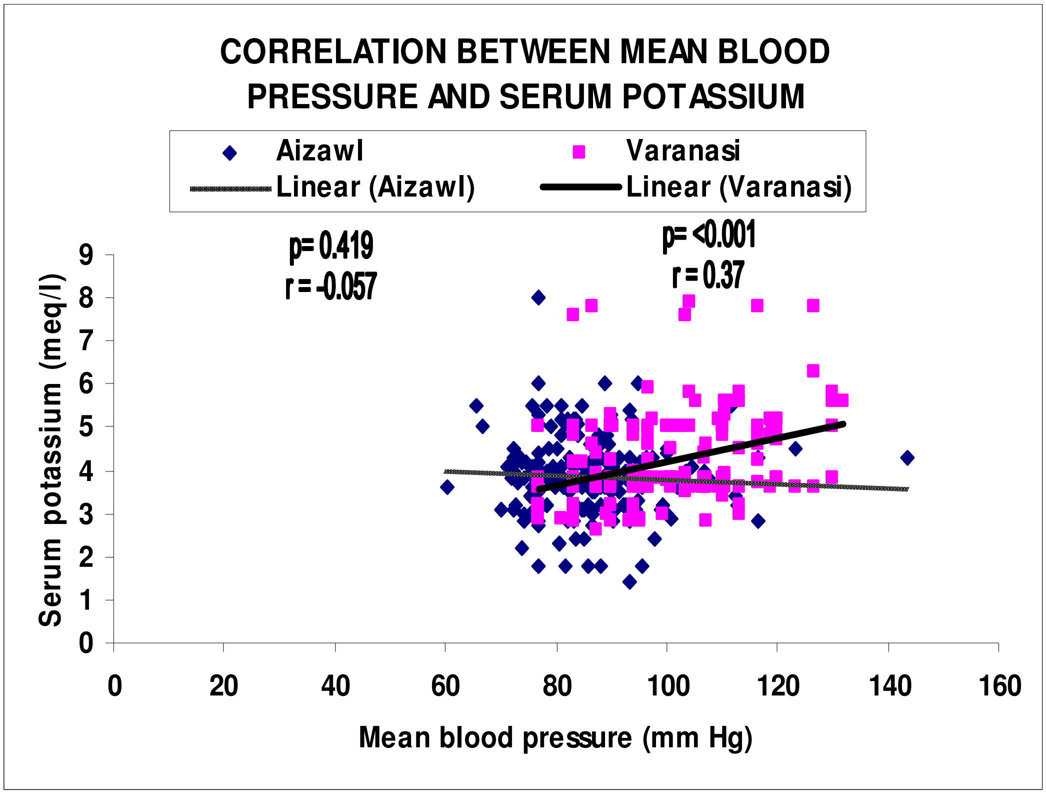


Table No. 5.64 **Correlation between mean blood pressure and urinary calcium excretion**

	Mean Blood pressure (Mean ± SD)	Urinary calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	2.53 ± 0.88	0.297	0.074
Varanasi	99.08 ± 13.86	2.96 ± 0.84	0.504	0.0476

The urinary calcium excretion in both Aizawl and Varanasi subjects have shown nonsignificant positive correlation with mean blood pressure.

Fig 5.77

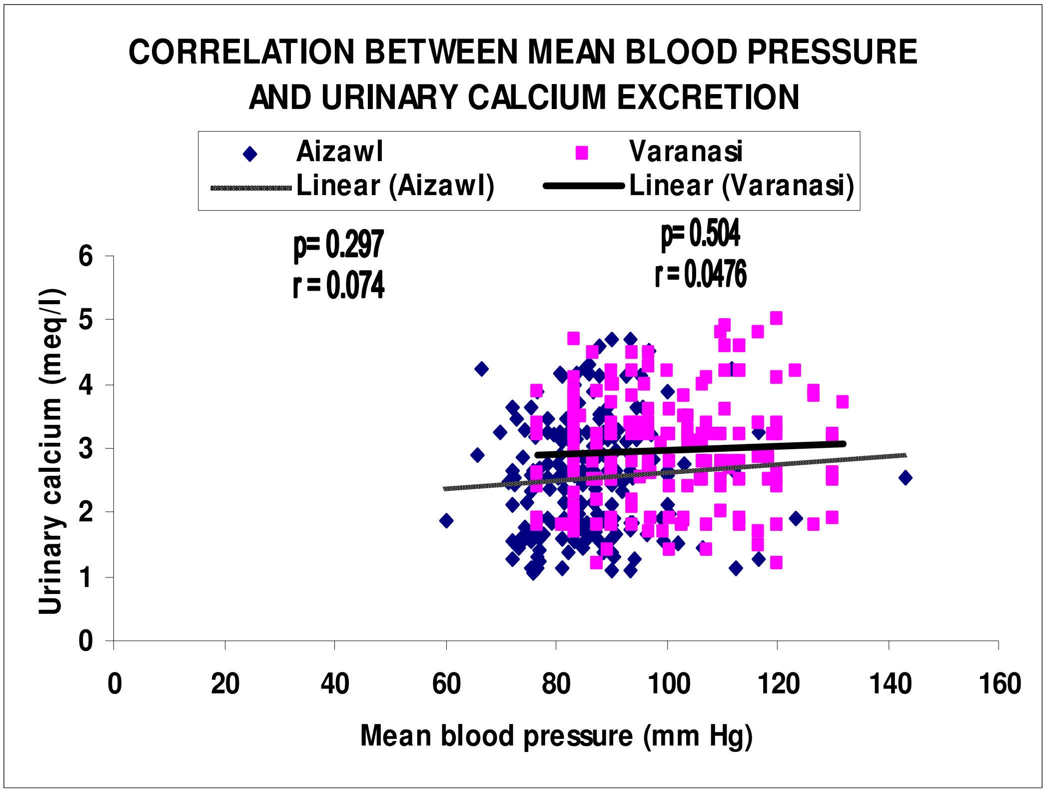


Table No. 5.65 Correlation between mean blood pressure and serum calcium

	Mean Blood pressure (Mean ± SD)	Serum calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	8.47 ± 1.37	0.696	- 0.0278
Varanasi	99.08 ± 13.86	7.91 ± 1.60	0.999	0.002

The mean blood pressure and serum calcium have shown a nonsignificant negative correlation in Aizawl subjects, whereas in Varanasi subjects nonsignificant positive correlation was observed.

Fig 5.78

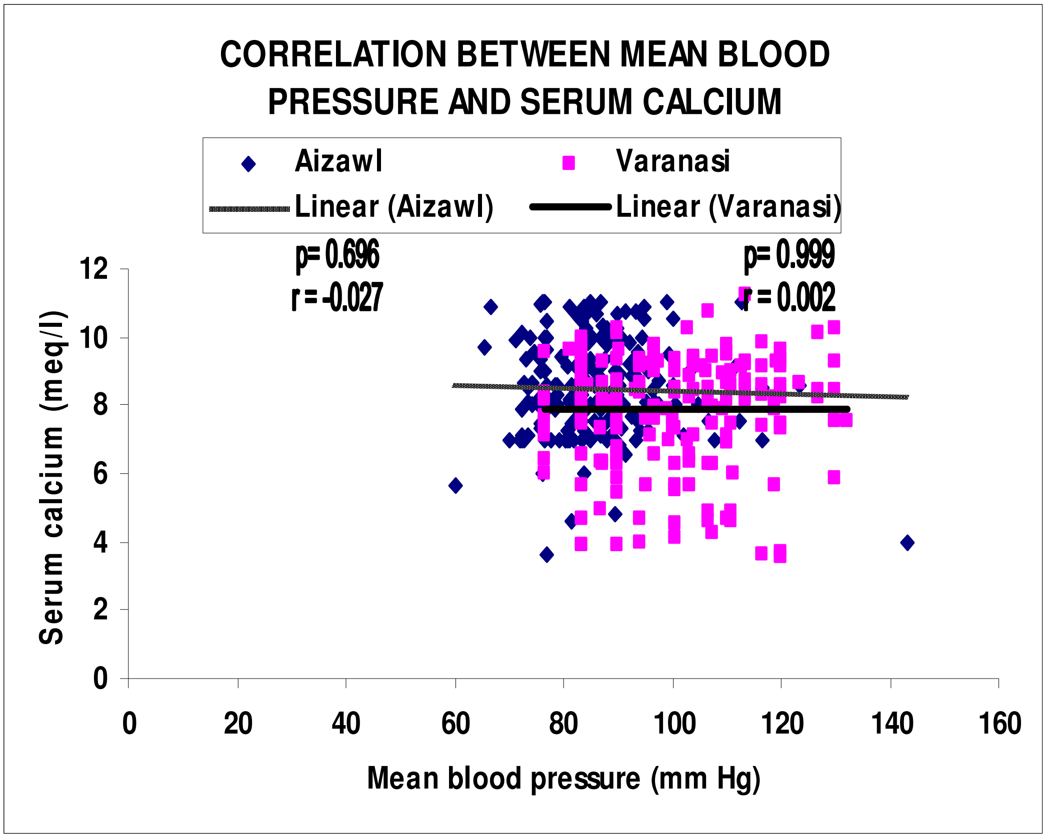


Table No. 5.66 **Correlation between mean blood pressure and urinary chloride excretion**

	Mean Blood pressure (Mean ± SD)	Urinary chloride (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	86.13 ± 10.45	80.89 ± 33.29	0.946	0.004
Varanasi	99.08 ± 13.86	70.74 ± 31.82	0.725	0.025

The subjects from both sites have shown nonsignificant positive correlation between mean blood pressure and urinary chloride excretion.

Fig 5.79

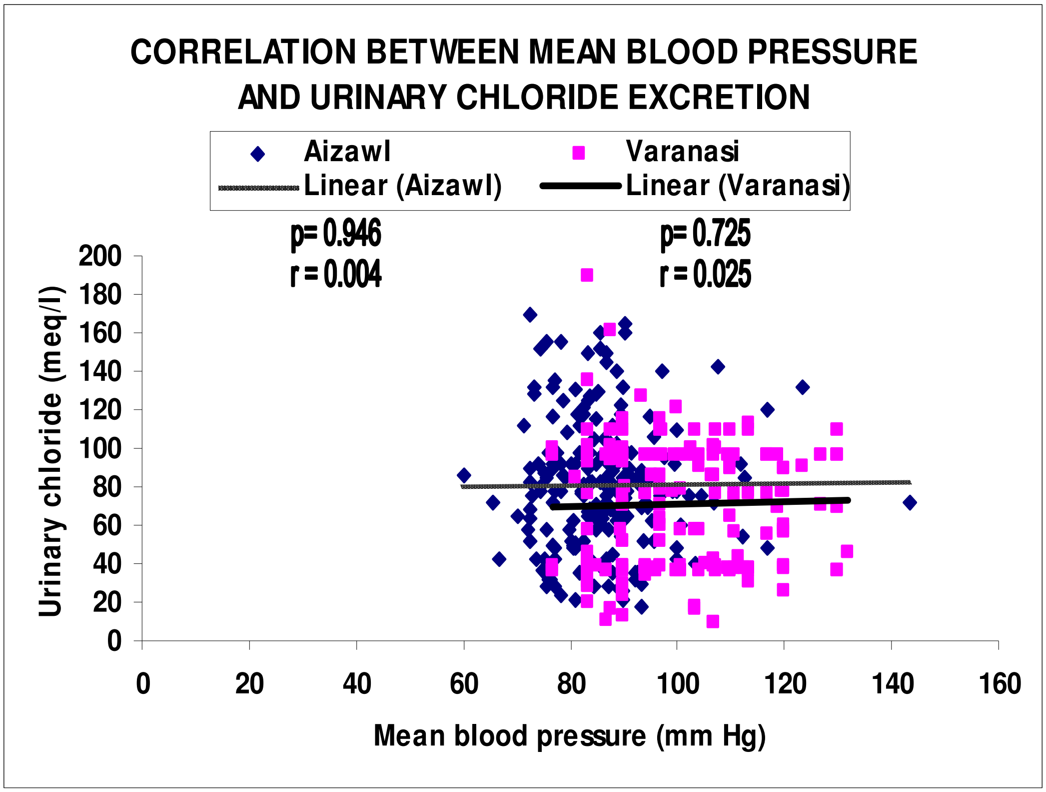


Table No. 5.67 Correlation between mean blood pressure and serum chloride

	Mean Blood pressure (Mean ± SD)	Serum chloride (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	86.13 ± 10.45	81.34 ± 18.58	0.287	- 0.0756
Varanasi	99.08 ± 13.86	99.84 ± 16.47	0.334	0.0686

The Aizawl individuals have shown nonsignificant negative correlation between mean blood pressure and serum chloride. However in Varanasi individuals linear positive correlation was observed having no statistical significance.

Fig 5.80

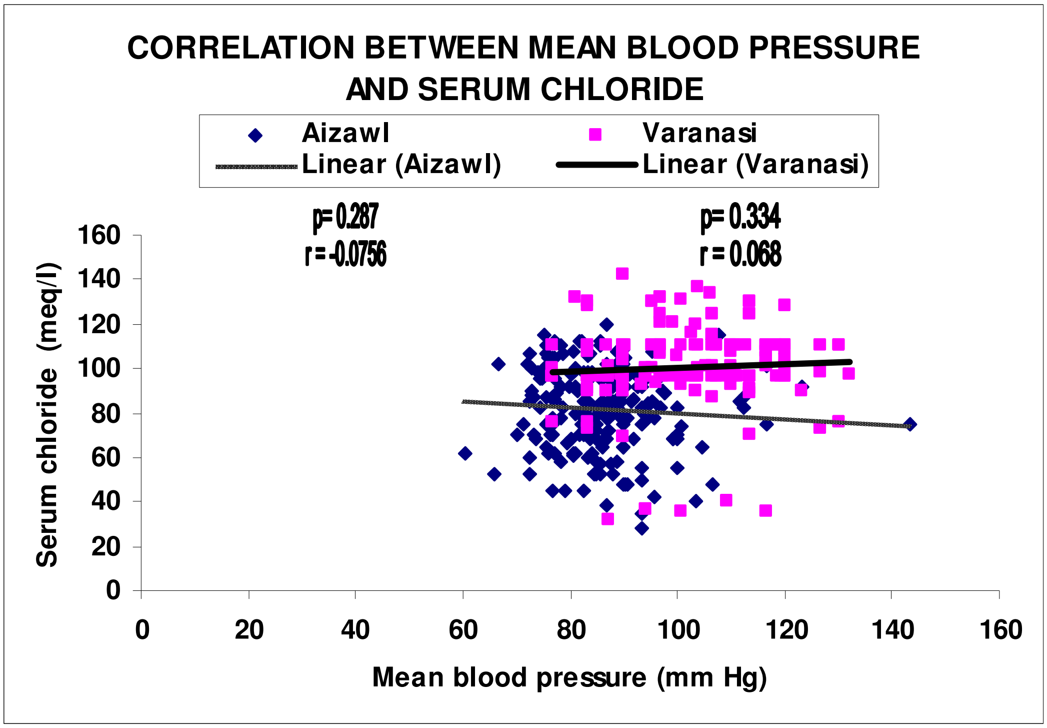


Table No. 5.68 Blood pressure pattern in winter and summer

MEAN BLOOD PRESSURE	WINTER (Mean ± SD)	SUMMER (Mean ± SD)
Aizawl	92.72 ± 14.43	84.52 ± 8.55
Varanasi	94.74 ± 10.50	99.28 ± 13.98
***p* Value**	0.948	0.39

The mean blood pressure was observed during winter (Aizawl 92.72 ± 14.43 mm Hg and Varanasi 94.74±10.50 mm Hg) than summer at both sites (Aizawl 84.52 ± 8.55 mm Hg and Varanasi 99.28 ± 13.98 mm Hg). However no statistically significant difference was observed at both sites.

Fig 5.81

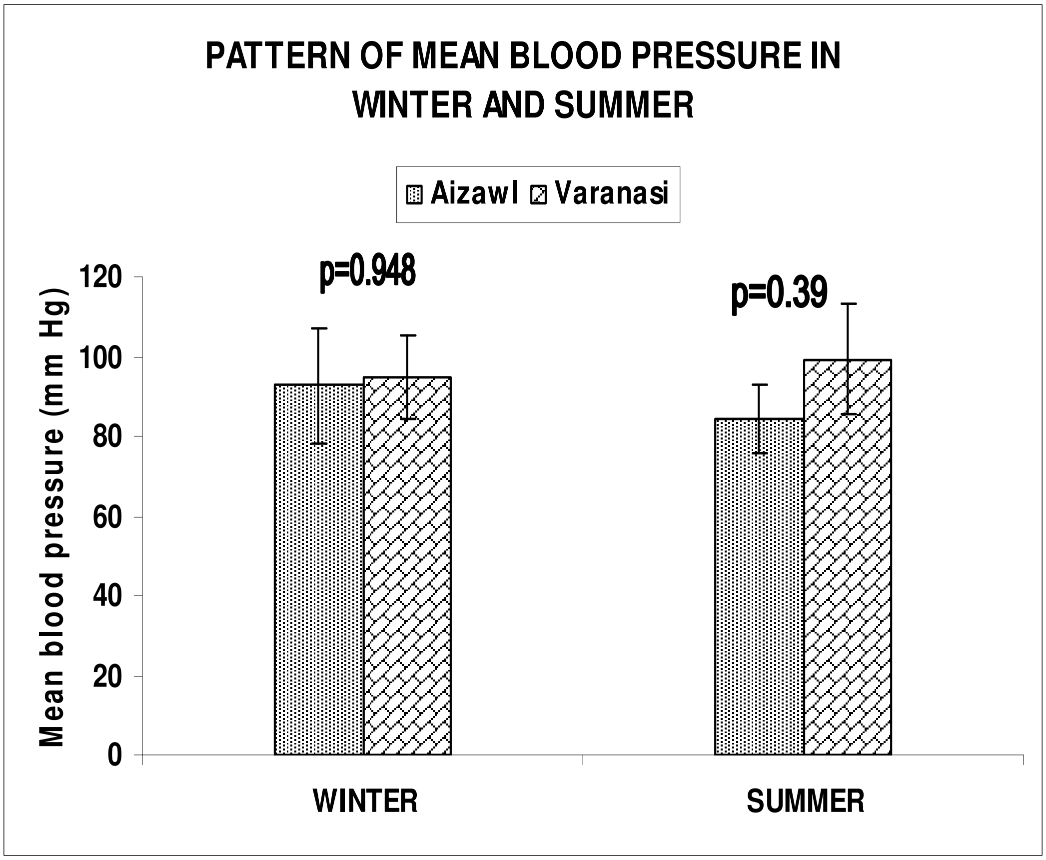


Table No. 5.69 Correlation between ambient temperature and calorie intake

	Ambient temperature (Mean ± SD)	Calorie intake (Mean ± SD)	*p* Value	Correlation Coefficient (r)
Aizawl	22.73 ± 2.45	2316.38 ± 664.30	0.137	0.105
Varanasi	35.75 ± 6.40	2689.09 ± 300.37	0.773	0.0206

The calorie consumption in both Aizawl and Varanasi subjects was found to have nonsignificant linear positive correlation with ambient temperature.

Fig 5.82

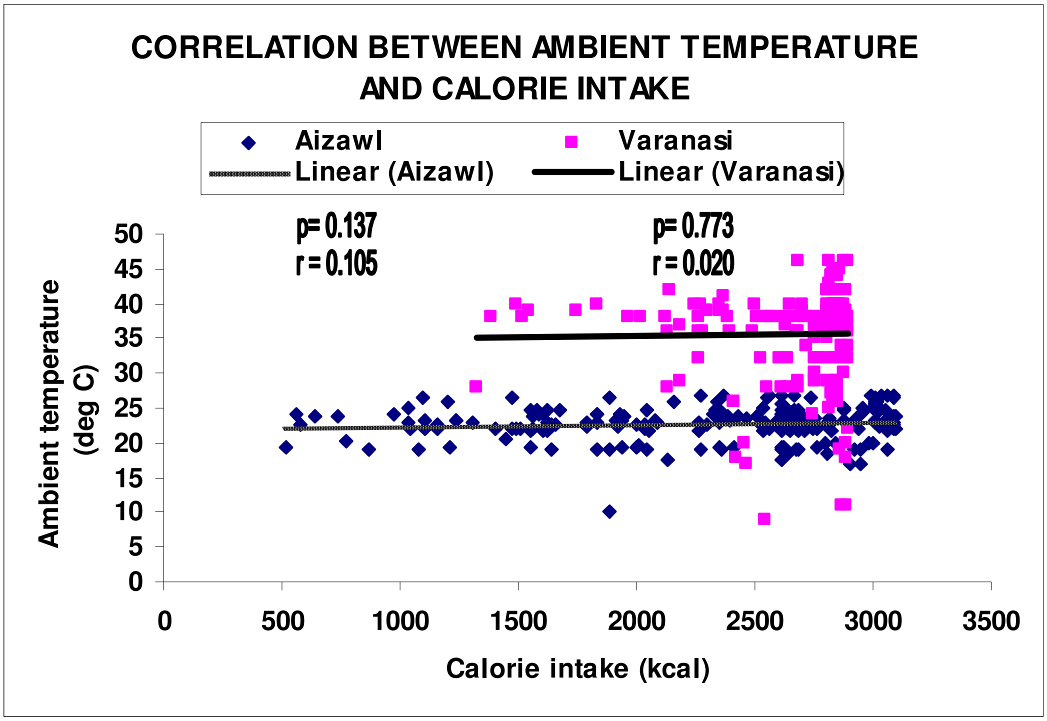


Table No. 5.70 Correlation between ambient temperature and carbohydrate intake

	Ambient temperature (Mean ± SD)	Carbohydrate intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	547.91 ± 272.09	0.0266	0.157
Varanasi	35.75 ± 6.40	587.98 ± 150.15	0.136	- 0.106

The carbohydrate intake was found to have a significant negative correlation (Aizawl *p= 0.0266 & r=0.157)* with ambient temperature in Aizawl subjects. However in Varanasi nonsignificant linear negative correlation was observed.

Fig 5.83

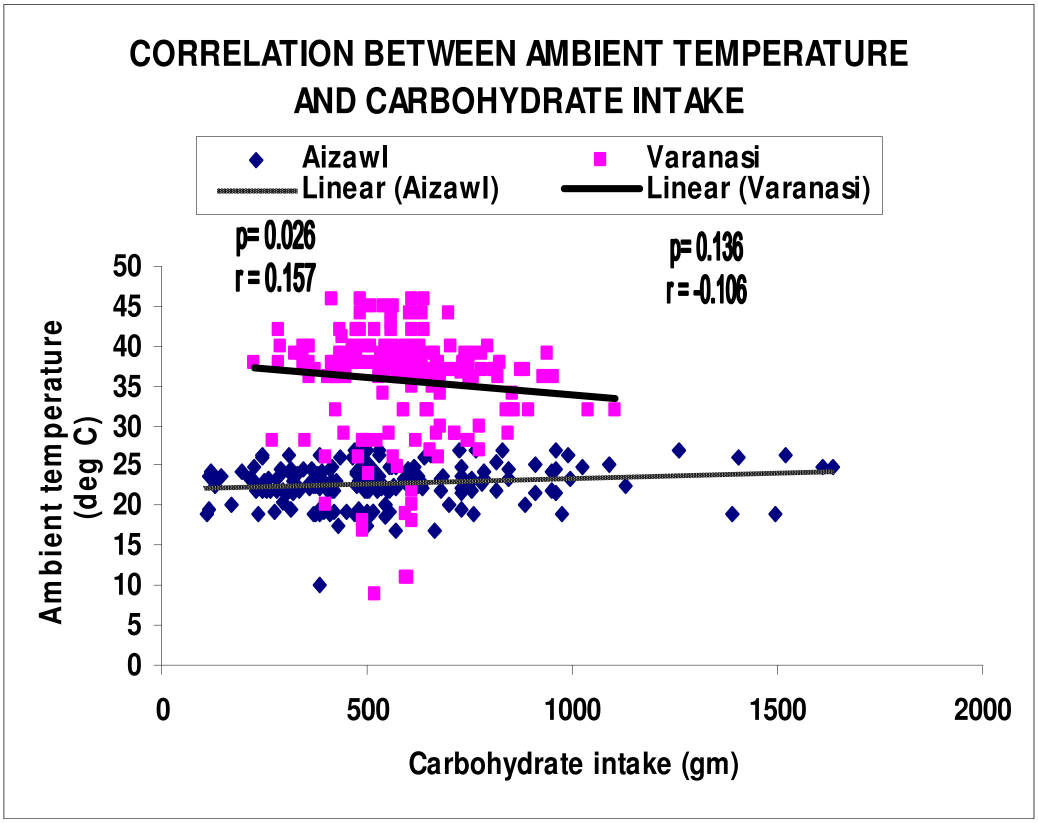


Table No. 5.71 Correlation between ambient temperature and protein intake

Dietary Intake	Ambient temperature (Mean ± SD)	Protein intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	127.80 ± 70.04	0.0816	0.123
Varanasi	35.75 ± 6.40	147.55 ± 42.65	0.835	0.0149

The ambient temperature and protein intake was observed to have a nonsignificant linear positive correlation in both Aizawl and Varanasi subjects.

Fig 5.84

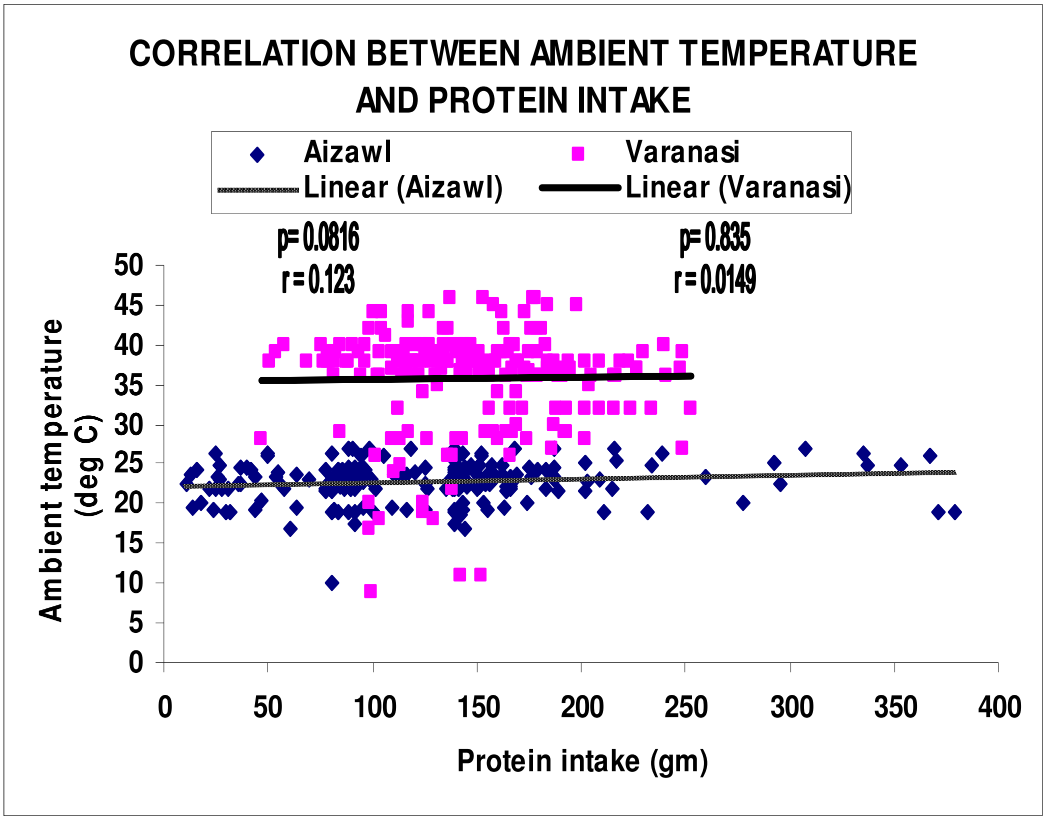


Table No. 5.72 **Correlation between ambient temperature and urinary sodium excretion**

	Ambient temperature (Mean ± SD)	Urinary sodium (Mean ± SD)	p Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	131.07 ± 51.25	0.327	0.0696
Varanasi	35.75 ± 6.40	134.98 ± 68.85	0.349	0.0666

The ambient temperature and urinary sodium excretion had shown nonsignificant linear positive correlation at both Aizawl and Varanasi.

Fig 5.85

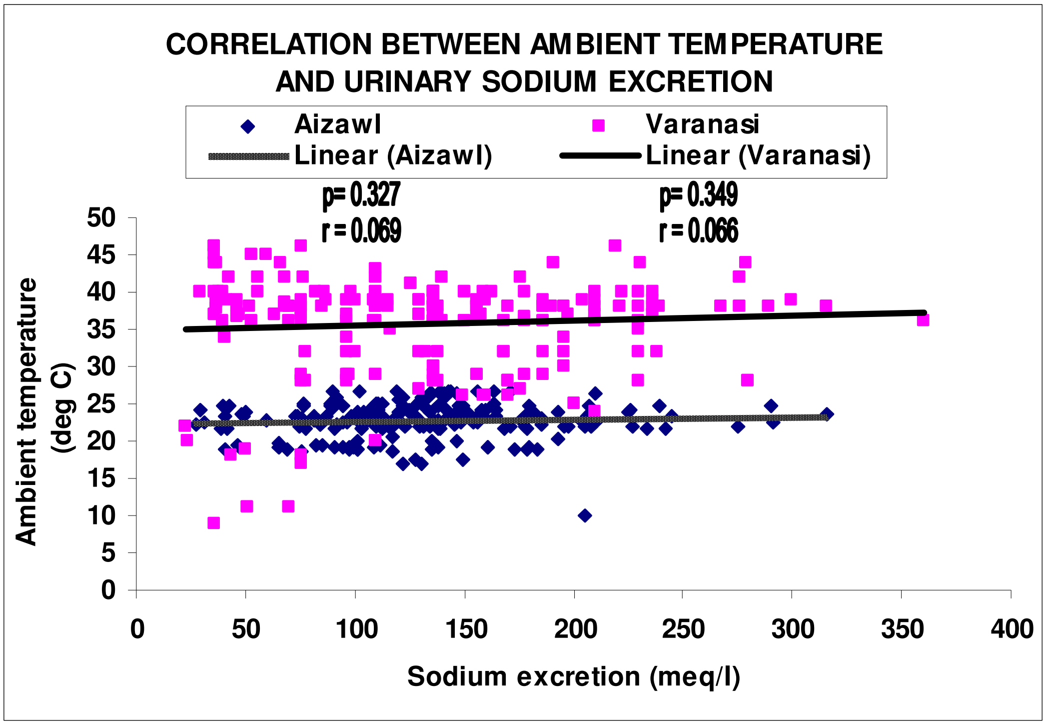


Table No. 5.73 Correlation between ambient temperature and serum sodium

	Ambient temperature (Mean ± SD)	Serum sodium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	137.92 ± 13.82	0.003	0.207
Varanasi	35.75 ± 6.40	143.58 ± 26.26	0.169	0.0975

The individuals at Aizawl had shown statistically significant positive correlation between ambient temperature and serum sodium (Aizawl *p=0.003 & r=0.207*), whereas at Varanasi nonsignificant positive correlation could be established.

Fig 5.86

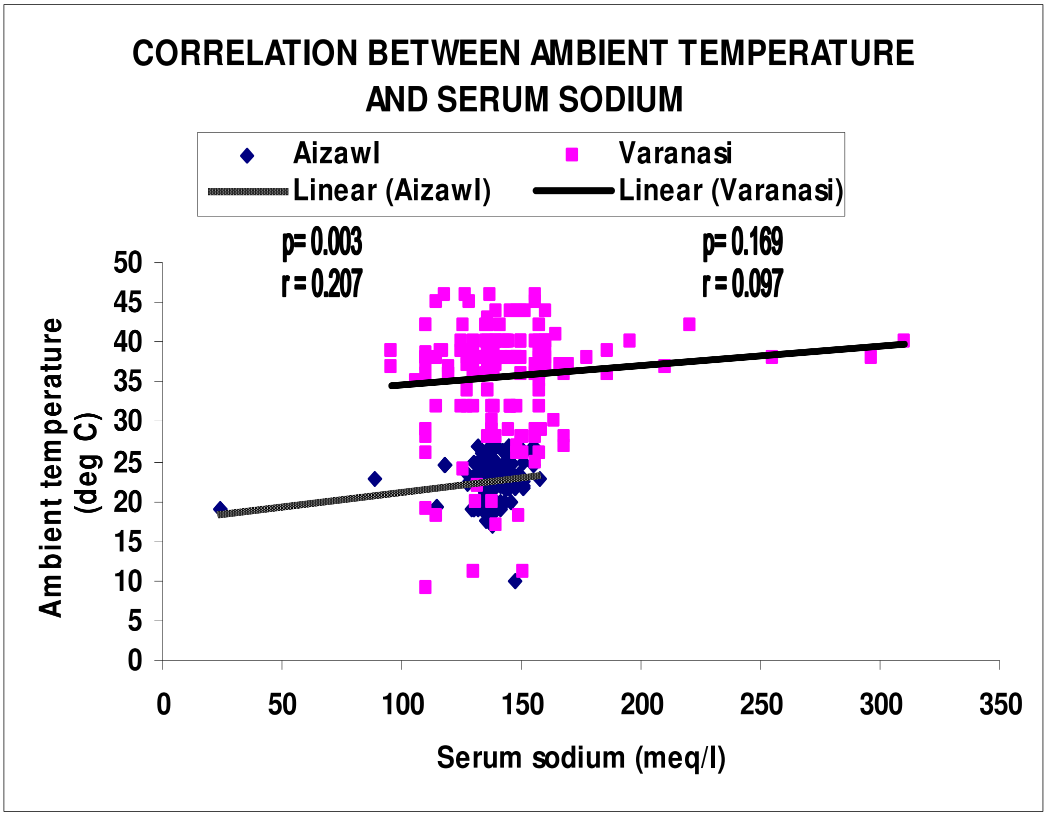


Table No. 5.74 **Correlation between ambient temperature and urinary potassium excretion**

	Ambient temperature (Mean ± SD)	Urinary potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	32.20 ± 16.44	0.120	0.110
Varanasi	35.75 ± 6.40	42.64 ± 30.44	0.423	0.057

The ambient temperature and urinary potassium excretion had shown nonsignificant positive correlation at both Aizawl and Varanasi.

Fig 5.87

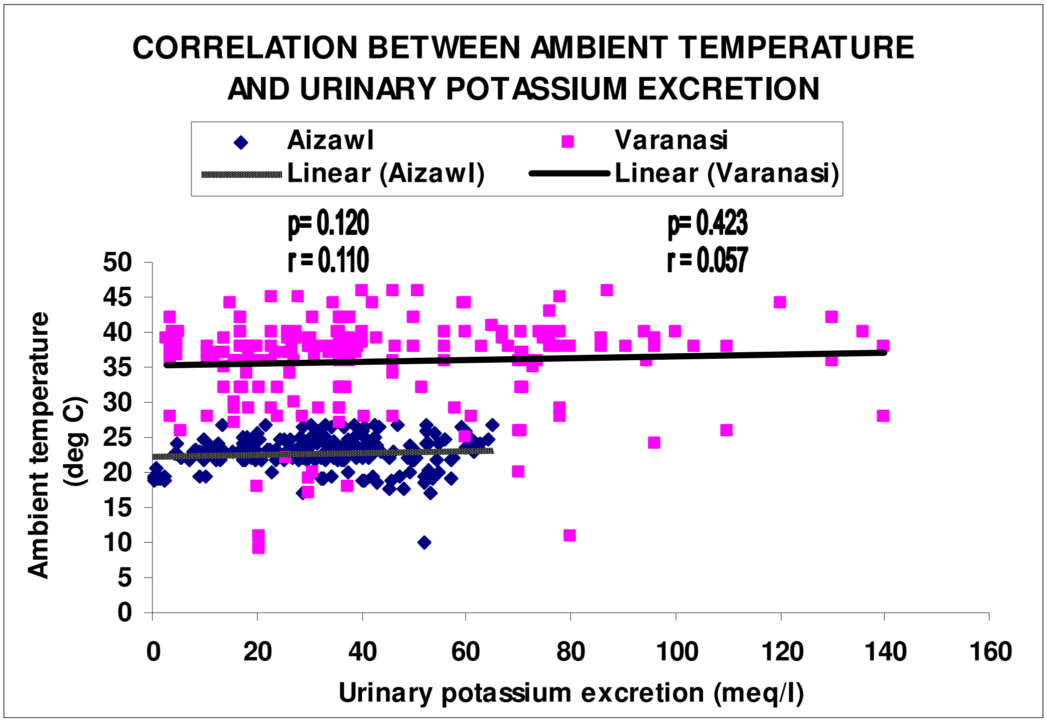


Table No. 5.75 Correlation between ambient temperature and serum potassium

	Ambient temperature (Mean ± SD)	Serum potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	3.82 ± 0.91	0.0418	- 0.144
Varanasi	35.75 ± 6.40	4.19 ± 1.01	0.775	0.0203

The Aizawl residents had shown statistically significant positive correlation between the ambient temperature and serum potassium (Aizawl *p=0.0418 & r= -0.144*), whereas at Varanasi nonsignificant positive correlation could be established.

Fig 5.88

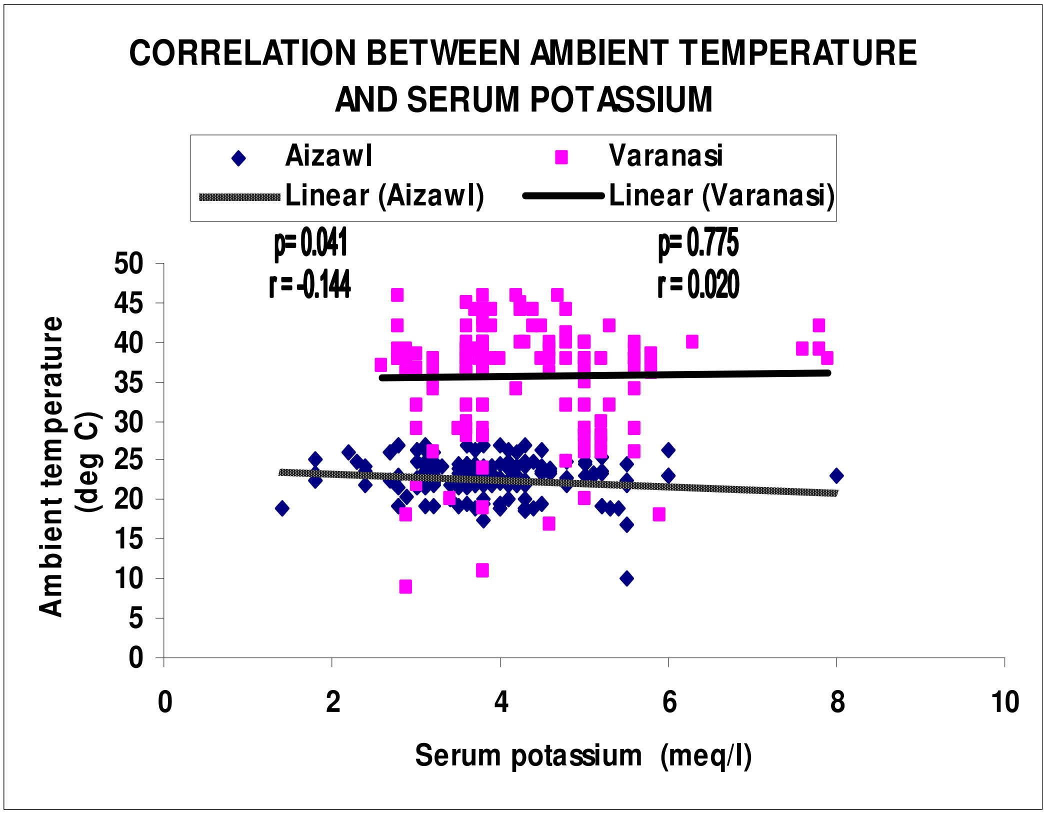


Table No. 5.76 **Correlation between ambient temperature and urinary calcium excretion**

	Ambient temperature (Mean ± SD)	Urinary calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	2.53 ± 0.88	0.0695	0.129
Varanasi	35.75 ± 6.40	2.96 ± 0.84	0.0668	0.13

The ambient temperature and urinary calcium excretion had shown nonsignificant positive correlation at both Aizawl and Varanasi.

Fig 5.89

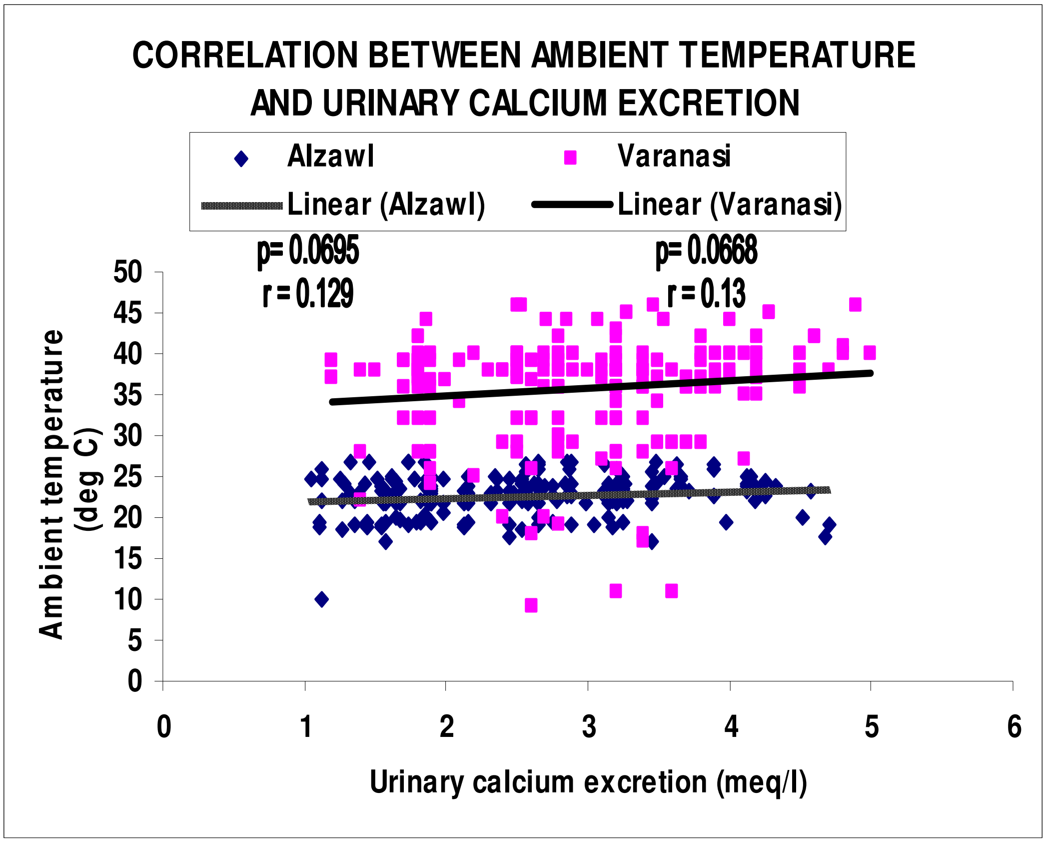


Table No. 5.77 Correlation between ambient temperature and serum calcium

	Ambient temperature (Mean ± SD)	Serum calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	8.47 ± 1.37	0.686	- 0.0287
Varanasi	35.75 ± 6.40	7.91 ± 1.60	0.35	-0.0664

The ambient temperature and the value of serum calcium had shown nonsignificant positive correlation at both Aizawl and Varanasi.

Fig 5.90

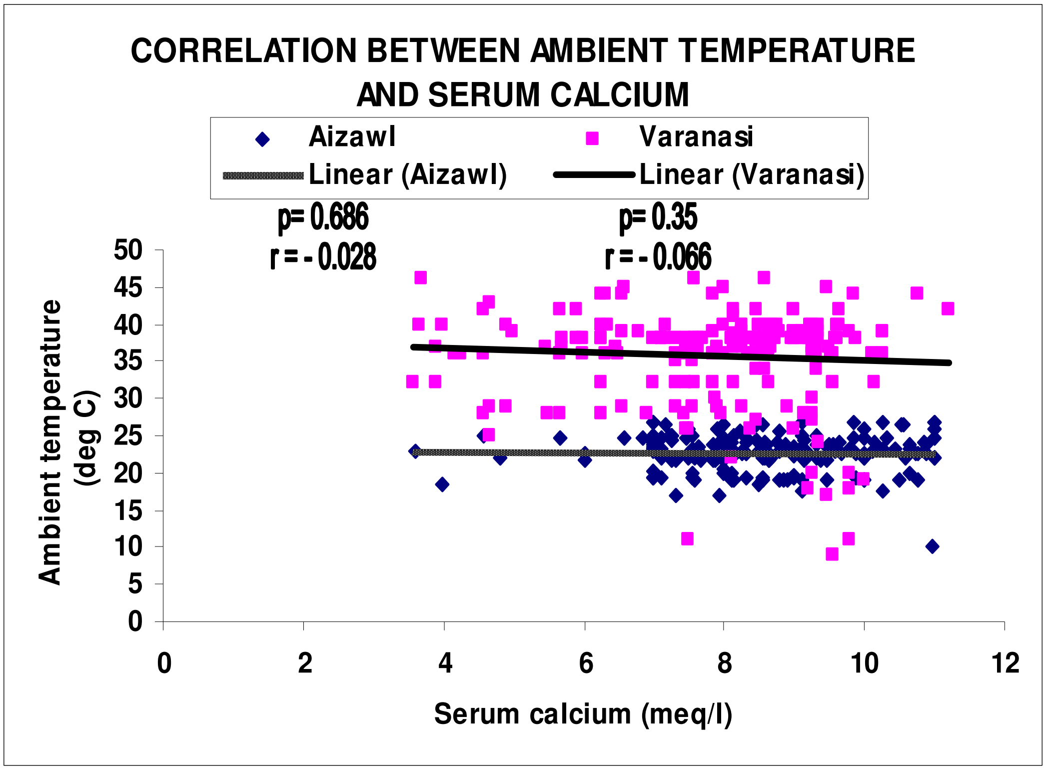


Table No. 5.78 Correlation between ambient temperature and urinary chloride excretion

	Ambient temperature (Mean ± SD)	Urinary chloride (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	80.89 ± 33.29	0.531	0.0445
Varanasi	35.75 ± 6.40	70.74 ± 31.82	0.0186	0.166

The individuals of Gangetic plain had shown statistically significant positive correlation between ambient temperature and urinary chloride excretion (Varanasi *p=0.0186 & r=0.166*), whereas at Aizawl nonsignificant positive correlation was observed.

Fig 5.91

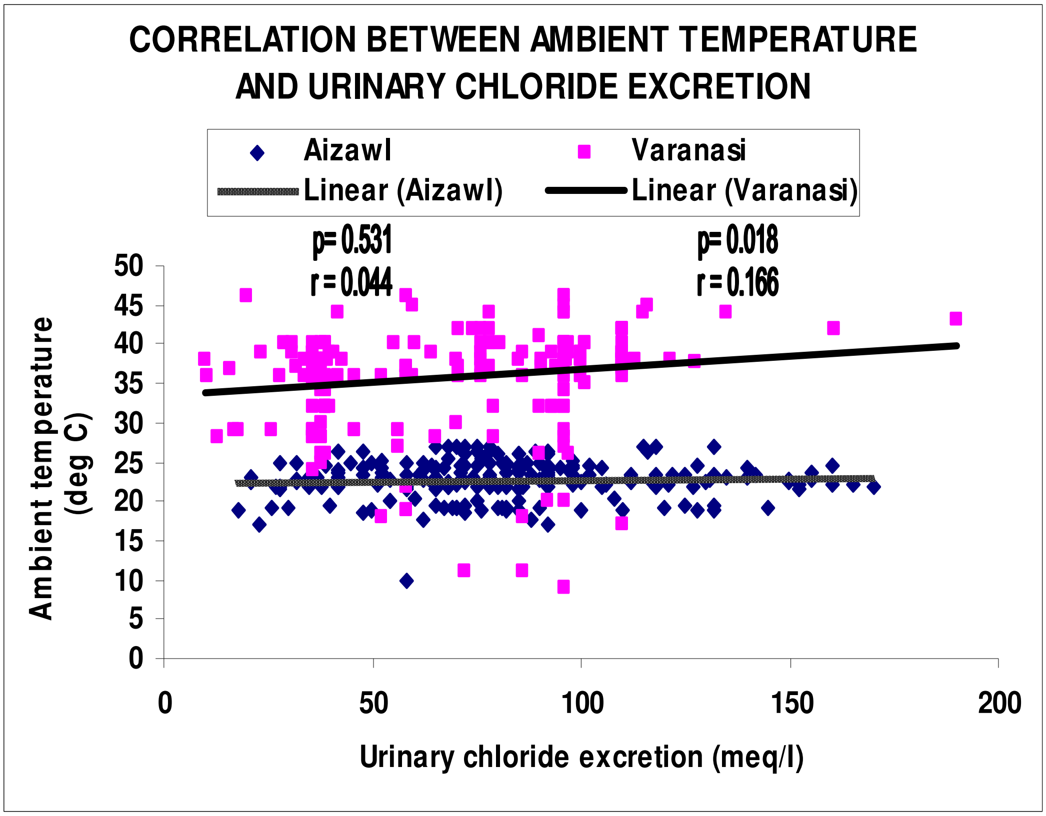


Table No. 5.79 Correlation between ambient temperature and serum chloride

	Ambient temperature (Mean ± SD)	Serum chloride (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	22.73 ± 2.45	81.34 ± 18.58	0.129	0.108
Varanasi	35.75 ± 6.40	99.84 ± 16.47	0.267	-0.0789

The ambient temperature and the value of serum calcium had shown nonsignificant positive correlation at Aizawl and negative correlation at Varanasi.

Fig 5.92

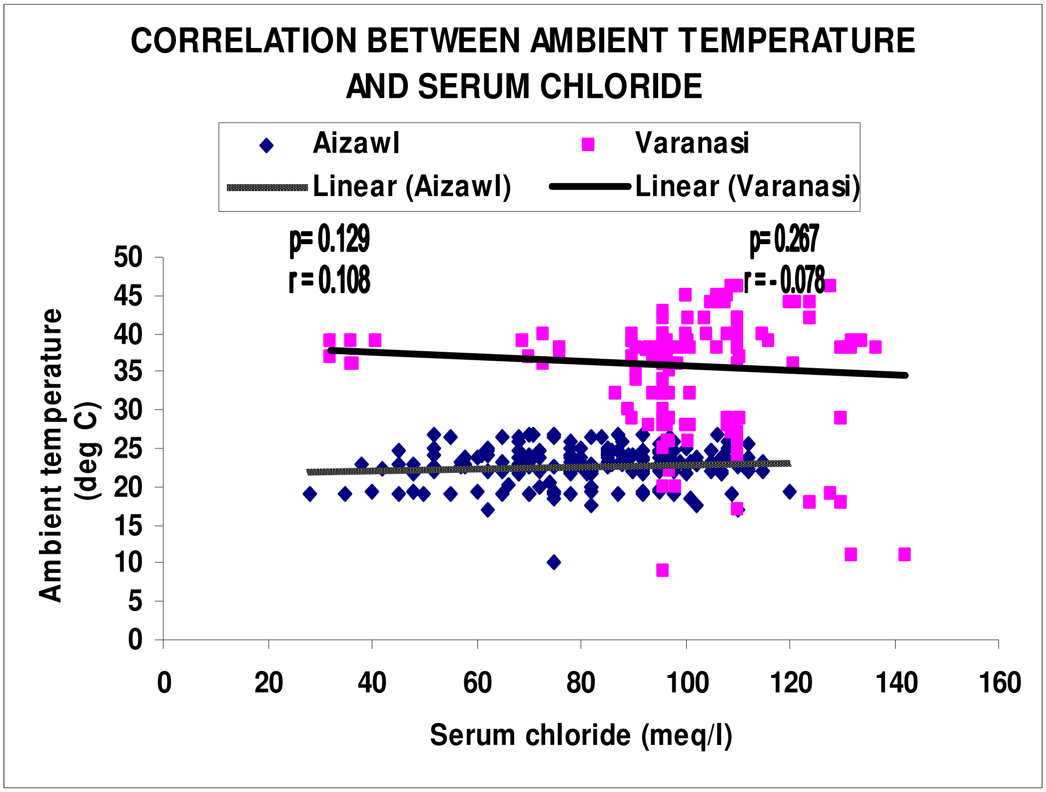


Table No. 5.80 Correlation between relative humidity and calorie intake

	Relative humidity (Mean ± SD)	Calorie intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	2316.38 ± 664.30	0.395	0.0605
Varanasi	50.66 ± 21.73	2689.09 ± 300.37	0.001	-0.222

The total calorie consumption and relative humidity was observed statistically highly significant negative correlation in Varanasi subjects (Varanasi *p=0.001 & r= -0.222*), whereas in Aizawl residents nonsignificant linear correlation (Aizawl *p=0.395 & r= 0.0605*) was noted.

Fig 5.93

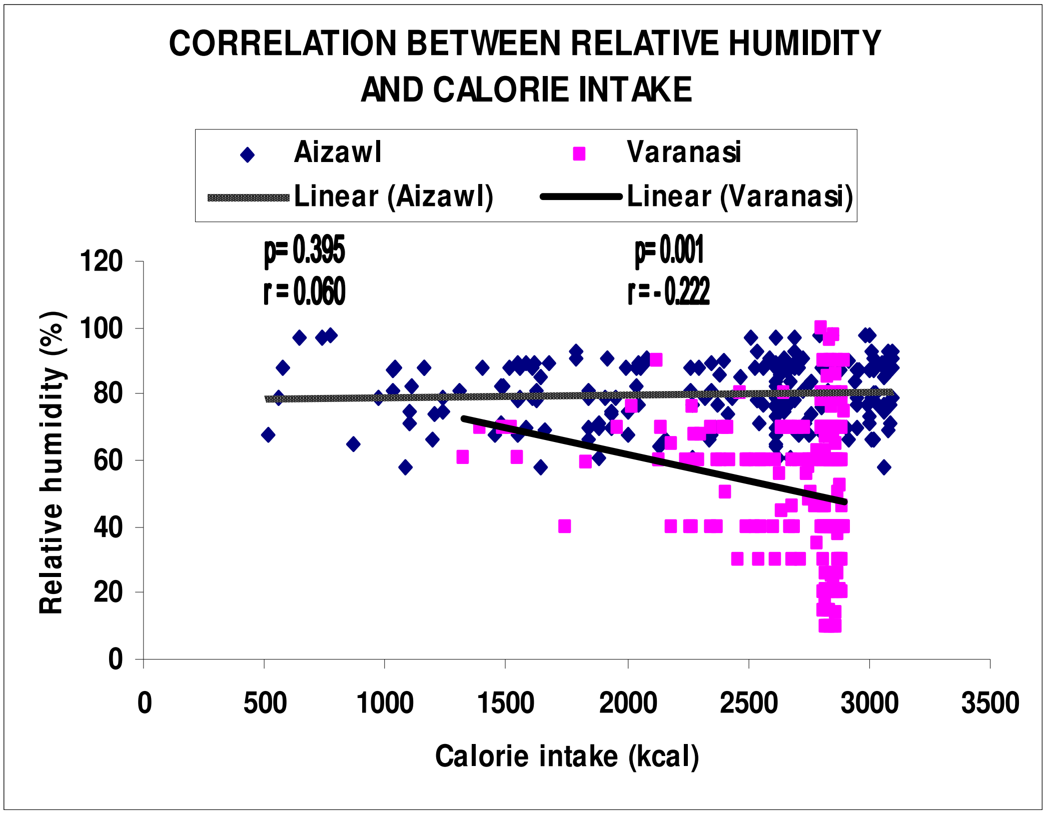


Table No. 5.81 Correlation between relative humidity and carbohydrate intake

	Relative humidity (Mean ± SD)	Carbohydrate intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	547.91 ± 272.09	0.605	-0.0368
Varanasi	50.66 ± 21.73	587.98 ± 150.15	0.582	-0.0391

The Carbohydrate intake was found to have a linear negative correlation with relative humidity at both sites. Though, none of the value was statistically significant.

Fig 5.94

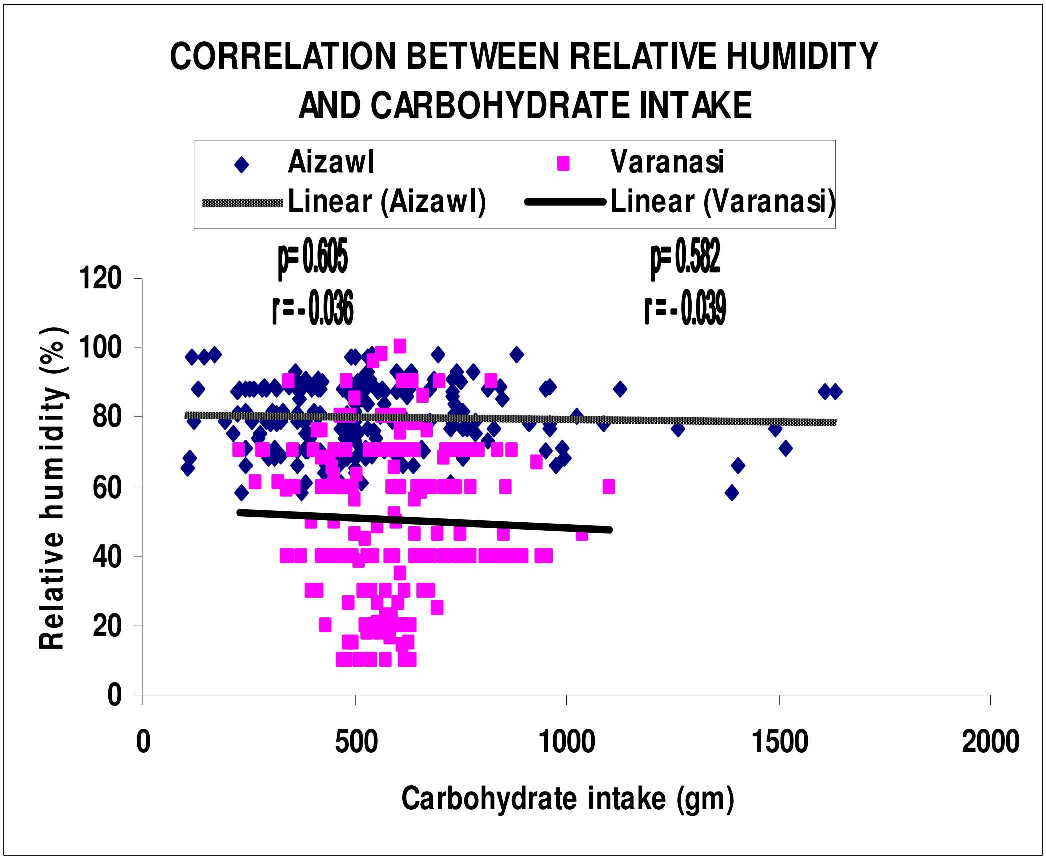


Table No. 5.82 Correlation between relative humidity and protein intake

	Relative humidity (Mean ± SD)	Protein intake (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	127.80 ± 70.04	0.822	-0.0160
Varanasi	50.66 ± 21.73	147.55 ± 42.65	0.687	-0.0286

The protein consumption in individuals from both sites was found to have a nonsignificant linear negative correlation with air humidity.

Fig 5.95

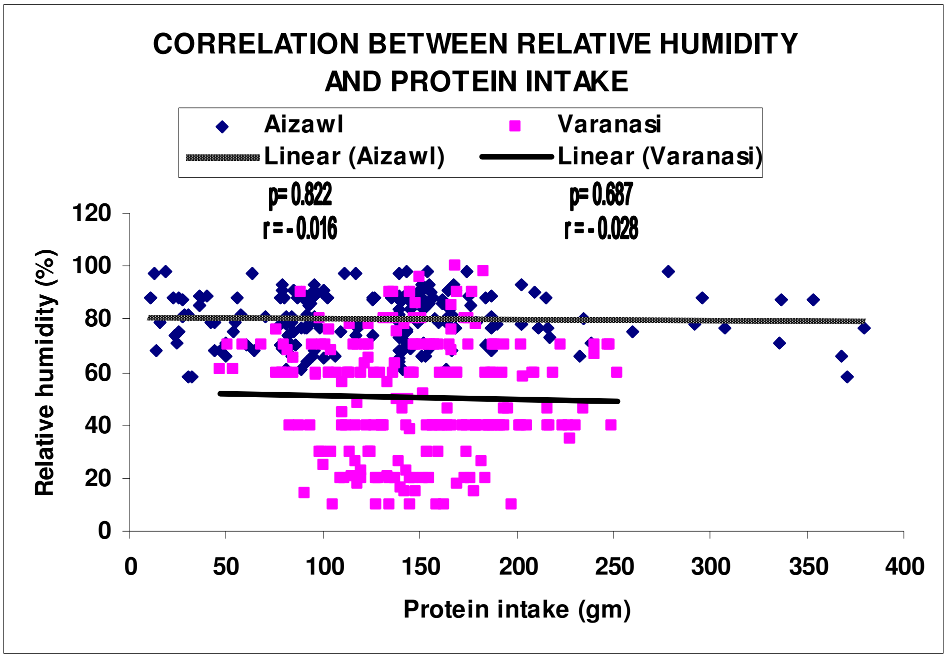


Table No. 5.83 Correlation between relative humidity and urinary sodium excretion

	Relative humidity (Mean ± SD)	Urinary sodium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	131.07 ± 51.25	0.131	0.107
Varanasi	50.66 ± 21.73	134.98 ± 68.85	<0.001	0.253

The urinary sodium excretion and relative humidity of subjects from Varanasi showed statistically highly significant positive correlation (Varanasi *p=<0.001 & r=0.253*), whereas in Aizawl nonsignificant linear correlation was observed.

Fig 5.96

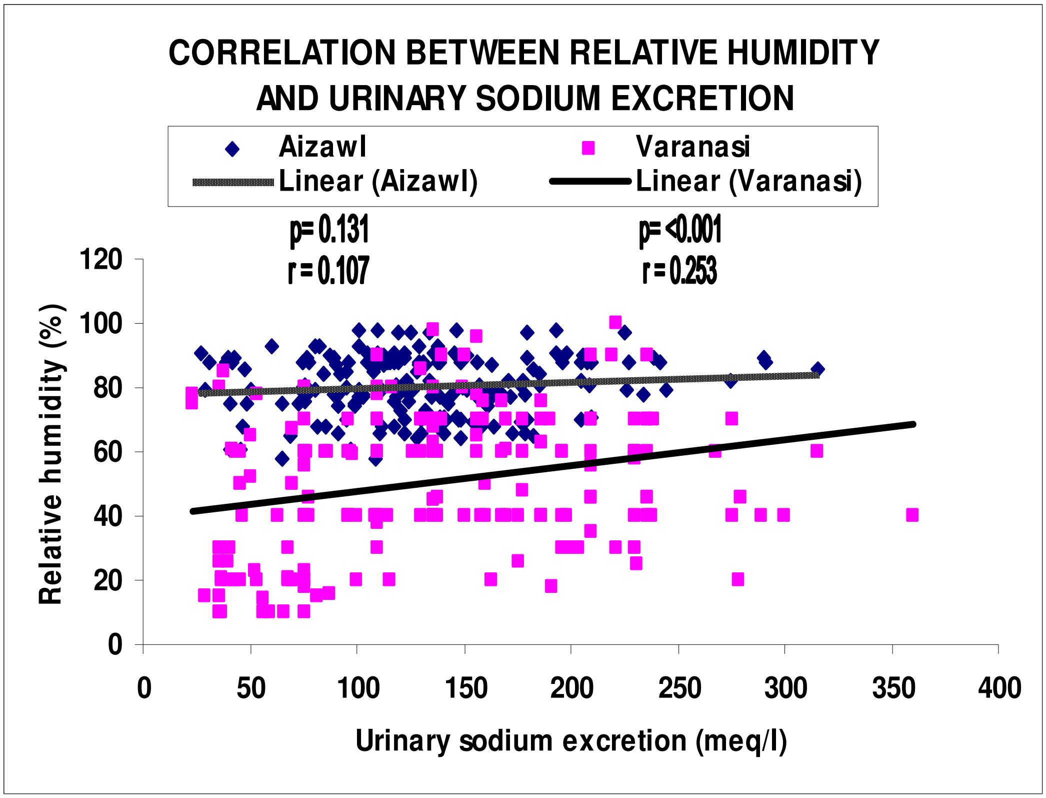


Table No. 5.84 Correlation between relative humidity and serum sodium

	Relative humidity (Mean ± SD)	Serum sodium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	137.92 ± 13.82	<0.001	0.271
Varanasi	50.66 ± 21.73	143.58 ± 26.26	0.004	0.202

The relative humidity was found to have a statistically highly significant positive correlation with serum sodium at both sites (Aizawl *p=<0.001 & r=0.271*) and (Varanasi *p=0.004 & r=0.202*).

Fig 5.97

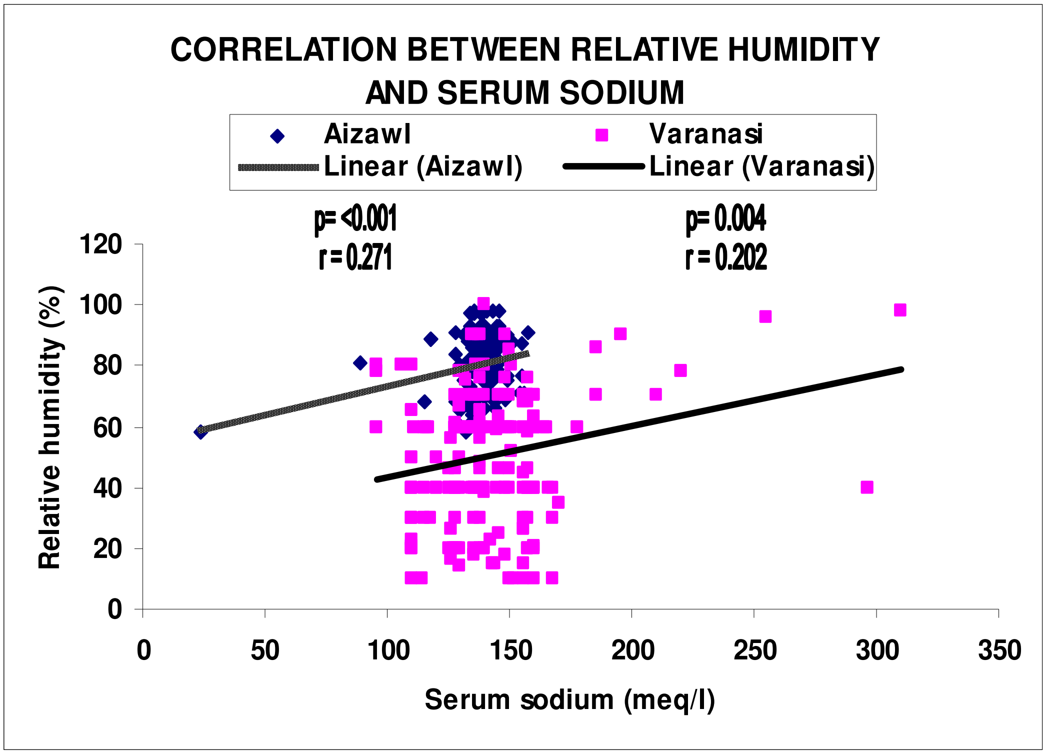


Table No. 5.85 Correlation between relative humidity and urinary potassium excretion

	Relative humidity (Mean ± SD)	Urinary potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	32.20 ± 16.44	0.962	0.003
Varanasi	50.66 ± 21.73	42.64 ± 30.44	0.597	-0.0377

There was no statistically significant correlation was observed between relative humidity and urinary potassium excretion in both Aizawl and Varanasi individuals.

Fig 5.98

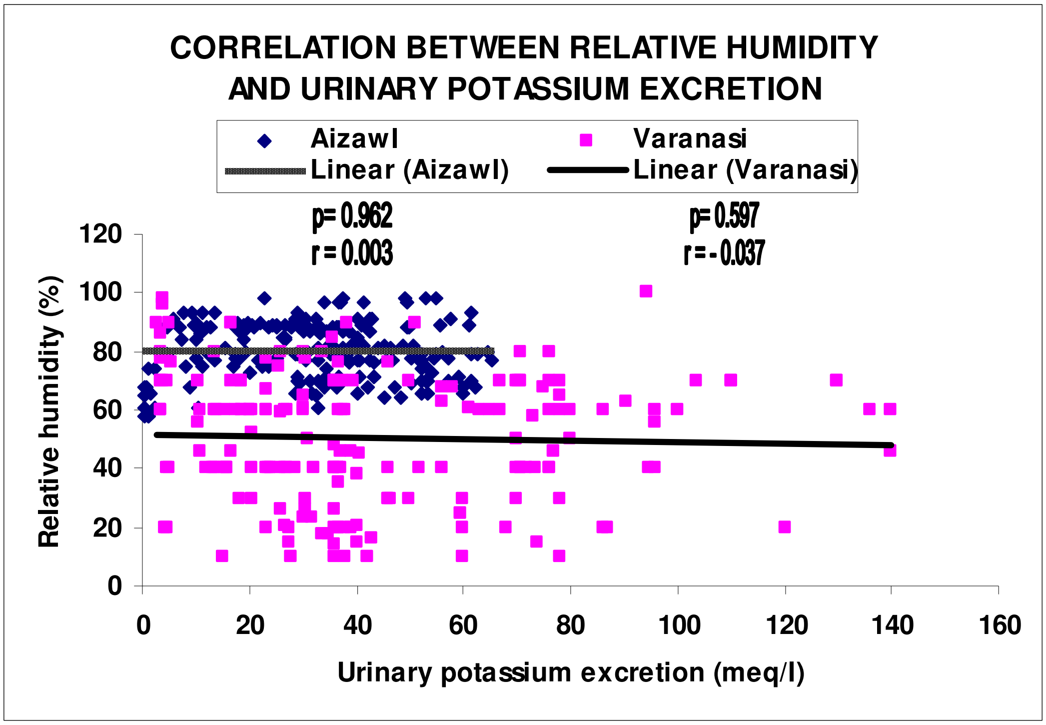


Table No. 5.86 Correlation between relative humidity and serum potassium

	Relative humidity (Mean ± SD)	Serum potassium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	3.82 ± 0.91	0.911	0.008
Varanasi	50.66 ± 21.73	4.19 ± 1.01	<0.001	0.231

The serum potassium in individuals from Gangetic plain of Varanasi has showed a statistically highly significant positive correlation (Varanasi *p=<0.001 & r=0.231*) with relative humidity of air. However the Aizawl subjects showed nonsignificant linear correlation.

Fig 5.99

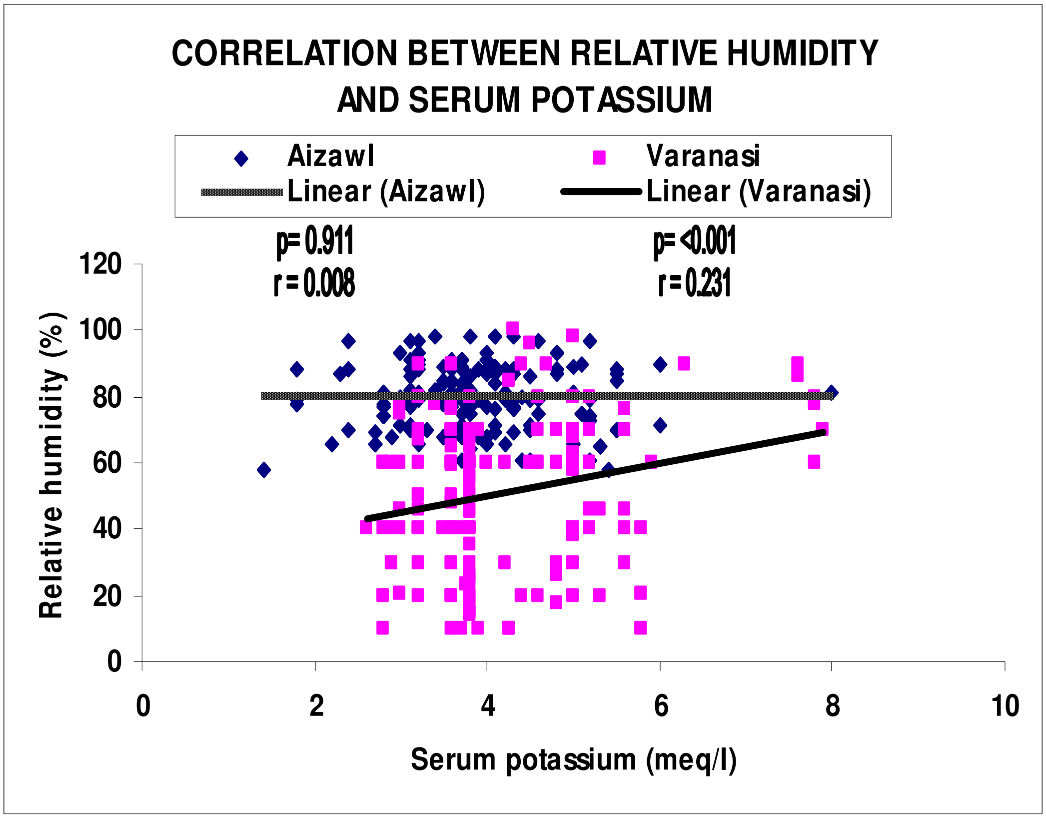


Table No. 5.87 **Correlation between relative humidity and urinary calcium excretion**

	RELATIVE HUMIDITY (Mean ± SD)	Urinary calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43±9.52	2.53±0.88	0.706	0.0268
Varanasi	50.66±21.73	2.96±0.84	0.217	-0.0877

There was nonsignificant correlation found between relative humidity and urinary calcium excretion in both Aizawl and Varanasi subjects.

Fig 5.100

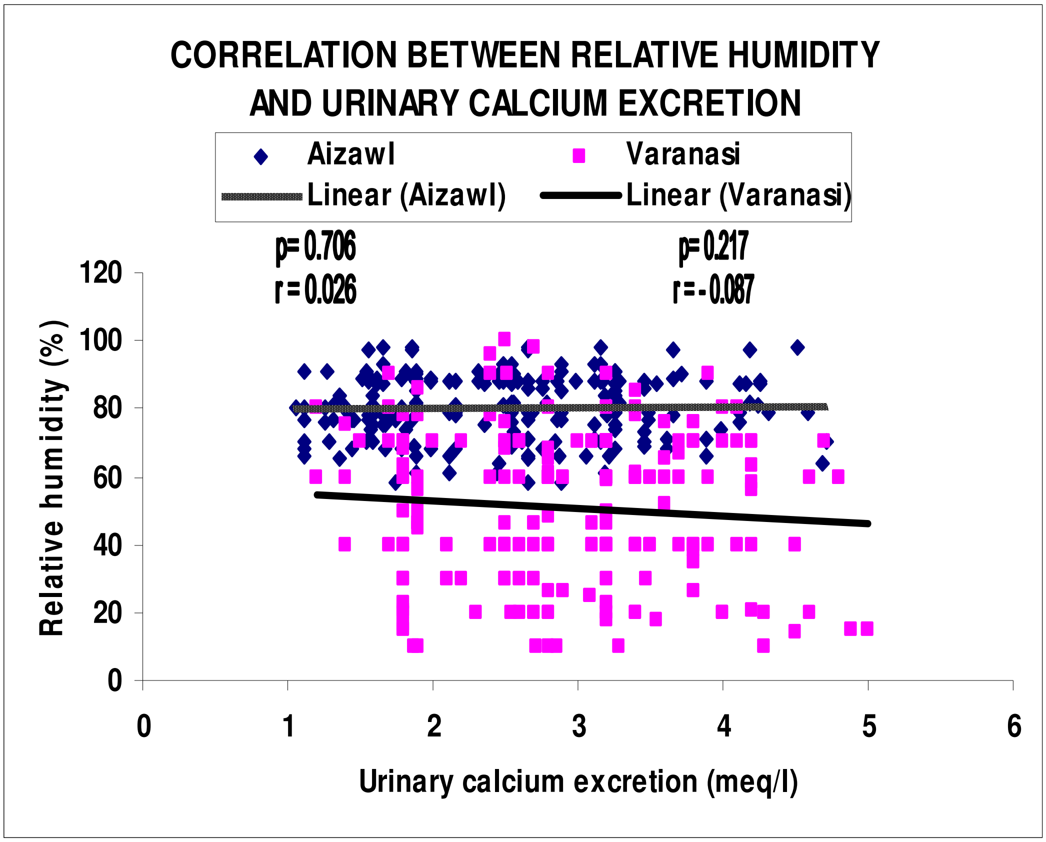


Table No. 5.88 Correlation between relative humidity and serum calcium

	Relative humidity (Mean ± SD)	Serum calcium (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	8.47 ± 1.37	0.316	-0.0712
Varanasi	50.66 ± 21.73	7.91 ± 1.60	0.158	-0.10

The relative humidity and value serum calcium had shown to have nonsignificant negative correlation at both of the sites.

Fig 5.101

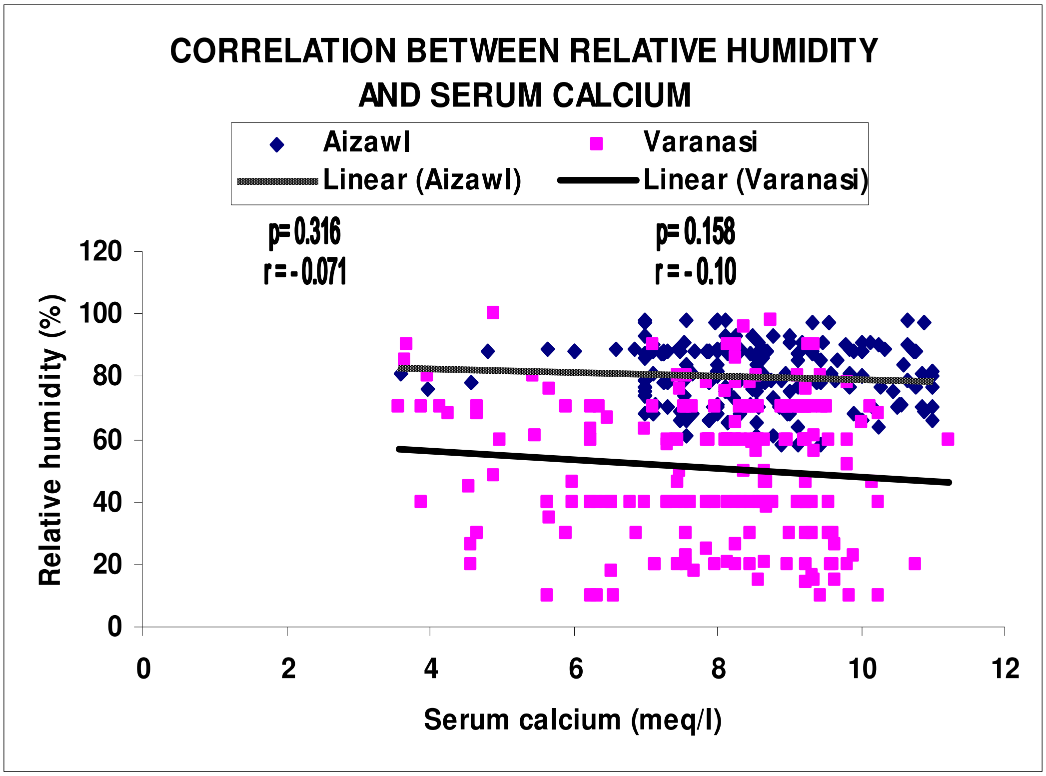


Table No. 5.89 Correlation between relative humidity and urinary chloride excretion

	Relative humidity (Mean ± SD)	Urinary chloride (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	80.89 ± 33.29	0.406	0.59
Varanasi	50.66 ± 21.73	70.74 ± 31.82	0.253	-0.0812

The residents of Aizawl had shown nonsignificant positive correlation between relative humidity and urinary chloride excretion, whereas the residents of Varanasi had shown negative correlation.

Fig 5.102

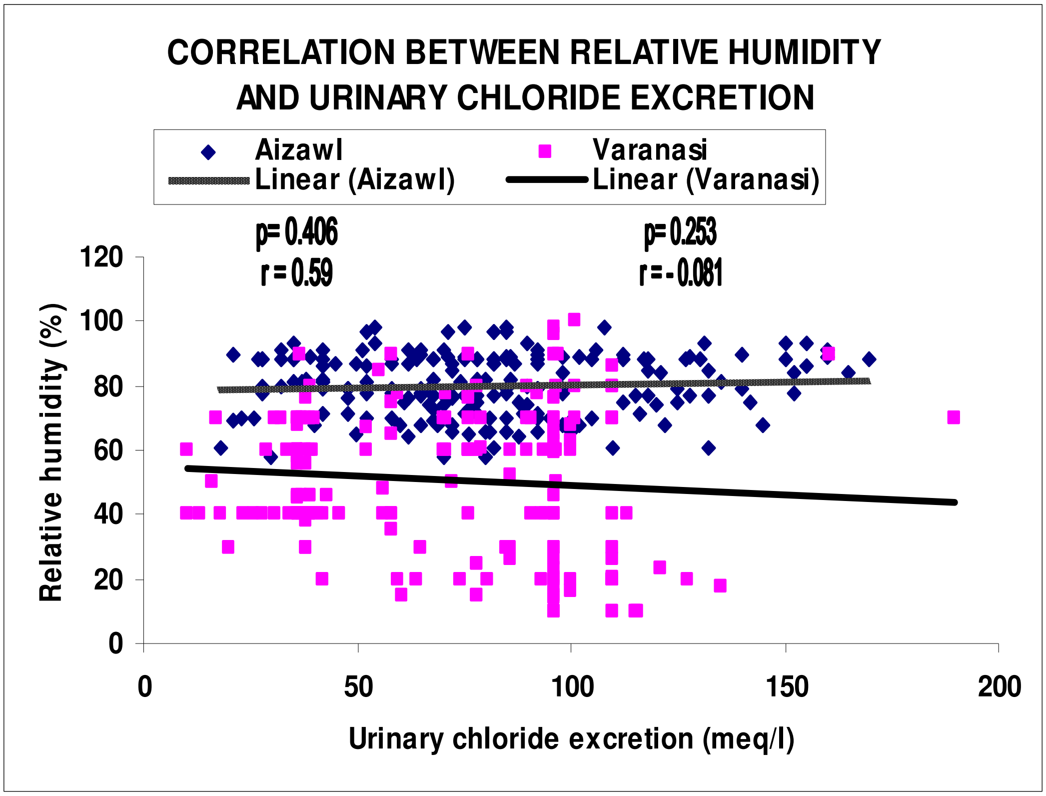
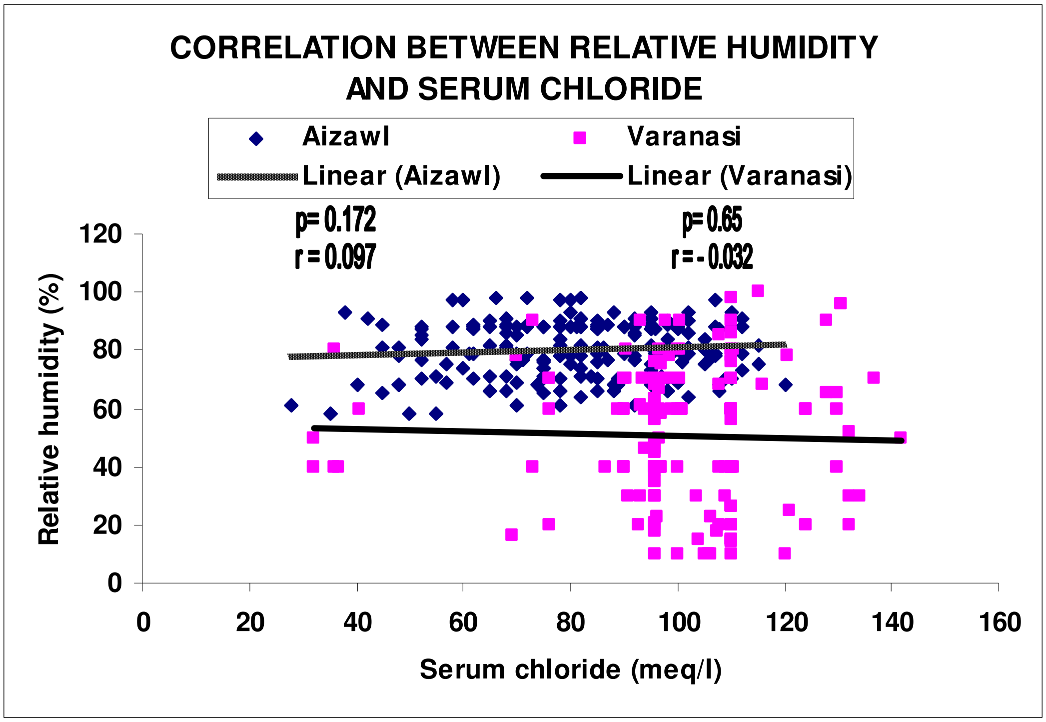


Table No. 5.90 Correlation between relative humidity and serum chloride

	Relative humidity (Mean ± SD)	Serum chloride (Mean ± SD)	*p* Value	Correlation coefficient (r)
Aizawl	80.43 ± 9.52	81.34 ± 18.58	0.172	0.097
Varanasi	50.66 ± 21.73	99.84 ± 16.47	0.650	-0.0323

The individuals of Aizawl had shown nonsignificant positive correlation between relative humidity and the value of serum chloride, whereas the residents of Varanasi had shown negative correlation.

Fig 5.103


CORRELATION BETWEEN RELATIVE HUMIDITY AND SERUM CHLORIDE
Aizawl
Varanasi
Linear (Aizawl)
Linear (Varanasi)
p= 0.172
r = 0.097
p= 0.65
r = - 0.032
Relative humidity (%)
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
Serum chloride (meq/l)

Chapter-6

Discussion

The present work was under taken to study the pattern of various electrolyte and important component of food viz. carbohydrate, protein and fat with other micronutrient in relation to serum electrolytes, value of these component in the individuals and the pattern of urinary excretion in the different geographical environment at the extreme of temperature variation amongst the residents of the North east hill area of Mizoram (Aizawl) and Gangetic plain of Uttar Pradesh (Varanasi). Total 400 individuals were subjected for the above study, of which 200 each from Aizawl and Varanasi from the study group.

There were younger people from the Aizawl group (71%) between the age group of 20-40, whereas in Varanasi majority of the individuals belonged above 40 years (45%). At both of the sites male dominated, however in Aizawl (Male 62%, Female 38%) there were more female individual than Varanasi (Male 73%, Female 27%). This could be a reflection of difference in the cultural background, where in Aizawl female contribute significantly in supporting the family as an earning member than the plain where male members are the principle bread earner. Amongst all individuals who participated in the present study, there were more white collar job seekers from Aizawl (83%) than Varanasi (67%). In the plain area of Varanasi there are more industrial and agricultural based job opportunities, which demand more manual workers than the hill area and this fact has been reflected in the present study. Non-vegetarian diet consumers were higher in proportion (81%) in Aizawl than in Varanasi (59%). However overall there has been tendency towards non-vegetarian diet at both of the site due to fast industrialization of the out skirts of the metro cities as well as urbanization of the rural areas, both has changed the dietary pattern of the individuals, the pattern has also been affected by relaxation in the cultural values where eggs are no more considered as non-vegetarian food. Nevertheless individuals living at the high hill areas covered with deep forests have easy access to non-vegetarian food because of the scarcity of farming land and the nature of the soil. Furthermore uneven rocky mountain and terrains further limits the possibility of easy cultivation and transport of the food material than the plain area, where the accessibility of the resources is much easy.

In the last millennium the body mass index has become one of the important epidemiological factors in health and diseases and is also directly correlated with various ethnic and tribal populations with their environmental factors. In our study, we observed higher body mass index in all the age group from the Varanasi than the individuals from Aizawl and the value were highly significant (*p=<0.001)* in the age group of 20-40 (Table no. 5.1). At both the sites female had higher body mass index, but this was statistically nonsignificant. However male individuals had significant (*p=<0.001*) body mass index in plain area of the Varanasi than Aizawl (Table no. 5.6). This pattern reflected equally, when the body mass index was compared with work place in which at both sites white collar individuals had higher body mass index than blue collar subjects and both data were statistically highly significant (*p=<0.001*) (Table no. 5.7). This study is well comparable to Australian study where white collar male had higher body mass index than blue collar male and the pattern was reversed in the female workers (Allman-Farinelli *et al* 2010).

In an Indian study from North-east tribal group by Khongsdier (2001) lower body mass index was observed (20.49 ± 1.13 and 19.85 ± 1.46), whereas another study from Jalandhar (Punjab) by Koley *et al* (2009) demonstrated higher body mass index amongst housewives (24.82 ± 4.45) than the laborers. Both of the above studies confirm our observation that white collar workers have higher body mass index and also people from tribal areas of Assam and Meghalay (Khongsdier 2001) have similar body mass index as the Aizawl residents, while individuals from Varanasi are well comparable with the residents of Punjab who had significantly higher body mass index (Koley *et al* 2009). The individuals from the Aizawl did not show so much difference between body mass index and dietary pattern, however at the site of Varanasi, vegetarians were found to have relatively higher body mass index. In a study from PUDUE university vegetarians had low body mass index than the non-vegetarian with low blood pressure and similar observation was also made in Mexico, China and UK (Christopher *et al* (1989), Wyatt *et al* (1995), Woo *et al* (1998) and Appleby *et al* (1998). In a Swedish study in 2002, vegetarians were found to have low body mass index and also low blood pressure (Larrson and Johansson 2002). No such study from the Indian continent has been reported, where body mass index has been considered with the dietary pattern. The difference in our study may be due to relatively higher carbohydrate intake amongst residents of Varanasi, who were also white collar workers and had less opportunity of physical exercise, which could shape their body mass index. When age was correlated with body mass index pattern in Aizawl, younger age group showed a lower body mass index (p=<*0.001*) than the Varanasi, where the older age had higher body mass index but this was statistically nonsignificant (Table no. 5.9).

Salt and electrolytes have been established as an important constituent of the human blood in regulating the blood pressure and urinary excretion in different environmental factors. This quality was acquired by animals millions of year before when life took its evolution in the great ocean and the cell developed the property of diffusion through its cell membrane for extra sodium back to ocean and to maintain intracellular environment in an osmotic state to keep the nucleus and other cytoplasmic contents in a viable state. As the animal became complex, it developed a system of excretion by which the diffusion process can be regulated through skin and urinary system (Natochin 2007).

The movement of animal from sea to terrestrial plain further made the excretory system in able to conserve the water as well as salt depending upon change in humidity and ambient temperature as well as the type of food which was consumed by the individual animals. In human beings this quality is maintained by kidney and by process of sweating through exposed body surface area in accordance with the variation of humidity and temperature. The adaptive response to these variables depends upon the perfusion of the kidney, which is regulated by systemic blood pressure. Thus study of blood pressure is important physical parameter in the adaptation of the human being during extreme variation of the environmental factors as well as the altitude. Within the physiological limit blood pressure varies between 120-160 systolic and 70-85 diastolic and has got minor variation during exercise and stress (Natochin 2007).

In present study the distribution of mean blood pressure was observed lower in the hill area (86.13 ± 10.45 mm Hg) than plain (99.08 ± 13.86 mm Hg). Individuals above 40 year of age group had higher mean blood pressure (95.34 ± 15.86 mm Hg) than the younger group below 20 year (83.81 ± 7.88 mm Hg) at Aizawl. Though, it was within the physiological limit. Amongst the residents from Gangetic plain of Varanasi a similar trend was observed Varanasi (Above 40 year 104.32 ± 13.79 mm Hg and below 20 year 91.99 ± 9.38 mm Hg). These values were statistically significant in the age group of 20 to

40 year ($p=<0.001$) and there could be small segment of individuals who may fall in the range of hypertension (Table No. 5.10). The male individual at both of the sites had higher mean blood pressure value (Aizawl 86.64 ± 9.78 mm Hg and Varanasi 99.14 ± 14.11 mm Hg) than the female individuals (Aizawl 85.29 ± 11.48 and Varanasi 98.91 ± 13.28) and this was uniformly found to be statistically significant ($p=<0.001$) (Table No. 5.11). Taking into consideration the type of occupation blue collar individuals had low blood pressure (Aizawl 91.78 ± 8.87 mm Hg and Varanasi 95.18 ± 12.69 mm Hg) than the white collar individuals (Aizawl 85.01 ± 10.40 mm Hg and Varanasi 100.95 ± 14.05 mm Hg) at both of the sites (Table No. 5.12).

A study from Africa and other Caribbean native individuals have shown positive correlation between body mass index and blood pressure in both sexes (Kaufman *et al* 1997), whereas a study from London in 1998 demonstrated that white collar men and women had low systolic and diastolic blood pressure with low body mass index amongst men (Ferrie *et al* 1998). In an Indian study from North-East Assam blue collar labourers were found to have high systolic and diastolic blood pressure amongst the female (126.22 and 66.74 mm Hg) than the male (115.20 and 62.67 mm Hg) (Wilson 1954) and similar finding were observed by Singh *et al* (1997) and Hazarika *et al* (2000) from North East.

In our study at both of the sites blue collar individuals had relatively low blood pressure than white collar because hard work keeps them a better opportunity to sustain low body mass index as well as promote excretion of extra salt in the urine. Amongst the residents of the Varanasi females had tendency of higher mean blood pressure (Table No. 5.10) than the Aizawl with high body mass index, though statistically it was nonsignificant (Table No. 5.6).

The dietary pattern did not affect the pattern of mean blood pressure at both of the site, though among the residents of Varanasi non-vegetarian consumers had higher blood pressure (100.57 ± 13.84 mm Hg) than vegetarians (96.93 ± 13.69 mm Hg) (Table No. 5.13). In the beginning of 20th century Saile (1930) observed that vegetarian have low blood pressure than meat eater in the same age group and this has direct correlation with the pattern of urinary sodium excretion. This observation has been supported by Israeli workers where vegetarian diet is associated with low blood pressure and high urinary potassium excretion than non-vegetarian (Ophir *et al* 1983). Contrary to this Chinese studies have found high diastolic blood pressure in female vegetarians (Ko and Chang 1983). Most of the study from all over the world except few have supported that vegetarians have low blood pressure due to low dietary sodium intake and these observation have continued to be significant till the study from Lin *et al* (2010), where they found that diastolic blood pressure in the vegetarians was significantly higher. Since our study was basically concerned with cross sectional observation, we could only correlate positively between mean blood pressure and age group (Figure No. 5.18) as well as body mass index (Figure No. 5.19) at par with the studies reported from other countries as well as from North-East states from India. However the significant difference was observed in the residents of the Gangetic plain area of the Varanasi, where we found significant positive correlation between body mass index and mean blood pressure (Aizawl $p=<0.001$ & $r=1.00$ and Varanasi $p=<0.001$ & $r=0.942$) (Table No. 5.15).

There seems to be strong association of calorie intake between vegetarian and nonvegetarian diet at both of the sites in which the overall consumption of calorie was higher amongst non-vegetarian consumers (more than 2800 calorie) in the residents of Varanasi, whereas relatively lower calorie was being consumed by the Aizawl residents (Table No. 5.16). The dietary calorie intake was higher in the younger age group and significantly (*p*=<*0.001*) low in the age group of 20 - 40 year and above 40 year at both of the sites (Table No. 5.17). We also observed that females consumed low calorie (2576.10 ± 335.24) than the male (2730.87 ± 276.10) in the Gangetic plain of Varanasi, whereas in Aizawl the consumption of overall calorie was significantly (*p*=<*0.001*) higher amongst the female residents (Table No. 5.18). There was reversal of the pattern in the hill area of the Aizawl were female consumed more calorie than the male individual and this was well comparable with the nature of job in which white collar individuals in Aizawl consumed more calorie than their blue collar counter part, while in Varanasi blue color labour workers consumed higher calorie than white collar residents (Table No. 5.19). When individual component of the diet was considered amongst the non-vegetarian, protein content of the individuals from the Aizawl was significantly (*p*=<*0.001*) lower than the Varanasi individual, whereas no correlation could be established between carbohydrate content of vegetarian and non-vegetarian diet amongst Gangetic plain and hill area (Table No. 5.20). When gender was considered, female individuals from Aizawl consumed significantly (*p*=<*0.001*) higher amount of carbohydrate and protein than the Varanasi individual, whereas male individual in Aizawl consumed less carbohydrate and protein in comparison with Varanasi individuals (Table No. 5.21).

While calculating the main electrolyte component of diet overall there was no difference in sodium content of the diet between vegetarian and non-vegetarian individuals in Aizawl, whereas in Varanasi there was significantly (*p*=<*0.001*) higher dietary sodium content in non-vegetarian consumer than vegetarian (Table No. 5.22). When dietary potassium value was calculated, further there was higher potassium content amongst Varanasi residents then Aizawl. However amongst vegetarian eater potassium was on higher side in the Aizawl hill area tribal in comparison to the non-vegetarian diet (Table No. 5.23). There was no difference when dietary sodium potassium ratio was considered at both of the site. The value was higher in the non-vegetarian consumers amongst Varanasi residents than residents from Aizawl (Table No. 5.24). The dietary calcium was significantly (p=<*0.001*) higher in the residents of Varanasi and much lower in the Aizawl individuals and similar pattern was observed in the chloride content of the diet in which higher value of dietary chloride was found amongst the residents of Varanasi which was significantly (p=<*0.001*) double of the value what was observed amongst the residents of Aizawl (Table No. 5.25 and 5.26). The extra dietary consumption of salt was significantly (p=<*0.001*) higher in both of the non-vegetarian group (Aizawl 6.48 ± 3.20 and Varanasi 9.20 ± 4.78) than the vegetarian (Aizawl 5.66 ± 2.37 and Varanasi 8.67 ± 4.55).

There is a scarcity of the literature regarding the overall calorie consumption and various component of the food in relation to hill and plain area. However a study by Melby *et al* (1989) had shown statistically significant correlation between dietary intake of Carbohydrate, protein, sodium as well as potassium intake with blood pressure. In another study, low sodium intake and high potassium intake was found in vegetarian (Wyatt *et al* 1995). A Chinese study by Woo *et al* (1998) found that elder subjects consumed low calorie diet and electrolyte component in vegetarian diet for example calcium, potassium and sodium is much low in the vegetarian diet. Furthermore study from Melbourne by Li Duo *et al* (2000) demonstrated that vegetarians have higher potassium intake with low dietary sodium potassium ratio than the non-vegetarian. Appleby *et al* (2002) demonstrated positive association of calcium intake with blood pressure in women and study from Taiwan (Yen *et al* 2008), the total carbohydrate consumption and calcium intake was significantly higher in vegetarian diet than non-vegetarian. A similar study from Taiwan by Lin *et al* (2010) also demonstrated that vegetarian could have high diastolic blood pressure.

The association of dietary potassium and low blood pressure has been observed since 1928 by Addison, which was further confirmed by Woo *et al* (1998). However in Georgia study in black and white population showed a negative correlation between blood pressure and dietary potassium (Grim *et al* 1980). Many other studies (Geleijnse 1990) from Netherland, Rotterdam have shown that higher potassium intake is associated with low blood pressure, which has been further confirmed by (Bazzano 2001 and Green *et al* 2002) from Honolulu. In a similar study from India Krishna *et al* (1989) found low dietary potassium may increase significant blood pressure.

Studies regarding calcium intake and blood pressure have found inverse association by Smith (1977) and Witteman (1989) as well as Iso *et al* (1991), whereas a study by (Jorde *et al* 1999) showed increased blood pressure with higher dietary calcium intake. All over the world many studies have shown a positive correlation between high dietary sodium intake and blood pressure (Kihara *et al* (1984), Vollmer *et al* (2001), Nowson and Morgan (1988) and Francesco *et al* (2006). All the above studies can very well be compared with our present work with the only difference that our residents from Gangetic plain consumed higher calorie as well as higher protein diet than the hill area counter part. Further more in Gangetic plain of Varanasi the salt concentration was also significantly higher irrespective of non-vegetarian and vegetarian diet with high calcium and chloride content. This pattern could be a reflection of labors and blue collar workers, who have more opportunity to work in open field as well as the white collar individuals, who may have to commute long distance of travel in hot humid atmosphere. The relative high dietary content of the salt may be an adaptive response by compensating loss of electrolytes in urine and sweat and to prevent them from getting dehydration and heat stroke. This observation would be further supplemented when other environmental factors as well as the other urinary excretory pattern of the electrolyte will be taken in to account.

The overall consumption of calorie was higher amongst the residents of Varanasi (2689.09 ± 300.37) than the residents of Aizawl (2316.38 ± 664.30) and there was positive linear correlation between carbohydrate intake and total calorie consumption at both of the sites (Aizawl $p=0.018$ & $r=0.721$ and Varanasi $p=0.016$ & $r=0.659$) (Figure No. 5.32). The consumption of protein was also higher in Varanasi (147.55 ± 42.65 gm) than Aizawl (127.80 ± 70.04 gm) and had positive correlation with calorie intake (Aizawl $p=0.012$ & $r=0.745$ and Varanasi $p=0.012$ & $r=0.632$) (Figure No. 5.33). However the carbohydrate intake of Varanasi residents was higher (587.98 ± 150.15 gm) than Aizawl residents (547.91 ± 272.09 gm) and had statistically highly significant positive correlation with protein intake at Varanasi ($p=<0.001$ & $r=0.251$) (Figure No. 5.34). When the different individual dietary component in relation to electrolyte was calculated, the overall consumption of sodium and potassium was much higher in Varanasi residents (Na^+ 326.47 ± 118.02 gm and K^+ 3475 ± 1141.74 gm) and when sodium and potassium intake was correlated, we found a significant positive correlation at Aizawl ($p=0.026$ & $r=0.965$) (Figure No. 5.35). Accordingly Na^+ and Cl^- were also being consumed in higher quantity by the residents of Varanasi (Na^+ 326.47 ± 118.02 gm and Cl^- 209.14 ± 100.43 gm) than Aizawl (Na^+ 183.50 ± 106.03 gm and Cl^- 120.20 ± 72.67 gm) and there was significant positive correlation between Na^+ and Cl^- intake (Aizawl $p=0.019$ & $r=0.866$ and Varanasi $p=0.041$ & $r=0.563$) (Figure No. 5.36). This dietary pattern also reflected in body mass index and calorie intake, where we found significant positive correlation at Aizawl ($p=0.043$ & $r=0.143$) (Figure No. 5.37). When the body mass index was compared with total carbohydrate intake, we found nonsignificant positive correlation amongst the residents of Aizawl and negative correlation in the residents of Varanasi (Table No. 5.34). Similar pattern was also found, when protein intake was taken in to account, where the residents of the Aizawl showed nonsignificant positive correlation with body mass index and protein intake and negative correlation in Varanasi individuals (Table No. 5.35). There was also positive correlation between dietary sodium intake and body mass index amongst Aizawl residents, while at the Gangetic plain of Varanasi negative correlation was observed (Table No. 5.36). The dietary chloride consumption of residents from Varanasi was higher (209.14 ± 100.43 gm) than Aizawl residents (120.20 ± 72.67 gm) and have statistically significant positive correlation with body mass index at Varanasi ($p=0.05$ & $r= -0.133$) (Figure No. 5.43) and similar pattern continued in dietary K^+ and Ca^{++} intake in which there have been positive correlation between Aizawl residents and negative correlation between Varanasi residents. Both of these correlations were statistically nonsignificant (Table No. 5.37 and 5.38). The higher body mass index amongst Varanasi residents is a direct reflection of relatively high intake of total calorie, protein, carbohydrate and higher salt which are added in abundance in almost all the spicy dishes as well as the snacks which are consumed quite often round the day than the residents of North East hill. This observation was made by Chinese worker (Woo *el al* (1998) as well as Japanese (Appleby *et al* 1998). In a study by Yen *et al* (2008) from Taiwan on preschool children and their parents found individuals consuming vegetarian diet have high carbohydrate intake, higher total calorie consumption as well as Ca^{++} than the non-vegetarians.

Since population living in Varanasi consume more vegetarian diet than the north hill area of Aizawl, it is quite obvious that people of Aizawl will have low calorie consumption, low carbohydrate diet, lower electrolyte component of the food (Na^+, K^+, Ca^{++} and Cl^-) than the people in the plain.

This also reflects the casual consumption of snacks in form of more carbohydrate and fat like chips, samosa, kurkure and other cheaper edible objects, which is readily available in plain than in hill area where the processing of the diet and fast food is not easy. Furthermore higher value of Ca^{+} in diet amongst the residents of Varanasi could be due to cultural tradition of consuming more dairy products in the form of sweats, lassi and milk resulting in high calcium than the Aizawl residents. Since no such study is available from Gangetic plain area it is difficult for us to compare though our results are at par with Chinese studies which have more cultural similarity with our North hill residents as both of them belongs to Mongolian race.

When the total calorie intake was compared with mean blood pressure at both of the sites no statistical significance could be established, though amongst the residents of Varanasi, mean blood pressure was higher (99.08 ± 13.86 mm Hg) than the Aizawl residents (86.13 ± 10.45 mm Hg) with nonsignificant negative correlation with dietary calorie and carbohydrate intake (Table No. 5.40 and 5.41). The protein consumption also did not show any statistically significant pattern at both of the site, but there was negative correlation between mean blood pressure and overall protein consumption (Table No. 5.42). The dietary Na^{+} intake showed a negative correlation with mean blood pressure and statistically this was not significant (Table No. 5.43). When K^{+} intake was taken in to consideration, this showed a statistically significant positive correlation with mean blood pressure amongst the residents of Varanasi (*p=0.0293 & r=0.68*), whereas at the site of Aizawl, there was negative correlation and this was statistically nonsignificant (Table No. 5.44). The Ca^{++} intake did not showed any significant correlation with mean blood pressure at both of the sites (Table No. 5.45), whereas the Cl^{-} consumption was found to have negative correlation with mean blood pressure in Aizawl and positive in Varanasi without any statistical significance (Table No. 5.46).

The correlation between mean blood pressure and extra salt consumption showed a positive correlation, in which higher salt intake of 8.99 ± 4.68 gm was associated with high mean blood pressure (99.08 ± 13.86 mm Hg) at the site of Varanasi, but these data were nonsignificant at both of the sites (Table No. 5.47).

Dietary salt and potassium consumption has always remained a point of great interest to the nutritionist and clinician in prevention of BP programme ever since from the beginning of the 20th century. Though early studies in 1912 (Medico-Actuarial Mortality Investigation) as well as in 1932 (Adolph RF and Associates 1947) considered that there could be some correlation between high body mass index, high calorie, high protein as well as salt intake with blood pressure. Addison in 1928 found role of potassium salts in lowering the blood pressure and was subsequently confirmed by several studies by Grim *et al* (1980) and Ueshima *et al* (1981), however only in 1995 in a study by Wyatt *et al* found that low dietary sodium is associated with low mean blood pressure. In a Melbourne study by Li Duo *et al* (2000) the dietary Na^+, K^+ ratio has been considered as an important factor to have an important association with high blood pressure. Another similar study by Ascherio *et al* in 2001 found significant negative correlation between K^+ intake and blood pressure and Green *et al* (2002) from Honolulu found inverse correlation of K^+ with blood pressure in older individuals. The Indian study from Krishna *et al* (1989) found that, low potassium diet increases the risk of blood pressure. Considering the dietary Ca^{++} component Witteman *et al* (1989) reaffirmed the hypothesis that there is a linear correlation between dietary Ca^{++} intake and blood pressure. A study from Japan by Iso *et al* (1991) found inverse association and Osborne *et al* (1996) observed negative association between dietary Ca^{++} and blood pressure.

None of the above studies have taken into account the geographical distribution of the site neither they have considered all the parameter like calorie dietary protein, Ca^{++}, Na^{+}, K^{+} and Cl^{-} in a single group. Therefore our study can not be compared with these cross sectional observations. However two important observations have immerged from our study, that higher dietary salt consumption have a positive correlation with mean blood pressure within the physiological range, whereas higher dietary K^{+} plays an important role in prevention of the blood pressure. Both of these electrolytes (Na^{+} and K^{+}) depends upon type food in which high K^{+} diet is associated with vegetarian diet, whereas sodium could be associated with non-vegetarian, which contain additional sodium either in the form of preservatives or added salt during the cooking process. The dietary Ca^{++} depends on dairy products, whereas chloride is usually associated with salts and other various food items. The tradition of observing various religious rituals amongst the people of Varanasi could also be contributing factor for high dietary Ca^{++} and Cl^{-} intake and may be a co-factor in overall calorie consumption making individuals prone for high blood pressure. However physiological compensation by excreting these extra salts in the urine could also be a significant determining factor and will be considered in the subsequent discussion.

The urinary excretion of various electrolytes plays the main role in adaptation of the individuals in relation to variation in blood pressure and other anthropometric measures. Sodium being important component of the food has significant concentration in serum as well as in the urine and is excreted in the urine to balance the extra dietary load. In our observation amongst the residents of the Aizawl the value of urinary and serum Na^{+} was almost equal in the male individuals (Urinary Na^{+} 132.34 ± 55.75 meq/l and Serum Na^{+} 137.98 ± 12.60 meq/l), while in the female the excretion of mean urinary Na^+ was much lower (Urinary Na^+ 129.01 ± 43.20 meq/l and Serum Na^+ 137.82 ± 15.68 meq/l) than their female counterparts in Varanasi (Urinary Na^+ 176.77 ± 68.43 meq/l and Serum Na^+ 144.32 ± 13.39 meq/l) and this value was statistically significant ($p = 0.015$ & <0.001). There was no statistical difference in the mean urinary excretion of Na^+ in either sex at both of the sites (Table No. 5.48). When the nature of job was taken into consideration the blue collar individuals at the site of Varanasi excreted more sodium in the urine (152.31 ± 65.98 meq/l), than their white collar counterparts (126.64 ± 68.89 meq/l). The lower value of serum sodium almost remains normal in both of the groups (Table No. 5.49). At the site of Aizawl individuals consuming vegetarian diet excreted more sodium in the urine (137.18 ± 39.60 meq/l), than the Varanasi residents (103.66 ± 47.91 meq/l) and this was statistically highly significant ($p=<0.001$). On contrary amongst non-vegetarians the mean urinary excretion of Na^+ was higher amongst the residents of Varanasi (156.75 ± 72.86 meq/l), than their Aizawl counterparts (129.64 ± 53.63 meq/l). Both of the values were statistically highly significant ($p=<0.001$), whereas no difference was observed in serum sodium value amongst vegetarian and non-vegetarian consumers (Table No. 5.50). When value of serum and urinary K^+ was considered, we observed overall higher excretion amongst female individuals at the site of Varanasi (Varanasi Serum 4.15 ± 0.71 meq/l and Urinary 84.72 ± 20.80 meq/l) (Aizawl Serum 3.84 ± 1.03 meq/l and Urinary 32.96 ± 15.86 meq/l), whereas male individuals in Aizawl had higher urinary excretion of potassium (Aizawl Serum 3.81 ± 0.84 meq/l and Urinary 31.74 ± 16.83 meq/l) (Varanasi Serum 4.20 ± 1.11 meq/l and Urinary 27.08 ± 14.50 meq/l). The values of serum and urinary excretion of K^+ was normal amongst both male and female individuals of Aizawl, though none of the data were statistically significant (Table No. 5.51). There was no significant difference in the serum and urinary K^+ excretion between blue and white collar individuals. However the overall values of both serum and urinary K^+ were on the higher side amongst the Varanasi residents (Table No. 5.52). Vegetarian food consumers had a tendency to excrete more K^+ in the individuals of Aizawl than their non-vegetarian counterparts. However individuals from Varanasi had a tendency to excrete more K^+ amongst non-vegetarian food consumers. There was no statistical significant difference at both sites in the value of serum potassium (Table No. 5.53). The pattern of serum and urinary Ca^{++} excretion in male and female was almost identical and no statistical difference was noted (Table No. 5.54). Nature of occupation did not affect the urinary Ca^{++} excretion profile at both of the sites. However the serum Ca^{++} value was found to be higher amongst the Aizawl residents (Blue collar 8.62 ± 1.22 meq/l and White collar 8.44 ± 1.40 meq/l) than Varanasi (Blue collar 7.84 ± 1.55 meq/l and White collar 7.94 ± 1.63 meq/l). A similar pattern was observed when serum and urinary Ca^{++} was taken in to consideration between vegetarian and non-vegetarian food consumers (Table No. 5.56). When serum and urinary chloride values were calculated no statistical difference was found at both of the sites in relation to gender, nature of job and dietary pattern (Table No. 5.57, 5.58 & 5.59).

Very few studies are available to compare our data in relation to serum and urinary excretion of electrolytes. However the Israeli vegetarian association study showed a high urinary potassium excretion amongst vegetarian food consumers (Ophir *et al* 1983). In a previous study by Armstrong *et al* (1979) the dietary sodium was not much affected by vegetarian and non-vegetarian food. In 2007 in a study by Nowson and Morgan found a significant positive correlation between dietary and urinary Na^+, K^+ ratio. In a West African study by Cappuccio (2006) the urinary Na^+ had a significant positive correlation with systolic blood pressure only.

In our observation only female individuals of Varanasi had a significant (*p=<0.001*) higher urinary sodium excretion (Varanasi 176.77 ± 68.43 meq/l and Aizawl 129.01 ± 43.20 meq/l), whereas male individuals from Aizawl were found to have higher urinary sodium excretion (Aizawl 132.34 ± 55.75 meq/l and Varanasi 119.53 ± 62.48 meq/l) (Table No. 5.48). A similar pattern was observed in non-vegetarian diet consumers from the site of Varanasi in relation to serum and urinary sodium profile (Table No. 5.50). In the Varanasi residents female have tendency to consume more pickles and spicy food than their male counterparts, which has reflected in their higher dietary sodium content (287.74 ± 110.12 gm) and higher urinary excretion value (176.77 ± 68.43 meq/l), whereas no such cultural tradition exist in Aizawl residents which reflect low serum sodium (Male 137.98 ± 12.60 meq/l and Female 137.82 ± 15.68 meq/l) as well as lower urinary sodium excretion (Male 132.34 ± 55.75 meq/l and Female 129.01 ± 43.20 meq/l). The vegetarian food consumers of Aizawl had significant (*p=<0.001*) higher excretion of Na^+ in the urine (Vegetarian 137.18 ± 39.60 meq/l and Non-vegetarian 129.64 ± 53.63 meq/l) and this reverse difference is difficult to explain. It could be a phenomenon of adaptation in the male counterpart to protect them from developing hypertension who are exposed to less hard ship and manual work than the female residents.

Since urinary Na^+ excretion is an important parameter in deciding the mean blood pressure depending upon the dietary consumption of the Na^+ as well as change in atmospheric condition, we observed a statistically significant negative correlation (*p=0.0266 & r= -0.157*) in the residents of Aizawl, whereas in the residents of the Varanasi this showed a nonsignificant linear positive correlation (Table No. 5.60). There was statistically significant positive correlation (*p=<0.001 & r=0.381*) between serum Na^+ and mean blood pressure in the residents of Varanasi (Table No. 5.61). The urinary K^+

excretion was almost identical at both sites. However there was no correlation between urinary K^+ excretion and mean blood pressure in the hill areas of the Mizoram (Table No. 5.62). The serum K^+ value was found to be statistically highly significant positive correlation (*p=<0.001 & r=0.370*), whereas this was statistically insignificant amongst Aizawl residents and has shown the tendency of negative correlation (Table No. 5.63). Urinary Ca^{++} excretion though had a linear trend amongst both the residents of Aizawl and Varanasi but, it did not show significant correlation (Table No. 5.64 and 5.65). Similar pattern was observed between blood pressure and urinary Cl^- excretion at both of the sites, whereas there was a negative correlation between serum Cl^- and mean blood pressure amongst Aizawl residents (Table No. 5.66 and 5.67).

There are many physiological considerations to decide the pattern of urinary excretion of electrolytes amongst healthy individuals based on dietary consumption and environmental factors. In the residents of the Aizawl the dietary consumption of Na^+ was significantly on the lower side amongst both vegetarian (183.39 ± 119.96 gm) and non-vegetarian (183.53 ± 102.90 gm) and this reflected in almost identical pattern of urinary Na^+ excretion (Vegetarian 137.18 ± 39.60 meq/l and Non-vegetarian 129.64 ± 53.63 meq/l), which could have been the reason of mean blood pressure of Aizawl residents on lower side (86.13±10.45 mm Hg). It's quite apparent with our observation that the Aizawl residents continue to excrete more Na^+ (Urinary 131.07 ± 51.25 meq/l) in spite of low dietary intake (183.50 ± 106.03 gm) and thereby remain protected from the rise of blood pressure. It's quite possible that the individuals living in the plain area compensate the urinary excretion by loosing more salt in urine as well as in sweat. Thus Aizawl residents are better adapted for their urinary excretion in spite of low dietary Na^+ intake, which is manifested in the form of a negative correlation (*p=0.0266 & r= -0.157*) (Figure No. 5.73). On contrary individuals from Varanasi have a positive correlation, excrete less Na^+ (Urinary 134.98 ± 68.85 meq/l) than their dietary intake (326.47 ±118.02 gm) and therefore have higher mean high blood pressure (99.08 ± 13.86 mm Hg) than their Aizawl counterparts (86.03 ± 10.45 mm Hg) (Table No. 5.60).

High dietary K^+ content have been found to be protective in blood pressure by many workers (Melby *et at* (1989), Li Duo *et al* (2000) and Ophir *et al* (1983) and this was observed, ever since studies by Addition (1928), Ascherio *et al* (1998) and Green *et al* (2002). There is only one such study by Krishna *et al* (1989), where as Kaplan and Rose (2009) demonstrated s positive correlation between dietary K^+ intake and urinary Na^+ excretion. Thus our finding can well be comparable with many international studies, though there are no comparative data of the individuals at different altitude and socio cultural backgrounds. As the mean blood pressure was always on lower side in Aizawl residents, we observed a negative linear correlation and similar trend was also seen in serum Ca^{++} and serum Cl^- value. Majority of the individuals at Aizawl were non-vegetarian and therefore had higher serum Ca^{++} than Cl^- value which physiologically would have reflected in higher urinary excretion than the individuals from Varanasi. This could be an adaptive phenomenon in regulation of hypertension and therefore protects many tribal communities from developing hypertension whose life style is close to nature. In Gangetic plain this natural protection privilege is lost and hence forth residents of Varanasi are at disadvantage of consuming more dietary salt inform of Sodium chloride as well as calcium and potassium and could be victim of developing high blood pressure.

Salt and electrolyte homeostasis has been a major concern towards adaptation in human being in maintaining blood pressure within the physiological limit and has been also important observation in the present study. In our observation Aizawl residents had low blood pressure during summer (84.52 ± 8.55 mm Hg) and winter (92.72 ± 14.43 mm Hg), whereas Varanasi residents had relatively higher blood pressure in summer (99.28 ± 13.98 mm Hg) than winter (94.75 ± 10.50 mm Hg). The ambient temperature and calorie intake have shown a linear correlation with no statistical significance (Table No. 5.69). There was nonsignificant negative correlation (*r= -0.106*) amongst the residents of Varanasi between ambient temperature and carbohydrate intake, where as in the residents of Aizawl this had a statistically significant positive correlation (*p=0.0266 & r=0.157*) (Table No. 5.70). The protein intake was identical at both of the site in relation to temperature variation (Table No. 5.71). However the urinary Na^+ excretion was on higher side amongst Varanasi residents than the Aizawl and there was non significant positive correlation (Table No. 5.72). The serum Na^+ pattern in relation to ambient temperature have shown a statistically significant positive correlation (*p=0.003 & r=0.207*) amongst the Aizawl residents than Varanasi, whereas no significant correlation could be established between urinary K^+ excretion at both of the sites, though in Varanasi residents the overall urinary K^+ excretion was significantly high (Table No. 5.73 and 5.74). We observed statistically significant negative correlation (*p=0.041 & r= -0.144*) between serum K^+ and ambient temperature amongst Aizawl residents while in Varanasi there was non significant positive correlation (Table No. 5.75). There was no statistical difference in urinary Ca^{++} and ambient temperature at both sites, whereas serum Ca^{++} was found to have negative correlation at both of the sites with ambient temperature variation (Table No. 5.76 and 5.77). The value of urinary Cl^- excretion showed a statistically significant positive correlation (*p=0.0186 & r=0.166*) pattern with ambient temperature amongst Varanasi residents but this was statistically nonsignificant in Aizawl residents (Table No. 5.78) However there was negative correlation between ambient temperature and serum Cl^- value at the site of Varanasi and positive at Aizawl but both of them were nonsignificant (Table No. 5.79)

In the Western countries there are studies to support that there has been seasonal influences over blood pressure and body mass index. In a study by Rose (1961) from UK the seasonal influence has been described on blood pressure. The Heller *et al* (1978) had found inverse correlation between diastolic blood pressure and room temperature. Brennan *et al* in 1982 observed that urinary Na^+ excretion has been higher during winter than the summer and a joint study from US, Great Britain and Australia among school children has found a significant correlation (Jenner et al (1987) and De Swiet *et al* (1984). A study by Kristal-Boneh *et al* (1996) found inverse association between blood pressure and body mass index, where as Argilés *et al* (1998) from Germany have shown highest mean blood pressure during winter and lowest during summer. In 2006 Modesti *et al* established an inverse correlation between air temperature and systolic blood pressure. In a study from 3 French cities blood pressure was significantly low during spring and summer by Alpérovitch *et al* (2009), while study from Bostan demonstrated inverse correlation between temperature and blood pressure Halonen *et al* (2010).

Our observation has been consistent between the residents of the Aizawl and all other Western studies where mean blood pressure has been found high during winter though it was statistical non significant , where as in Varanasi residents a reverse pattern was observed. This difference could be because most of the Western studies are from US, UK and Europe and has been based upon higher altitude while none of the study are from the plain tropical sites where there is extremes of the temperature variation and significant difference in the life style of the dietary pattern of the individuals. However our study supports the observation that residents of Aizawl are better adapted for their ambient variation in temperature since they had narrow range of temperature variation (22.73 ± 2.45 ^{0}C) than the Varanasi

(35.75 ± 6.40 ^{0}C). There is only one study by Kristal-Boneh *et al* (1996), where body mass index has been found to vary with seasonal variation. However in our case, we did not find any such change and this could be explain by further better adaptability by the Aizawl residents during winter season (BMI Aizawl 22.71 ± 3.55 and Varanasi 22.16 ± 3.45). There is further possibility that better natural physical exercise during winter season by the Aizawl residents keep them well compensated and equal to the residents of the plain against the conservation of the body heat which was not required during summer season. During hot summer there is increased sweating as well as loss of fluid and electrolyte from the urine and this is more pronounced amongst the residents of Varanasi, whose body mass index is on higher side more (23.97 ± 3.69) and have higher body surface area. In Varanasi most of the residents wear light clothing, drink more water and consume more salt to protect themselves from heat stroke.

In 1910 famous physiologist Harvey demonstrated that when an individual is exposed to high Altitude of 18000 feet above sea level they compensate by diuresis of an alkaline urine. In 1929 Norn also demonstrated that during morning time there is increased excretion of Na^+, K^+ and Cl^- in urine. Same observation was supported Devis *et al* (1920-21). In simulated experiment by Marrie *et al* (1944) from Chicago on a fixed diet of 2750 calorie containing 3.29 gm Na^+, 3.27 K^+ and 4.93 Cl^- found, that there has been temporary rise in excretion of all the three electrolytes, whereas Hennon *et al* (1970) from USA observed that both serum Na^+ and K^+ are decreased at high altitude whereas Ca^{++} and Cl^- value remain high. The Japanese worker have also demonstrated of significant low serum Ca^{++} and high serum K^+ at high altitude. A similar study Galster Morrison (1973) observed high urinary Na^+ and K^+ excretion at high altitude. There has been only one study from Saudi Arabia in which individuals from plain have been studied and have shown, that higher blood pressure and body mass index in high lenders than low lenders (Khalid *et al* 1994). A comparative study by Zaccaria *et al* (1998) on human acclimatization found that urinary Na^+ excretion increases at high altitude, whereas study from turkey Arslan *et al* (2003) found positive correlation between body mass index and blood pressure at high altitude. There has been only one Indian study by Amitabh *et al* (2009) in which low body mass index has been found at high altitude with high systolic blood pressure and diastolic blood pressure, than the residents of the plain area. These observations could well be correlated with all the parameters amongst the residents of Aizawl where high urinary Na^+ excretion has remained a major adaptive factor in regulation of the blood pressure during summer in which it was low (84.52 ± 8.55mm Hg), where as during winter it was found to be identical with the residents of Varanasi due to low excretion of Na^+ in the urine. Other electrolytes like K^+, Ca^{++} and Cl^- were statistically insignificant and did nor affect our targeted population at both of the site because these individuals are well adapted to seasonal variation.

The North-east area has been blessed by the nature with an unique climatic privilege of high humidity round the year than the residents of the Gangetic plain of the Varanasi and has been the major cause of change in food habits as well as the physiological adaptations. Accordingly there has been no significant variation in the calorie intake amongst the Aizawl residents where as at the site of Varanasi there was negative correlation between calorie intake and relative humidity and this was statistically significant (*p=0.001 & r= -0.222*) (Table No. 5.80). At both of the sites, we observed negative correlation between carbohydrate intake, protein intake with humidity, whereas amongst Varanasi residents, there was statistically highly significant (*p=<0.001*) positive correlation (*r=0.253*) between relative humidity and urinary Na^+ excretion (Table No. 5.81, 5.82 and 5.83). Serum sodium was found to have statistically significant positive correlation with relative humidity at both sites of Aizawl (*p=<0.001 & r=0.271*) and Varanasi (*p=0.004 & r=0.202*) (Table No. 5.84). On contrary at both of the sites, there was a positive correlation between serum K^+ and relative humidity and this was found to be statistically highly significant (Varanasi *p=<0.001 &* (*r=0.231*) amongst the residents of Varanasi (Table No. 5.86). The urinary K^+ excretion showed a negative correlation at the site of Varanasi and positive at Aizawl, though both were statistically not significant (Table No. 5.85). No difference was observed in urinary Ca^{++} excretion at both of site, when relative humidity was taken in to account, however there was statistically insignificant negative correlation at the site of Varanasi (Table No. 5.87). We observed negative linear correlation between serum Ca^{++} and relative humidity at both of the sites (Table No. 5.88). There has been consistent negative linear correlation in serum and urinary Cl^- excretion amongst the residents of Varanasi though statistically none of them were significant (Table No. 5.89 and 5.90).

Humidity has not been considered by many workers as an important variable in relation to various factors of adaptation by the environmental scientist. However with the human physiological point of view this plays an important role in deciding the excretion of various electrolytes in the urine and sweat. Tropical zone where humidity has been consistently high round the year creates an environment where there is increased loss of solvent through sweat, which reflects in decreased urinary electrolytes excretion. This also affects the total body water and their by could predispose to the individuals towards high blood pressure. None of the study from western countries have considered this point however most of the study from North-East hill area from Meghalay and Mizorum has found significant positive correlation between age and systolic blood pressure. These workers have not differentiated the serum and urinary pattern, however the consistent high humidity in this area could have reflected in moderate Na^+ excretion as a result of low serum Na^+ value (137.92 ± 13.82meq/l), low dietary intake of Na^+ (183.50 ± 106.03gm) and have resulted in better adaptation of mean blood pressure in high humid environment than the residents of Varanasi. In western countries the humidity tends to be higher during winter season and in a study from UK by Medical Research Council Middlesex have shown higher systolic blood pressure and diastolic blood pressure and have also shown higher urinary Na^+ excretion which was greater in older subjects than the younger one (Brennan *et al* 1982). Further the German study by Argilés *et al* (1998) has further supported highest mean systolic blood pressure and diastolic blood pressure during winter, where humidity is higher than the dry summer. Our observation has been consistent with the above parameter and the Aizawl residents showed almost identical urinary Na^+ excretion value (131.07 ± 51.25meq/l) with Varanasi residents (134.98 ± 68.85meq/l), which was statistically highly significant (p=<0.001) and the serum Na^+ was statistically highly significant (p=<0.001) amongst Aizawl residents with a positive correlation ($r=0.271$). These two parameters are robust evidence to support our finding that Aizawl residents are able to maintain normal blood pressure in spite of high humidity, high altitude as well as higher urinary Na^+ excretion in relation to dietary sodium intake.

It appears that none of the other electrolytes i.e. Ca^{++} and K^+ play significant role in relation to altitude and humidity and the major adaptive changes with environmental variation depends upon salt content of the food, capacity to handle sodium excretion by the kidney and body mass index, which is decided by genetic as well as socio-cultural variation of occupation and the food habits. These observations are more pertinent while planning industrialization of the urban area and also to prevent the migration of skilled and unskilled individuals from rural to urban side especially amongst the hilly tribal residents whose migration to the plain area may affect their life style and health and also could affect their work capacity. All these parameters are also of the importance in formulation of the national health policy of the residents of Aizawl who may have propenicity to migrate in the plain area for better job opportunity and could also be at risk to their health and therefore they need protection as well as extra health care considering their environmental factor at the native place.

Chapter-7

Summary and Conclusion

SUMMARY

The variation in environmental factors such as ambient temperature, relative humidity and rain fall had an important role in serum and urinary electrolyte excretion pattern of human being. Based on the above aims & objectives present study has been conducted and the scientific data has been presented in seven chapters.

This chapter deals with observation and results in which epidemiological, anthropometric, meteorological, dietary and laboratory data were recorded. The seasonal variation, dietary intake and its correlation with body mass index, mean blood pressure and electrolyte excretion has been tabulated and graphically represented. Based on the observation over 400 subjects at two different geographical site and environmental conditions, the results obtained are as follows:

- Majority of the individuals in both group were between 20 to 40 year (71%) from Aizawl and (45%) above 40 year age group in Varanasi.
- Gender distribution in respect to male and female ratio was higher in Varanasi (2.70) than Aizawl (1.63).
- There were more white collar individuals in Aizawl than Varanasi (Aizawl 83% and Varanasi 67%).

- There were more non-vegetarian consumers in Aizawl than in Varanasi (Aizawl 81% and Varanasi 59%)
- Amongst all the three age group at Aizawl and Varanasi the subjects above 40 years had significantly higher body mass index (Aizawl 23.47 ± 4.92 and Varanasi 24.63 ± 3.56).
- Female individuals of Aizawl had significantly higher body mass index (BMI) than male (male 21.33 ± 2.99 and female 22.31 ± 5.16), whereas at Varanasi no significant difference was noticed. However overall it was higher amongst the residents of Varanasi.
- Body mass index amongst white collar subjects was significantly (*p=<0.001*) higher at both of the sites (Aizawl 21.89 ± 4.09 and Varanasi 24.33 ± 3.75) than blue collar subjects (Aizawl 20.75 ± 3.21 and Varanasi 23.22 ± 3.49).
- Vegetarian diet consumers of Varanasi had significantly (*p=<0.001*) higher body mass index than non-vegetarian (Vegetarian 24.15 ± 3.43 and Non-vegetarian 23.84 ± 3.88), whereas at Aizawl no significant difference was noticed.
- Statistically significant linear positive correlation was observed between body mass index and the mean age at both of the sites (Varanasi *p=<0.001 & r=0.254*) and (Aizawl *p=0.004 & 0.202*).
- An increasing trend of mean blood pressure was noted in respect to growing age at both of the sites. However the Varanasi individuals had significantly (*p=<0.001*) higher mean blood pressure in all three age; below 20, 20-40 and above 40 years (91.99 ± 9.38 mm Hg, 95.63 ± 13.16 mm Hg and 104.32 ± 13.79 mm Hg) than the subjects from Aizawl (83.81 ± 7.88 mm Hg, 84.70 ± 8.44 mm Hg and 95.34 ± 15.86 mm Hg).

- Male subjects of both Aizawl and Varanasi had significantly (*p=<0.001*) higher mean blood pressure than female (Aizawl male 86.64 ± 9.78 mm Hg and female 85.29 ± 11.48 mm Hg) and (Varanasi male 99.14 ± 14.11 mm Hg and female 98.91 ± 13.28 mm Hg)
- In Aizawl blue collar subject had higher mean blood pressure (Blue 91.78 ± 8.87 mm Hg and white 85.01 ± 10.40 mm Hg), whereas at Varanasi white collar had shown higher value (Blue 95.18 ± 12.69 mm Hg and White 100.95 ± 14.05 mm Hg)
- Non-vegetarian diet consumer of Varanasi had significantly (*p=<0.001*) higher mean blood pressure than vegetarian (Non-vegetarian 100.57 ± 13.84 mm Hg and Vegetarian 96.93 ± 13.69 mm Hg). No significant difference was noted in subjects from Aizawl.
- The mean blood pressure showed significant positive correlation with the growing age at both site (Aizawl *p=<0.001 & r=0.381*) and (Varanasi *p=<0.001 & r=0.369*).
- Body mass index and mean blood pressure had significant positive correlation at both of the sites (Aizawl *p=<0.001 & r=1.00*) and (Varanasi *p=<0.001 & r=0.942*).
- Non-vegetarian diet consumer of both sites consumed significantly (*p=<0.001*) more dietary calorie intake than vegetarian (Aizawl Vegetarian 2262.98 ± 717.80 & Non-vegetarian 2328.91 ± 652.84) and (Varanasi Vegetarian 2643.07 ± 357.55 & Non-vegetarian 2721.06 ± 249.86).
- Among all three age groups the calorie intake was nonsignificantly higher in younger group of below 20 years (Aizawl 2592.74 ± 599.24 and Varanasi 2705.47 ± 279.01) and significantly (*p=<0.001*) lower in middle age group of 20-40 years at both sites (Aizawl 2246.05 ± 670.23 and Varanasi 2681.67 ± 344.61).

- In Aizawl female had significantly ($p=<0.001$) higher calorie intake (Male 1980.02 ± 627.36 and Female 2730.87 ± 276.10), where as at Varanasi male consumed more calorie (Male 2865.18 ± 182.14 and Female 2576.10 ± 335.24)
- White collar subjects had significantly ($p=<0.001$) higher calorie intake at Aizawl (Blue 2211.38 ± 709.97 and White 2738.50 ± 195.16), whereas in Varanasi blue collar consumed more calorie (Blue 2337.13 ± 655.15 and White 2665.29 ± 337.70)
- Vegetarian diet consumer of Aizawl had nonsignificantly higher carbohydrate intake (Vegetarian 570.13 ± 297.56 gm and Non-vegetarian 542.69 ± 266.48 gm), whereas at Varanasi non-vegetarian consumed significantly ($p=<0.001$) higher carbohydrate diet (Vegetarian 558.70 ± 142.62 gm and Non-vegetarian 608.33 ± 152.46 gm).
- In Aizawl vegetarian diet consumers had higher protein consumption (Vegetarian 130.41 ± 78.98 gm and Non-vegetarian 127.19 ± 68.03 gm), whereas in Varanasi non-vegetarian had significantly ($p=<0.001$) higher protein consumption (Vegetarian 134.50 ± 38.78 gm and Non-vegetarian 156.62 ± 43.03 gm).
- The female subjects of Aizawl consumed significantly ($p=<0.001$) higher quantity of carbohydrate diet than male (Male 406.45 ± 165.71 gm and Female 778.70 ± 253.65 gm), whereas in Varanasi male had higher carbohydrate intake (Male 610.74 ± 151.21 gm and Female 526.44 ± 129.64 gm).
- The dietary sodium intake of non-vegetarian consumer from Gangetic plain was significantly ($p=<0.001$) higher than their vegetarian counterparts (Vegetarian 306.36 ± 114.71 gm and Non-vegetarian 340.45 ± 118.74 gm) and in Aizawl no significant difference was noted.

- Vegetarian diet consumers had significantly (*p=0.021*) higher dietary potassium intake at Aizawl (Vegetarian 2634.13 ± 1851.11 gm and Non-vegetarian 2579.14 ± 1561.30 gm), whereas in Varanasi non-vegetarian had significantly (*p=<0.001*) higher dietary potassium consumption (Vegetarian 3269.20 ± 1099.80 gm and Non-vegetarian 3618.34 ± 1153 gm).

- Dietary consumption ratio of sodium and potassium was significantly higher in Varanasi (Vegetarian 0.095 ± 0.02 and Non-vegetarian 0.096 ± 0.02) than Aizawl (Vegetarian 0.08 ± 0.03 and Non-vegetarian 0.083 ± 0.05). However no significant difference was noted amongst vegetarian and non-vegetarian.

- Dietary calcium consumption of non-vegetarian consumer was significantly (*p=<0.001*) high at both sites (Aizawl Vegetarian 404.84 ± 199.99 gm and Non-vegetarian 406.21 ± 234.11 gm) and (Varanasi Vegetarian 1111.59 ± 606.91 gm and Non-vegetarian 1240.57 ± 634.72 gm).

- Non-vegetarians consumer had significantly (*p=<0.001*) higher dietary chloride intake (Aizawl 120.48 ± 69.51 gm and Varanasi 212.64 ± 99.15 gm) than vegetarian at both sites (Aizawl 119.03 ± 85.87 gm and Varanasi 204.09 ± 102.64 gm).

- The consumption of extra salt with diet was significantly (*p=<0.001*) higher in non-vegetarian (Aizawl 6.48 ± 3.20 gm and Varanasi 9.20 ± 4.78 gm) than vegetarian at both sites (Aizawl 5.66 ± 2.37 gm and Varanasi 8.67 ± 4.55 gm).

- Total calorie consumption had a statistically significant positive correlation with carbohydrate intake at both sites (Aizawl *p=0.018 & r=0.721* and Varanasi *p=0.016 & r=0.659*).

- Total calorie intake had a statistically significant positive correlation with protein intake at both sites (Aizawl *p=0.012 & r=0.745* and Varanasi *p=0.012 & r=0.632*).
- Carbohydrate intake and protein intake had a statistically highly significant positive correlation was observed at Varanasi (*p=<0.001 & r=0.251*), whereas in Aizawl insignificant positive correlation could be established.
- Dietary sodium and potassium showed a statistically highly significant positive correlation in Aizawl (*p=0.026 & r=0.965*), whereas in Varanasi nonsignificant positive correlation could be established.
- Dietary sodium intake showed a statistically significant positive correlation with chloride intake in both sites (Aizawl *p=0.019 & r=0.866*) and (Varanasi *p=0.041 & r=0.563*).
- Body mass index and calorie consumption had a statistically significant positive correlation at Aizawl (*p=0.043 & r=0.143*), whereas in Varanasi insignificant negative correlation was noticed.
- Body mass index and carbohydrate consumption had a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.34).
- Body mass index and protein intake showed a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.35).
- Dietary sodium intake and body mass index had a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.36).

- Body mass index and potassium intake showed a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.37).
- Body mass index and dietary calcium intake showed a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.38).
- Body mass index and dietary chloride intake showed a statistically significant negative correlation at Varanasi ($p=0.05$ & $r= -0.133$), whereas at Aizawl insignificant positive correlation was noticed.
- Mean blood pressure showed nonsignificant negative correlation with total calorie consumption at both sites (Table No. 5.40).
- Nonsignificant negative correlation was observed between mean blood pressure and dietary carbohydrate consumption at both sites (Table No. 5.41).
- Mean blood pressure and protein intake had a nonsignificant negative correlation at both sites (Table No. 5.42).
- Mean blood pressure showed nonsignificant negative correlation with dietary sodium intake at both sites (Table No. 5.43).
- Dietary potassium intake and mean blood pressure showed a statistically significant positive correlation at Varanasi ($p=0.0293$ & $r=0.680$), whereas in Aizawl residents nonsignificant negative correlation could be established (Table No. 5.44).
- Mean blood pressure and dietary calcium intake had a statistically nonsignificant negative correlation at both sites (Table No. 5.45).
- Mean blood pressure and dietary chloride intake had a nonsignificant negative correlation at Aizawl and positive correlation at Varanasi (Table No. 5.46).

- Dietary extra salt consumption and mean blood pressure had a nonsignificant positive correlation at both sites (Table No. 5.47).
- Male subjects had higher value of urinary sodium excretion at Aizawl (male 132.34 ± 55.75 meq/l and female 129.01 ± 43.20 meq/l), whereas in Varanasi reverse pattern was observed (male 119.53 ± 62.48 meq/l and female 176.77 ± 68.43 meq/l).
- No significant difference was observed in the value of serum sodium in male and female at both sites (Table No. 5.48).
- White collar individuals of Aizawl had higher urinary sodium excretion (blue 123.95 ± 34.24 meq/l and white 132.48 ± 53.96 meq/l), whereas in Varanasi blue collar had significantly ($p=0.023$) higher urinary sodium excretion (blue 152.31 ± 65.98 meq/l and white 126.64 ± 68.89 meq/l).
- White collar subjects from both Aizawl and Varanasi had higher serum sodium (Aizawl 138.50 ± 7.70 meq/l and Varanasi 143.90 ± 25.02 meq/l) than the blue collar counterpart (Aizawl 134.94 ± 29.48 meq/l and Varanasi 142.92 ± 28.85 meq/l).
- Vegetarian consumers had significantly ($p=<0.001$) higher urinary sodium excretion at Aizawl (Vegetarian 137.09 ± 14.78 meq/l and Non-vegetarian 129.64 ± 53.63 meq/l), whereas in Varanasi non-vegetarian had excreted significantly ($p=<0.001$) higher urinary sodium (Vegetarian 103.66 ± 47.91 meq/l and Non-vegetarian 156.75 ± 72.86 meq/l).
- Urinary potassium excretion was higher in female (Aizawl 32.96 ± 15.86 meq/l and Varanasi 34.72 ± 20.80 meq/l) than their male counter part male counterpart (Aizawl 31.74 ± 16.83 meq/l and Varanasi 27.08 ± 14.50 meq/l) at both Aizawl and Varanasi.

- Female individuals at Aizawl had higher value of serum potassium (Male 3.81 ± 0.84 meq/l and Female 3.84 ± 1.03 meq/l), whereas in Varanasi male had higher value of serum potassium (Male 4.20 ± 1.11 meq/l and Female 4.15 ± 0.71 meq/l).
- Blue collar individuals from both sites had higher urinary potassium excretion (Aizawl 34.03 ± 16.69 meq/l and Varanasi 46.28 ± 33.46 meq/l) than their white collar counterpart (Aizawl 31.84 ± 16.42 meq/l and Varanasi 40.89 ± 28.84 meq/l).
- Value of serum potassium was higher in white collar individuals at both of sites in Aizawl and Varanasi (Aizawl 3.88 ± 0.90 meq/l and Varanasi 4.21 ± 1.00 meq/l) than blue collar (Aizawl 3.55 ± 0.93 meq/l and Varanasi 4.14 ± 1.05 meq/l).
- Vegetarian diet consumer of Aizawl had higher value urinary potassium excretion (Vegetarian 39.07 ± 14.44 meq/l and Non-vegetarian 30.59 ± 16.50 meq/l), whereas in Varanasi non-vegetarian excreted higher urinary potassium (Vegetarian 33.89 ± 20.96 meq/l and Non-vegetarian 48.73 ± 14.36 meq/l).
- The non-vegetarian of both Aizawl and Varanasi had higher value of serum potassium (Aizawl 3.88 ± 0.95 meq/l and Varanasi 4.32 ± 0.9 meq/l) than vegetarian (Aizawl 3.57 ± 0.69 meq/l and Varanasi 4.00 ± 1.03 meq/l).
- There was no significant difference in urinary calcium amongst male and female at both sites (Table No. 5.54).
- Female individuals had higher value of serum calcium at Aizawl (male 8.42 ± 1.26 meq/l and female 8.55 ± 1.53 meq/l), whereas in Varanasi male had higher value (male 7.93 ± 1.58 meq/l and female 7.85 ± 1.64 meq/l).

- Blue collar individuals had higher urinary calcium excretion (Aizawl 2.79 ± 0.91 meq/l and Varanasi 3.00 ± 0.83 meq/l) than white collar at both sites (Aizawl 2.48 ± 0.86 meq/l and Varanasi 2.94 ± 0.85 meq/l).
- Blue collar subjects had higher value of serum calcium at Aizawl (Blue 8.62 ± 1.22 meq/l and White 8.44 ± 1.40 meq/l), whereas in Varanasi white collar had higher serum calcium (Blue 7.84 ± 1.55 meq/l and White 7.94 ± 1.63 meq/l).
- Vegetarian diet consumer had higher urinary calcium excretion at Aizawl (Vegetarian 2.67 ± 0.84 meq/l and Non-vegetarian 2.50 ± 0.88 meq/l), whereas in Varanasi non-vegetarian had higher urinary calcium excretion (Vegetarian 2.82 ± 0.82 meq/l and Non-vegetarian 3.06 ± 0.85 meq/l).
- No significant difference was observed in the value of serum calcium amongst vegetarian and non-vegetarian diet consumer at both sites (Table No. 5.56).
- Female subjects had higher urinary chloride excretion (Aizawl 84.54 ± 33.76 meq/l and Varanasi 71.87 ± 33.19 meq/l) than their male counterpart at both of the sites (Aizawl 78.65 ± 32.93 meq/l and Varanasi 70.32 ± 31.41 meq/l).
- The value of serum chloride was higher in female individuals (Aizawl 87.86 ± 13.49 meq/l and Varanasi 100.14 ± 16.92 meq/l) than male at both of the sites (Aizawl 77.35 ± 20.14 meq/l and Varanasi 99.73 ± 16.36 meq/l).
- White collar subjects had higher urinary chloride excretion (Aizawl 82.83 ± 34.90 meq/l and Varanasi 73.29 ± 32.07 meq/l) than blue collar at both of the sites (Aizawl 71.06 ± 21.26 meq/l and Varanasi 65.45 ± 30.88 meq/l).

- Blue collar individuals had lower value of serum chloride (Aizawl 74.55 ± 19.69 meq/l and Varanasi 97.99 ± 15.38 meq/l) than white collar at both of the sites (Aizawl 82.68 ± 18.12 meq/l and Varanasi 100.73 ± 16.96 meq/l).
- Vegetarian diet consumer had higher urinary chloride excretion (Aizawl 84.05 ± 27.34 meq/l and Varanasi 75.68 ± 33.31 meq/l) than non-vegetarian at both places (Aizawl 80.15 ± 34.56 meq/l and Varanasi 67.31 ± 30.41 meq/l)
- Vegetarian diet consumer had higher value of serum chloride at Varanasi (Vegetarian 100.18 ± 17.75 meq/l and Non-vegetarian 99.61 ± 15.60meq/l), whereas at Aizawl no significant difference was observed (Table No. 5.59).
- Mean blood pressure was found to have a statistically significant negative correlation with urinary sodium excretion at the site of Aizawl ($p= 0.0266$, $r= -0.157$), whereas at Varanasi nonsignificant positive correlation could be established.
- Mean blood pressure had a statistically highly significant positive correlation with serum sodium at Varanasi ($p=<0.001$ & $r=0.381$), whereas at Aizawl nonsignificant negative correlation could be established.
- Individuals of Aizawl showed a nonsignificant negative correlation between urinary potassium excretion and mean blood pressure, whereas at Varanasi a nonsignificant positive correlation could be established (Table No. 5.62).
- The individuals from Gangetic Varanasi had a statistically highly significant positive correlation between mean blood pressure and serum potassium ($p=<0.001$ & $r=0.370$), whereas at Aizawl nonsignificant negative correlation was observed.

- Nonsignificant positive correlation could be established between urinary calcium excretion and mean blood pressure at both sites (Table No. 5.64).
- Serum calcium had a nonsignificant negative correlation with mean blood pressure at the site of Aizawl, whereas at Varanasi nonsignificant positive correlation could be established (Table No. 5.65).
- Mean blood pressure and urinary chloride excretion had a nonsignificant positive correlation at both of the sites (Table No. 5.66).
- Mean blood pressure and the value of serum chloride had a nonsignificant negative correlation at Aizawl and positive correlation at Varanasi (Table No. 5.67).
- Individuals of Aizawl had higher mean blood pressure in winter than summer (Winter 92.72 ± 14.43 mm Hg and Summer 84.52 ± 8.55 mm Hg), whereas in Varanasi reverse pattern was observed (Winter 94.74 ± 10.50 mm Hg and Summer 99.28 ± 13.98 mm Hg).
- Ambient temperature was found to have a nonsignificant positive correlation with calorie consumption at both sites (Table No. 5.69).
- Individuals of Aizawl had a statistically significant positive correlation between ambient temperature and dietary carbohydrate intake (Aizawl $p=0.0266$ & $r=0.157$), whereas at Varanasi nonsignificant negative correlation was observed.
- Protein consumption was found to have a nonsignificant positive correlation with ambient temperature at both sites (Table No. 5.71).
- Individuals of both sites showed a nonsignificant positive correlation between ambient temperature and urinary sodium excretion (Table No. 5.72).

- Individuals of Aizawl showed a statistically significant positive correlation between the value of serum sodium and ambient temperature (*p=0.003 & r=0.207*), whereas at Varanasi nonsignificant positive correlation could be established.
- Ambient temperature was found to have nonsignificant positive correlation with urinary potassium excretion at both sites (Table No. 5.74).
- Individuals of Aizawl showed a statistically significant negative correlation between ambient temperature and serum potassium (*p=0.0418 & r = -0.144*), whereas at Varanasi nonsignificant positive correlation was observed.
- Urinary calcium excretion and ambient temperature had a nonsignificant positive correlation at both Aizawl and Varanasi (Table No. 5.76).
- Ambient temperature was found to have a nonsignificant negative correlation with the value of serum calcium at both sites (Table No. 5.77).
- Individuals of Varanasi showed a statistically significant positive correlation between ambient temperature and urinary chloride excretion (*p=0.0186 & r=0.166*), whereas nonsignificant positive correlation was found at Aizawl.
- Serum chloride and ambient temperature was found to have a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.79).
- Dietary calorie consumption of individuals from Varanasi showed a statistically highly significant negative correlation with atmospheric humidity (*p=0.001 & r= -0.222*), whereas at Aizawl nonsignificant positive correlation was observed.

- Relative humidity had a nonsignificant negative correlation with carbohydrate intake at both sites (Table No. 5.81).
- Dietary protein consumption had a nonsignificant negative correlation with relative humidity at both sites (Table No. 5.82).
- Individuals of Varanasi showed a statistically highly significant positive correlation between relative humidity and urinary sodium excretion (Varanasi $p= <0.001$ & $r=0.253$), whereas at Aizawl it was nonsignificant.
- Relative humidity and serum sodium was found to have a statistically significant positive correlation at both sites (Aizawl $p=<0.001$ & $r=0.271$ and Varanasi $p=0.004$ & $r=0.202$).
- Relative humidity and urinary potassium excretion was found to have a nonsignificant positive correlation at Aizawl and negative correlation at Varanasi (Table No. 5.85).
- There had been statistically significant positive correlation between relative humidity and serum potassium at Varanasi ($p=<0.001$ & $r=0.231$), whereas nonsignificant positive correlation was observed.
- Relative humidity and urinary calcium excretion was found to have a nonsignificant positive correlation at Aizawl and negative at Varanasi (Table No.87).
- Serum calcium and relative humidity had a nonsignificant negative correlation at both of the sites (Table No.5.88).
- Serum chloride and Urinary chloride excretion had a nonsignificant positive correlation with relative humidity at Aizawl and negative correlation at Varanasi (Table No.5.89 & 5.90).

CONCLUSION

Survival of existence of the living being has been a constant challenge and those living creature, who could adapt themselves to changing environment continued to survive as well as thrived upon the nature in order to procreate their progeny which at present resulted in many flora and fauna. Billion years before what a life primordia has learnt from the nature to survive as unicellular creature in a high salt content sea, has retained the memory of keeping its metabolic milieu to maintain an iso-osmotic gradient and further the higher animal species, vertebrates and nonvertibrates animal continued to adapt the same biological quality in their respective tissues. The present human race, which immersed somewhere about 170 – 100,000 years ago adopted itself in different environmental conditions and migrated in the different part of the globe for their survival, which resulted into different food habits, social culture as well as life pattern. Apart from clothing and shelter, food and electrolyte played the leading role in human adaptation against the extremes of environmental changes in the temperate and tropical zone as well as an optimum physiological adaptation is also important to fight against natural calamity and diseases.

The present work has been conceived in order to understand the difference of various electrolyte excretion pattern in relation to seasonal variation as well as difference in food habits of two biological diversified area in the Northern India between the North-East hill area of Mizoram and Gangetic plain of the Varanasi. Traditionally North-east hill residents have been a nonvegetarian consumer having least communication with rest of the developing world and thereby unaffected with the complexity of the processed and fast food. This privilege has protected them against many diseases, which are related to high salt consumption and carbohydrate intake.

The ethnic background of the individuals of North east area has lower body mass index, which was very well adapted to excrete more amount of sodium in their urine even with the low consumption of the salt and this could protect them from high blood pressure. As the female traditionally work more in the hill area and are important earning member in the North east society, had higher body mass index and also had significantly higher mean blood pressure than the male individuals. These female individuals at Aizawl had significantly higher calorie intake and was related to their nature of job. The reason for having higher mean blood pressure amongst the female individuals of Aizawl is a reflection of poor urinary sodium excretion in spite high serum sodium value as well as dietary intake. This quality amongst the female was because of estrogen hormone, which have tendency to retain salt and water in the body specially during humid and cold environment on contrary amongst Varanasi individuals dry heat with less humidity predisposes them to have more salt excretion and more so in the laborers and blue collar workers who work in the Gangetic plain and in the industries. The total calorie consumption has also played significant role in deciding the body mass index and the individuals at the Gangetic plain who had a higher body mass index, have higher calorie consumption as well as high salt intake with more carbohydrate diet and those, who had a poor excretion of sodium in the urine resulted into high mean blood pressure.

The Blue collar individuals in the Gangetic plain of Varanasi consumed high calorie, excreted more sodium in the urine in spite of high sodium intake and therefore resulted in low mean blood pressure. Overall in the Gangetic plain tradition of observing fast and consuming more carbohydrate diet on the day of fast with high salt intake as well as use of pickles and various high calorie preparation in many ceremony predisposes them to have high serum sodium value, less natural fruit and low potassium intake. Thereby low dietary potassium as well as low serum potassium further creates a high risk for the Gangetic individuals to develop high blood pressure. On contrary North Hill individuals especially the female had higher serum potassium value which is contributed by their natural food specially the unprocessed non-vegetarian diet.

The ambient temperature and urinary sodium excretion are inter related and has shown significant positive correlation at both of the site and therefore high temperature with low humidity further demands food containing high salt for the protection. This has been further confirmed by our observation where a positive correlation was observed between relative humidity and serum sodium value. No other electrolyte other then Na^+ and K^+ had shown significant correlation with its dietary content, nature of the job, ambient temperature as well as the humidity. However traditional food, using less preservative, reducing the sodium content of the diet and natural exercise by climbing up hills and walking with the normal pace appears to protect the North-East hill residents from mean high blood pressure and this physiological adaptation is achieved by excreting more sodium in their urine and conserving potassium in their body. The individuals residing at Gangetic plain are at disadvantage of a dry low humidity, high temperature environment with extreme variation of the temperature and relatively short spell of high humidity during rainy season which last only few weeks. The low dietary potassium intake, high sodium dietary content, poor sodium excretion is a major contributory factor in sustaining the high mean blood pressure in reference to high body mass index and fast industrialization with immergence of fast food culture in fast growing urbanization society.

These above parameter are important in framing the national health policy to preserve and protect the primitive food habits in order to remain healthy at both of the geographical places and also to the immigrants who have to stay for a longer period at both of the diversified biological environment.

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Appendix

COMPARATIVE STUDY OF ELECTROLYTE EXCRETION IN RESIDENTS OF AIZAWL (MIZORAM) AND VARANASI (UTTAR PRADESH) IN RELATION TO ENVIRONMENTAL FACTORS

QUESTIONNAIRE

EPIDEMIOLOGICAL DATA

Name ________________________________

Age _________ Sex ________

Occupation __________ Income ________

Address

____

____

METEOROLOGICAL DATA

Temperature __________

R. Humidity __________

Avg. Rain Fall __________

ANTHROPOMETRIC DATA

Height ________

Weight ________

Body Mass Index ________

Blood pressure ________

DIETARY DATA

BREAKFAST					
Item	**Quantity**	**Item**	**Quantity**	**Item**	**Quantity**
LUNCH					
Item	**Quantity**	**Item**	**Quantity**	**Item**	**Quantity**

SNACKS					
Item	**Quantity**	**Item**	**Quantity**	**Item**	**Quantity**

DINNER					
Item	**Quantity**	**Item**	**Quantity**	**Item**	**Quantity**
Fruits		Water intake		Extra salt	
Liquor		Smoking		Pickles	

LABORATORY DATA			
URINARY ELECTROLYTES		SERUM ELECTROLYTES	
Parameter	**Result**	**Parameter**	**Result**
Sodium (meq /L)		Sodium (meq /L)	
Potassium (meq /L)		Potassium (meq /L)	
Calcium (meq /L)		Calcium (meq /L)	
Magnesium (meq /L)		Magnesium (meq /L)	
Chloride (meq /L)		Chloride (meq /L)	
HEMATOLOGICAL DATA			
Hemoglobin (Hb) (gm %)		Packed cell volume (PCV)	