UNIVERSITY OF KHARTOUM

Graduate College

MEDICAL & HEALTH STUDIES BOARD

THE BLOOD PRESSURE IN PRIMARY AND SECONDARY SCHOOL CHILDREN IN ADEN GOVERNARATE

By

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ABSTRACT

The objective of this study which is a cross sectional community based
study, was to provide the basic information on the normal pattern of blood pressure and the underlying causes of hypertension in school children in Aden Governorate. It also endeavors to identify the magnitude of the problem of hypertension (suspected and definitive) and to explore related demographic and socio-economic factors. The study aimed to examine and determine the association of high blood pressure with possible potential risk factors among school children aged 6 – 16 years.

Ten thousand and eighty two students were enrolled in this study during the period from November 2002 to April 2004 in different schools in Aden Governorate. They filled one questionnaire which involved all the demographic information, physical examination chest, CVS, abdomen, CNS and ophthalmologic. Anthropometric measurements were done for all students and BMI calculated. Blood pressure was measured and BP percentiles determined as well as BMI percentiles according to age, gender and height.

The age of the students ranged between 6-16 years with mean age 11.6 ± 2.94 S.D. Males constituted (47.3 %) and females constituted (52.7 %) with female to male ratio 1.1: 1. The prevalence of hypertension in the first screen was (4.4 %) while in the second screen was (2.0 %). High BP and hypertension is higher in females than males and in age group 13-16 years. Hypertension is more
frequent in Mansora (3.6 %) followed by Khormakser (2.3 %). In males the mean SBP ranged from $92.8 \pm 8.08$ to $104.5 \pm 11.15$ and the mean DBP from $54.16 \pm 8.27$ to $64.53 \pm 10.82$. In females, the mean SBP ranged from $92.38 \pm 8.36$ to $105.17 \pm 10.59$ and the mean DBP ranged from $51.35 \pm 9.96$ to $65.80 \pm 10.29$. Prevalence of hypertension increased with increase of the BMI from less than 5th percentile, 5th-85th percentile, >85th-95th percentile and > 95th percentile, 0.32 %, 1.39 %, 7.05 % and 13.43 % respectively. Stage 1 hypertension was detected in 133 students (66.5 %) while stage 2 hypertension, was in 67 students (33.5%). Rate of male students (73.1%) in stage 1 was higher than female students (62.3%). In stage 2 hypertension, female students (37.7%) were higher than male students (26.9%). Isolated systolic hypertension (51.0%) was more frequent followed by the systo-diastolic (45.0%) while the isolated diastolic was (4.0%). Hypertension was more frequent in children of hypertensive parents (7.8%) while in children of non hypertensive parents was only (1.4%). Consequently hypertension increased with increase in parents' education level, occupation and family income due to change in lifestyle. Also incidence of hypertension increased in families with more number of children due to overcrowding and stress. Students who smoked or chewed Kat had more incidence of hypertension. 35.2 % of students had renal problems which is
considered to be a cause of secondary hypertension while 64.8% of students without clear underlying causes were considered as essential hypertension.

The mean hemoglobin was 10.82±1.46g/dl, blood leukocyte 4,064.12 ± 1056.26 cells /m³ and the blood ESR was 30.29 ±14.40 mm/ 1st hour (Wastergren). The serum urea 28.36 ±5.79 mg/dl, serum creatinine 0.55 ±0.20 mg/dl, serum uric acid 4.66 ± 0.97 mg/dl, serum sodium 134.07 ±9.31 mg/dl and the serum potassium was 3.31 ± 0.71 mg/dl. The serum cholesterol 170.84 ± 22.32 mg/dl, serum triglyceride 103.90 ± 24.04 mg/dl, and serum sugar 91.50 ± 11.20 mg/dl. Urine culture was positive in 28 (57.1%) of students with renal problem while abdominal ultrasound showed chronic glomerulonephritis in 23 students (46%) with renal problems.

Students with hypertension were referred for further assessment and management in certain clinical centers.


\[ v \]

\[ 10.82 \pm 95 \% \]

\[ 10.29 \pm 11.6 \% \]

\[ 104.5 \pm 11.15 \% \]

\[ 8.36 \pm 92.38 \% \]

\[ 1.1 \pm 6.58 \]
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<tr>
<td>14.40</td>
<td>24.04</td>
<td>1.46 ± 10.82</td>
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<tr>
<td>14.40 ± 30.29</td>
<td>3056.26 ± 4064.12</td>
<td>9.3 ± 134.7</td>
</tr>
<tr>
<td>24.04 ± 103.90</td>
<td>2.32 ± 170.84</td>
<td>1.2 ± 91.50</td>
</tr>
</tbody>
</table>

**Notes:**
- **LTD:** لارتفاع لază 8.40 %
- **LTD±:** لارتفاع لază 91.50 %
- **LTD β:** لارتفاع لază 8.40 %
- **LTD± β:** لارتفاع لază 91.50 %
- **LTD γ:** لارتفاع لază 8.40 %
- **LTD± γ:** لارتفاع لază 91.50 %
- **LTD δ:** لارتفاع لază 8.40 %
- **LTD± δ:** لارتفاع لază 91.50 %
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABPM</td>
<td>Ambulatory Blood Pressure</td>
</tr>
<tr>
<td>ACE</td>
<td>Angiotensin Converting Enzyme</td>
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<tr>
<td>Ang II</td>
<td>Angiotensin II</td>
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<tr>
<td>BHS</td>
<td>British Hypertension Society</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BP</td>
<td>Blood Pressure</td>
</tr>
<tr>
<td>CBC</td>
<td>Complete Blood Count</td>
</tr>
<tr>
<td>CBPM</td>
<td>Conventional Blood Pressure</td>
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<tr>
<td>CT</td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>DBP</td>
<td>Diastolic Blood Pressure</td>
</tr>
<tr>
<td>DMAS</td>
<td>Dimercaptosuccinic acid scintigraphy</td>
</tr>
<tr>
<td>DTPA</td>
<td>Diethylene Triamine Pentaacetic Acid</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiography</td>
</tr>
<tr>
<td>ECHO</td>
<td>Echocardiography</td>
</tr>
<tr>
<td>HDL</td>
<td>High Density Lipoprotein</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous route</td>
</tr>
<tr>
<td>JNC</td>
<td>Joint National Committee</td>
</tr>
<tr>
<td>LDH</td>
<td>Low Density Lipoprotein</td>
</tr>
<tr>
<td>MIBG</td>
<td>Meta Iodobenzyl guanidine</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>NHAMES</td>
<td>National Health and Nutrition Examination Survey</td>
</tr>
<tr>
<td>NSAIDS</td>
<td>Non Steroidal Anti-inflammatory drugs</td>
</tr>
<tr>
<td>PO</td>
<td>Per Oral route</td>
</tr>
<tr>
<td>RAS</td>
<td>Renin Angiotensin System</td>
</tr>
<tr>
<td>SBP</td>
<td>Systolic Blood Pressure</td>
</tr>
<tr>
<td>UAE</td>
<td>United Arab Emirates</td>
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<tr>
<td>US</td>
<td>United State</td>
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Chapter One

1. INTRODUCTION AND LITERATURE REVIEW

1.1 The Systolic Pressure:

Systolic pressure is the maximum pressure in an artery, which carries blood from the heart at the moment when the heart is beating and pumping blood through the body.

1.2 The Diastolic Pressure:

Diastolic pressure is the lowest pressure in an artery in the moments between beats when the heart is resting. Both the systolic and diastolic pressure measurements are important; elevation of either one/or both constitute high blood pressure, hypertension. High blood pressure is initiated by processes that begin in utero and become amplified in later life.

1.3 Background and Rationale of the Blood Pressure:

Raised arterial blood pressure is a strong predictor of cardiovascular and renal disease. Indeed, high blood pressure or hypertension, may be considered as a major cause of death and morbidity in many populations. The causes of hypertension are generally unknown.
and high blood pressure of unknown origin is usually referred to as an essential or a primary hypertension and secondary hypertension, when there is underlying causes.

Investigations of blood pressure in children can therefore, contribute to the knowledge of the etiology of the condition. In addition, childhood studies have the important advantage that they may lead to the prevention of high blood pressure before its harmful sequelae can occur (7).

1.4 Trends in Blood Pressure Among Children and Adolescents:

The blood pressure (BP) varies with the age of the child and is closely related to the height and weight. Significant increases occur during adolescence and there are many temporary variations before the more stable levels of adult life are attained (9). During the pre-school years blood pressure begins to follow a pattern: children at given percentiles of blood pressure distribution tend to maintain that approximate value relative to their peer group as they grow older, with correlations ranging from 0.30 to 0.66 for systolic blood pressure and 0.12 to 0.57 for diastolic blood pressure in childhood and adolescence. The pattern continues from adolescence into adult life, which supports the hypothesis that essential hypertension begins in childhood (9). In industrialized countries, the risk of
becoming hypertensive for an individual with a family history of hypertension has been estimated to be up to four times higher than the average \(^{(10-12)}\). Blood pressure rises rapidly in the first few weeks of life. It plateaus with puberty, increases again with full maturity and thereafter, in industrialized and urban societies, again plateaus or rises slowly until the mid forties, before again accelerating into old age. Blood pressure in females tends to be lower than in males until after the menopause, when the situation usually reverses \(^{(13)}\).

### 1.5 Definition of Hypertension:

Hypertension is defined as a chronically increased systemic arterial pressure, which results from an increase in the cardiac output or in the total peripheral resistance, or both\(^{(14)}\).

In reality, however, the major abnormality in most cases of well-established hypertension is the increase of the total peripheral resistance caused by abnormally reduced arteriolar radius\(^{(14)}\). The definition of hypertension in children and adolescents is based on the normative distribution of (BP) in healthy children.

#### 1.5.1 Normal blood pressure:

Normal blood pressure is defined as systolic blood pressure (SBP) and diastolic blood pressure (DBP) that are at/or below the 90\(^{th}\) percentile for gender, age and height \(^{(15,16)}\).
1.5.2 Pre-hypertension:

Pre-hypertension in children is defined as average (SBP) or (DBP) levels that are $\geq$ 90th percentile but $< 95$th percentile. Average (SBP) or (DBP) levels that are $\geq$ 90th percentile but $< 95$th percentile which had been designated as "high normal" and considered to be an indication of heightened risk for developing hypertension \(^{15,16}\). If the child's blood pressure (systolic or diastolic) is $\geq$ 95th percentile, the child may be hypertensive and the measurement must be repeated on at least two additional occasions to confirm the diagnosis.

Staging of blood pressure, according to the extent to which a child's blood pressure exceeds the 95th percentile, is helpful in developing a measurement plan for evaluation and treatment that is most appropriate for an individual patient.

1.5.3 Stage 1 hypertension:

Stage 1 hypertension is the designation for (BP) levels that range from the 95th percentile to 5 mmHg above the 99th percentile. Once confirmed on repeated measurements, stage 1 hypertension allows time for evaluation before initiating treatment unless the patient is symptomatic.

1.5.4 Stage 2 hypertension:

Stage 2 hypertension is the designation for BP levels that are more than 5 mmHg above the 99th percentile. Patients with stage 2 hypertension
may need more prompt evaluation and pharmacological therapy. Symptomatic patients with stage 2 hypertension require immediate treatment and consultation with experts in pediatric hypertension\(^{(15-17)}\).

United States (US) guidelines mention that in adults blood pressure of 120/80 mmHg is not normal. The new guidelines categorize blood pressure as normal < 120 / 80 mmHg, Pre-hypertension 120/80 to 139/89 mmHg, hypertension stage 1 140/90 to 159/99 mmHg and hypertension stage 2 ≥ 160/100 or higher. In people aged over 50 years, high systolic blood pressure above 140 mmHg is considered a greater risk factor for cardiovascular disease than high diastolic blood pressure. The risk of cardiovascular disease begins at 115 / 75 mmHg and doubles with each increment of 20 / 10 mm Hg\(^{(18)}\).

The Joint National Committee (JNC) categorizes blood pressure levels as optimal <120/80 mmHg, normal < 130/85 mmHg and high normal 130-139 / 85-90 mmHg. Hypertension is classified as stage1 140-159/90-99 mmHg, stage 2 160-179/100-109 mmHg or stage 3 ≥ 180/110 mmHg\(^{(19)}\).

1.5.5 **White coat hypertension:**

White coat hypertension or isolated clinic hypertension is the transient elevation of a patient's blood pressure in response to the observer measuring the blood pressure\(^{(20)}\). White coat hypertension is more common in men than women (10.9 % versus 8.2 % respectively) and positively
related to age and body mass index\(^{(21)}\). Compared with patients with sustained hypertension, individuals with white coat hypertension have less end organ damage and better prognosis\(^{(22,23)}\).

1.6 **Historical Background:**

Blood pressure was measured for the first time by Stephen Hales in 1773. Hales also described the importance of blood volume in blood pressure regulation. The contribution of peripheral arterioles in maintaining blood pressure, described as ‘tone’, was first described by Lower in 1669 and subsequently by Senac in 1783. The role of vasomotor nerves in the regulation of blood pressure was observed by such eminent investigators as Claude Bernard, Charles E. Edouard, Charles Brown–Sequard and Augustus Waller. William Dayliss advanced this concept of humoral control of blood pressure and investigated pharmacologic effects of epinephrine. Three contributors who advanced the knowledge of humoral mechanisms of blood pressure control are T. R. Elliott, Sir Henry Dale and Otto Loew.

Richard Bright, a physician who practiced in the first half of the 19\(^{th}\) century, observed the changes of hypertension on the cardiovascular system in patients with chronic renal disease. George Johnson in 1868 postulated that the cause of left ventricular hypertrophy (LVH) in Bright disease was
due to the presence of muscular hypertrophy in the smaller arteries throughout the body. Further clinical pathologic studies by Sir William Gull and H. G. Sutton, in 1872, led to further description of the cardiovascular changes of hypertension. Frederick Mohamed was one of the first physicians to systematically incorporate blood pressure measurement as a part of a clinical evaluation. Recognition of primary or essential hypertension is credited to the work of Huchard, Vonbasch and Albutt. Observations of Janeway and Walhard led to the recognition of target organ damage, which branded hypertension as the 'silent killer'. The concepts of renin, angiotensin and aldosterone were advanced by several investigators in the late 19th and early 20th centuries. The names of Irwine, Page, Van Slyke, Goldblatt, Laragh, and Tuttle prominently appear throughout the hypertension literature, and their work enhances our understanding of the biochemical basis of essential hypertension. Cushman and Ondetti developed an orally acting converting enzyme inhibitor from snake venom peptides and are credited with the successful synthesis of the modern antihypertensive captopril (24).

Hypertension is one of the most common diseases affecting humans throughout the world. Because of the associated morbidity and mortality and the cost to society, hypertension is an important public health challenge. Over the past several decades, extensive research, widespread patient education and
a concerted effort on the part of health care professionals have led to decreased mortality and morbidity rates from the multiple organ damage arising from years of untreated hypertension. Hypertension is the most important modifiable risk factor for coronary heart disease, which is the leading cause of death in North America, stroke the third leading cause, congestive heart failure, end-stage renal disease and peripheral vascular disease. Therefore, health care professionals must not only identify and treat patients with hypertension but also promote a healthy lifestyle and preventive strategies to decrease the prevalence of hypertension in the general population (24).

1.7 Epidemiology:

1.7.1 General aspects:

As early as the first decades of this century, blood pressure was investigated in children and young adults. In these earliest studies, it was observed that the average level of blood pressure in childhood increases markedly with age. Since then, virtually all studies of blood pressure in childhood performed in a variety of populations, have shown a rise of blood pressure with age.

This rise is particularly marked for the systolic pressure. However, in adolescence the rise is steeper in boys than in girls. The average annual
increase in systolic pressure from birth until the age of 20 is about 2.0 mmHg in boys and about 1.0 mmHg in girls. Between the ages of 10 and 14 years, however, the average increase is greater. The rise in diastolic pressure is less marked than the increase in systolic pressure, while it does not seem to be a major difference between boys and girls. The average annual increase in diastolic pressure throughout childhood and adolescence for both boys and girls is about 0.5 - 1.0 mm Hg\(^7\).

Nearly one billion people worldwide have high blood pressure and the number is expected to increase to 1.56 billion people by 2025, as predicted by a new study\(^{25,26}\). The estimates came from pooled data of 30 population based studies involving more than 700,000 people from different regions of the world\(^{26}\). The greatest increase is in underdeveloped regions such as Africa and Latin America\(^{26}\). The incidence and prevalence of hypertension remain very high despite efforts focused on its detection, evaluation and treatment\(^{27}\).

1.7.2 Researches worldwide:

1.7.2.1 Researches in Arab countries

- In Sana'a an overall prevalence of hypertensive subjects in a clinic population was (23%), 370 males (56%) and 289 females (44 %) , the median age was 53 years\(^{28}\).
• In a Saudi Arabia, study 9.1% and 8.7% of the total sample investigated were systolic and diastolic hypertensive, respectively. However, 12.4% and 7.9% of children younger than 18 years were systolic and diastolic hypertensive. Among adults aged 18 years and above, 5.3% were systolic and 7.3% were diastolic hypertensive, 87.5% of systolic and 79.4% of diastolic hypertensive were aged 40 years and over. Females had statistically significant elevated systolic hypertension compared with males (p<0.01) which is statistically significant(29).

• In Kuwait, a cross-sectional population survey was conducted in four out of the five health districts in Kuwait from September 2001 to May 2002. 2910 school children ranging in age from 5-13 years were screened for hypertension, the prevalence of hypertension was 6.8%, (51%) in males and (49%) in females (30).

• In United Arab Emirates (UAE), a stratified random sample of 220 (UAE) citizens of both sexes in the 18 to 75 years of age group was selected from Sharjah and Abu Dhabi districts, the overall prevalence of hypertension was found to be 33.1%, with no statistically significant difference between Sharjah and Abu Dhabi, 33.4% vs. 32.7% respectively(31). Hypertension prevalence was statistically significant higher among
males compared with females in all subjects in Abu Dhabi (36.6%) vs. (30.5%) and (41.1%) vs. (27.9%), while no statistically significant difference was found between males and females in Sharjah (34.3%) vs. (32.2%). The prevalence of hypertension was found to be significantly higher in Abu Dhabi male participants compared to Sharjah male participants\(^{(31)}\).

- In Egypt, report from the Egyptian National Project presents national estimates of the prevalence of hypertension and the extent to which high blood pressure is being detected, treated with medications and controlled in the Egyptian population. The results were based on findings from a national probability survey of adults \(\geq 25\) years of age conducted in six Egyptian governorates. Overall, the estimated prevalence of hypertension in Egypt was (26.3%). Hypertension prevalence increased progressively with age from (7.8%) in 25 to 34 years old to (56.6%) in those 75 years or older. Hypertension was slightly more common in women than in men (26.9%) versus (25.7%)\(^{(32)}\).

- In Sudan, a study was done on healthy school going children, estimated the prevalence of hypertension as (3.3%) in Sudanese children\(^{(33)}\).
• In Jordan, a study which was a subset of a comprehensive health examination survey of all schoolchildren and adolescents 6-17 years of age (7260 students) attending military-run schools, the prevalence rate of definite hypertension was (3.6%) (34).

• In Algeria, four prospective studies have been carried out in urban areas using representative samples of two main cities, 3 in the capital, Algiers (H.Khoja 1981, Boukhari 1984, Kemali 1993) and one in Annaba (Ben Hassine 1996) (35). The prevalence in Algiers was estimated at (11.4%) by Kemali, (12.9 %) by Boukhari and 7% by H. Khoja. The low prevalence reported by H. Khoja could be explained by the young age of the selected population, only (5 %) were over 50 years old (35).

• In Tunis, the first epidemiological study was conducted in the urban area and concerned 1875 individuals out of 1419 families age > 30 years. These were 822 males (43.7%) and 1053 females (56.3%). The results of the study showed that the prevalence of hypertension was 29.8% and tended to increase with age in both sexes. The second epidemiological study was conducted in the rural zone of Kalaa Kbira, in the center of Tunisia. It concerned 555 individuals out of 300 families. There were 221 men (40%) and 334 women (60%) age >20 years. The prevalence
of hypertension was 15% and it increased with age and overweight \(^{(36)}\).

1.7.2.2 In South Asia:

- In Iran, the prevalence of hypertension in many cities of the country was different, having a range between (7.7%) in Boshehr to (28.8%) in Hamadan \(^{(37)}\). According to the results of national study conducted in 1990 in 24 cities on 27,030 men and women aged between 12-70 years, the prevalence of hypertension using the definition of blood pressure 140/90 mmHg was (9.5%) . Another big community-based study using the World Health Organization's standardized criteria in Isfahan showed that the age adjusted prevalence rate among 8,624 men and women aged 19 years and above was 18 % (16% for men and 19.4% for women ) . No sex-based significant differences were found when the mean levels or prevalence of hypertension were adjusted for body mass index \(^{(37)}\).

- In India, Screening studies for essential hypertension in school going children showed a prevalence of 0.46 % - 11.7 % \(^{(38)}\).

- In Pakistan, a study performed on 5641 (South Asian children) 5-14 years old included in the nationally representative National Health Survey of Pakistan (NHSP) 1990-1994, on 4756
white children 5-14 years old included in Third National Health and Nutrition Examination Survey (NHANES 111), 1988-1994. The overall prevalence of high blood pressure in South Asian children 5 to 14 years old was 12.2% (11.3% to 13.1%): 15.8% (14.5% to 17.1%) in boys and 8.7% (7.6% to 9.8%) in girls (39).

- In Malaysia a recent survey, the National Health and Morbidity Survey 11, indicated that the prevalence of hypertension was 24% among Malaysian population aged 30 years and above (40).

- Another study done in China indicated that (27.2%), or 130 million, adults age 35 to 74 years in China had hypertension (41).

1.7.2.3 In the United States of America:

- In the United States, the prevalence of hypertension in adult population, as defined by a single measurement of 140/90 mmHg or more obtained under non-standardized condition, is estimated to be (15-20%). This compares with a prevalence of (1.5-2.0%) among children aged 4-14 years in whom hypertension was defined as a blood pressure persistently greater than 95th percentile for age (42).
• It is estimated that in the United States approximately 50 million or 1 in 4 adults have high blood pressure based on the Third National Health and Nutrition Examination Survey of 30 million to 40 million based on the fifth report of the Joint National committee on Detection, Evaluation and Treatment of High Blood Pressure criteria. The prevalence of hypertension increases with age and is higher in blacks than whites.

• Women have lower blood pressure measurements than men in early adult life, but their blood pressures increase more steeply with age, to reach or exceed those of men beyond middle age.

• Hypertension in the United States increased during the 1990s and now affects more than a quarter of the population. Less than a quarter of those affected have their hypertension under control.

• An analysis of the national health and nutrition examination survey (NHANES) published in JAMA, showed that (29%) of Americans, more than 58 million people, have hypertension defined as 140 / 90 mmHg or above.

• Between the 1988-91 survey and the 1999-2000 survey, hypertension increased by 3.7% (95% confidence interval 0%
to 8.3%). More than half of the increase (2%) is due to an
increase in body mass index, even after adjustment for age,
sex and race or ethnicity. This has been reported by the
investigators, Dr Ihab Hajjar of Palmetto Health Richland,
University of South Carolina, Columbia and Dr Theodore
Kotchen of the Medical College of Wisconsin, Milwaukee\(^{(44)}\).

- Hypertension prevalence was highest in non-Hispanic
  black Americans (34%), those aged 60 years or older (65%),
  and 30% of them were women\(^{(44)}\). Population-based studies
  that used criteria from the Task Force Report on High Blood
  Pressure in Children and Adolescents have reported a
  prevalence of systolic hypertension ranging from (2.7%) to
  (5.8%) in school-aged children. All studies showed higher
  prevalence of systolic than diastolic hypertension\(^{(45-47)}\).

### 1.7.2.4 Hypertension prevalence versus control:

National health surveys in various countries have shown high prevalence
of poor control of hypertension. These studies have reported the
followings:

- In Canada, the prevalence of hypertension is (22%), of whom
  (16%) are controlled.
In Egypt, the prevalence of hypertension is (26.3 %), of whom (8 %) are controlled.

In China, the prevalence of hypertension is (13.6 %), of whom (3 %) are controlled.

1.7.2.5 Other researches:

Hypertension is a worldwide epidemic; in many countries, (50 %) of the population older than 60 years have hypertension. Based on a prevalence of (20 %), 3.45 billion adults in the world are estimated to have hypertension. The (20%) prevalence is for hypertension defined as blood pressure in excess of 140/90 mmHg. The prevalence dramatically increases in patients older than 60 years\(^{(32)}\).

The prevalence rate of definite hypertension reported among Irish, Native American, Estonia, North Portuguese and Spanish school children and adolescents, ranged from 5.2-23 % \(^{(34)}\).

Others studies reported the prevalence in Indian and German children and adolescents to be (0.46%) and (1%) respectively \(^{(34)}\).

Another study was carried out in an area around Kumasi, the second largest city in Ghana, the prevalence of hypertension was (28.7%) which is similar to the prevalence of 28.3% in Accra \(^{(48)}\).
• In Africa the prevalence of hypertension in adults ranged from (2%) to (41%), with a recent study finding the prevalence in two West African countries to be between 15 and 23% (49).

• In Nigeria, the prevalence of hypertension was (14%) in rural countries. The prevalence of hypertension was (26%) in Jamaicans of African descent (50).

• Hypertension prevalence in llala was (30%) in men and (28.6%) in women. In men (32.2%) and in women (31.5%) in Shari. Age standardized hypertension (to the New World Population) prevalence was (37.3%) among men and (39.1%) in women in llala, (26.3%) in men and (27.4%) in women in Shari. In both areas, just under (20%) of hypertensive subjects were aware of their diagnosis, approximately (10%) reported receiving treatment and less than (1%) had a controlled blood pressure lower than 140/90 mmHg (51).

1.8 Etiology of Hypertension:

1.8.1. Primary or essential hypertension:

Hypertension is referred to as essential or primary, when the physician is unable to identify a specific cause. It is by far the most common type of high blood pressure. The causes of this type are unknown but
are likely to be a complex combination of genetic, environmental and other factors.

1.8.1.1 Genetic factors:

A number of genetic factors or interactions between genes play a major role in essential hypertension (52). Family and twin studies indicate that as much as (30 %) of hypertension is due to genetic causes. Rare forms of genetic hypertension have different molecular etiologies but a common pathophysiology is mediated by abnormal sodium metabolism (53).

1.8.1.2 Abnormalities in the angiotensin-renin-aldosterone system:

Abnormalities in the angiotensin-renin-aldosterone system influence all aspects of blood pressure control, including blood pressure vessel contraction, sodium and water balance and cell development in the heart.

1.8.1.3 Inherited abnormalities in the sympathetic nervous system:

Studies suggest that some people with essential hypertension may have inherited abnormalities of the sympathetic nervous system. This is the part of the autonomic nervous system that controls heart rate, blood pressure and the diameter of the blood vessels. Hypertension is strongly associated with both type 1 and 2 diabetes. Kidney damage is generally the cause of high blood pressure in type I diabetes.
1.8.1.4  Insulin, obesity and type 2 diabetes:

Insulin increases renal sodium retention while increasing free water clearance \(^{(54-57)}\). Insulin resistance is also associated with increased sympathetic nervous system activity and stimulation of vascular smooth muscle growth \(^{(58,59)}\). Insulin levels have been found to be significantly higher in adult patients with essential hypertension and borderline hypertension than in normotensive control patients \(^{(60,61)}\).

Raised blood pressure is more common in people with type 2 diabetes than in the general population \(^{(61)}\). In people without diabetes it is a major risk factor for myocardial infarction and stroke \(^{(61)}\).

During the past decade several studies have shown that a large proportion of patients with hypertension, are resistant to insulin stimulated glucose uptake and are hyper-insulinaemic compared with normotensive controls \(^{(62)}\). Hypertension and obesity have been identified as risk factors for cardiovascular and mortality, a number of studies have found that lean hypertensive subjects are at greater risk than obese hypertensive \(^{(63)}\). Some authors had suggested that the high mortality rate among lean people with hypertension may be due to unhealthy lifestyles such as smoking and excess alcohol intake.

Hypertension is a health problem most commonly associated with obesity, which in turn is strongly associated with type 2 diabetes. People
with this form of diabetes generally have normal or high levels of insulin, i.e. they are insulin resistant. Some researches indicate that insulin resistance stimulates parts of the sympathetic nervous system and may cause sodium retention, a contributor to high blood pressure \(^{63,64}\). Obesity on its own right has a number of possible effects that could lead to hypertension, it may blunt certain actions of insulin that open blood vessels and it may cause structural changes in the kidney and abnormal handling of sodium \(^{65}\). It is also associated with alterations in the systems that regulate blood flow \(^{65}\).

More than (50\%) of adults in the United States and United Kingdom are overweight, putting them at increased risk of hypertension, hyperlipidemia, type 2 diabetes, coronary heart disease, stroke and other chronic disorders \(^{65}\). In many developing countries, excess weight and related disorders now rival malnutrition as major public health problems \(^{66}\).

In obese hypertensive patients, a decrease in body weight by one kg resulted in a reduction of systolic and diastolic pressure by 1.2 and 1.0 mmHg, respectively \(^{67}\). The association between obesity and hypertension in children has been reported in numerous studies among a variety of ethnic and racial groups, with virtually all studies finding higher blood pressures and/or higher prevalence's of hypertension in obese compared to lean children\(^{68-70}\).
Recent reports showed that there is a three times greater prevalence of hypertension in obese, compared with non-obese adolescents in a school based hypertension and obesity screening study (68). The prevalence of hypertension increased progressively as the BMI percentile increased from (2%) to (11%) from $\leq 5^{th}$ percentile to $\geq 95^{th}$ percentile (71).

1.8.1.5 **Low level of nitric oxide:**

The gas nitric oxide can be produced in the body, where it affects the smooth muscles cells that line blood vessels; it helps keep them relaxed and flexible. It may also help to prevent blood clotting (72). Nitric oxide is thought to reduce peripheral vasomotor tone and blood pressure both by causing active vasodilatation and decreasing central sympathetic vasoconstrictor drive (73,74).

1.8.1.6 **Magnesium and calcium:**

Magnesium contributes to blood pressure regulation partly in terms of vasodilator actions. Its sympatholytic effect may also play an important role to control blood pressure (42). A rise in intracellular concentration of calcium, brought about by changes in plasma calcium concentration, increases vessel contractility (42). In addition, calcium stimulates the release of renin, the synthesis of epinephrine and the activity of the sympathetic nervous system (42). On the other hand, increased potassium intake suppresses production and release of renin and induces natriuresis, thus decreasing blood pressure (42).
1.8.1.7 **Low birth weight:**

Low birth weight has been associated with high blood pressure in both childhood and adulthood. Whether this relationship is due to malnutrition in the mother or abnormalities in the placenta is not clear\(^{75,76}\).

The development of hypertension is associated with reduced fetal growth and catch up growth in early childhood\(^{77-81}\). A raised blood pressure is then amplified from infancy to old age, perhaps by a positive feedback mechanism\(^{82,83}\). Epidemiological studies have indicated that susceptibility of human adults to hypertension and cardiovascular disease may result from intrauterine growth restriction and low birth weight induced by maternal under-nutrition\(^{84-96}\). Lower birth weight is related to increased blood pressure and increased arterial stiffness\(^{97}\). Barker and colleagues argued that early life factors, acting particularly in utero may have a strong influence on subsequent cardiovascular risk\(^{98-100}\). An inverse relation between birth weight and subsequent blood pressure (lower birth weight being associated with higher subsequent mean blood pressure) has been reported in adults and children\(^{101,102}\). Earlier reports suggested that a large placenta, particularly in the presence of low birth weight, was related to subsequent high blood pressure and the risk of hypertension\(^{103}\).

People who had been small at birth but who gained weight rapidly during early childhood 1-5 years, had the highest adult blood pressure\(^{104}\).
Systolic pressure increased by 1.3 mmHg for every standard deviation score decrease in birth weight and independently increased by 1.6 mmHg for every standard deviation score increases in early childhood weight gain\textsuperscript{(104)}. Another study found that the relationship of lower birth weight with higher blood pressure was independent of postnatal growth, adult body mass or other lifestyle factors. This suggests that, at least part of the risk of hypertension is determined in fetal life. Possible mechanisms operating in fetal life that might determine blood pressure include the structural development of resistance arteries, setting of hormone levels and nephron development\textsuperscript{(104)}.

The relation between growth and later blood pressure is complex and has prenatal and postnatal components\textsuperscript{(104)}. The lower birth weight and greater weight gain between 1 and 5 years of age were associated with higher systolic blood pressure in young adult life. However, weight gain in infancy (the first year of life) was not associated with adult high systolic blood pressure\textsuperscript{(104)}.

Beside babies low birth weight. Three other early factors that are considered to be important risk factors for developing high blood pressure in adult life have been identified in individuals with intrauterine growth retardation as follows:
- Accelerated postnatal growth in weight and length is suggested to increase the risk for developing hypertension and type 2 diabetes in later life, especially in low birth weight individuals\(^{(105-108)}\).

- Altered angiotensin activity is an important factor underlying the "fetal origins of adult diseases" hypothesis.

- Hypoxia increased sympathetic nerve activity and catecholamine production and proliferation of juxta-glomerular cells and thus renin-producing cells are suggested as factors in the pathogenesis\(^{(108)}\).

1.8.1.8 Gestational age:

Preterm infants are probably at even greater risk for developing adults diseases compared with individuals who were born at term\(^{(109)}\). A large Swedish study showed that an inverse association between gestational age ranging from 35 to 44 weeks, and systolic blood pressure in 165136 Swedish men\(^{(109)}\). The correlation between adult blood pressure and gestational age was stronger in preterm subjects with a gestational age less than 38 weeks. While there was no correlation between adult blood pressure and gestational age in subjects born at term between 38 and 41 complete weeks of gestation or post-term more than 42 weeks of gestation.
The inverse correlation between adult (SBP) and gestational age was stronger in low birth weight subjects less than 2500g\textsuperscript{(109)}. Preterm birth might induce permanent changes in vascular structure and function as well as in blood pressure. Preterm girls have higher blood pressure and an increased resistance in the vascular tree after puberty. These findings may have implications for future cardiovascular risk in the growing adult population surviving preterm birth\textsuperscript{(110)}.

### 1.8.1.9 Breast feeding:

Breast feeding in infancy has been mentioned to be associated with decreased coronary heart disease mortality, but the underlying mechanisms are unclear\textsuperscript{(111,112)}. A number of mechanisms have been proposed. Firstly, neonatal sodium restriction was associated with a 2 mmHg reduction in blood pressure that persisted into adolescence. Secondly, breast milk contain long chain polyunsaturated fatty acids (LCPUFAs), important structural components of tissue membrane systems, including the vascular endothelium. Long chain polyunsaturated fatty acids found in breast milk may play a role in blood pressure control. Thirdly, higher energy and protein intakes in bottle-fed compared with breastfed infants may stimulate insulin secretion and promote insulin resistance that persists into adolescence and adulthood\textsuperscript{(113)}. Fourthly, formula-fed infants are more likely to be overweigh than breastfed infants\textsuperscript{(111)}. 
Accelerated postnatal weight gain among formula fed is associated with raised blood pressure. For each increase in quartile of dried milk consumption (in oz) at three month of age, there was a 1.28 mmHg increase in systolic and a 0.63 mmHg increase in diastolic blood pressure \(^{114-117}\). Increased duration of breastfeeding and consumption of human milk compared with formula have been associated with reduced blood pressure in later childhood \(^{118}\).

### 1.8.2 Secondary causes of hypertension:

Hypertension resulting from other diseases accounts for 10-15% of all cases. Secondary hypertension is more common than essential hypertension in infants and children.

#### 1.8.2.1 Medical causes:

The medical conditions that causes hypertension include various causes such as:

1.8.2.1.1 Renal causes:

Renal causes which include chronic pyelonephritis, chronic glomerulonephritis, hydronephritis, congenital dysplastic kidney, multicystic kidney, solitary renal cyst, vesicoureteral reflux nephropathy, segmental hypoplastic, ureteral obstruction, renal tumors, renal trauma, rejection damage following transplantation, post-radiation damage and systemic lupus erythematosus.
1.8.2.1.2 Vascular causes:

Vascular causes include coarctation of the thoracic or abdominal aorta, renal artery lesions such as stenosis, thrombosis, aneurysm, umbilical artery catheterization with thrombus formation, neurofibromatosis, renal vein thrombosis, vasculitis, arterio-venous shunt (119).

Hypertension is implicated in (35%) of all atherosclerotic cardiovascular events, including (49%) of all cases of heart failure (120). In hypertensive children, the reported prevalence of left ventricular hypertrophy (LVH) ranges from (10%) to (38%), depending on the left ventricular mass (121,122). Adult hypertension is a major health problem and drug treatment of hypertension is expensive and has adverse side effects.

By the time treatment of hypertension begins during adulthood, considerable damage may have already occurred to the arterial system, to the left ventricle and to other organs (123). Lowering systolic blood pressure by 10 mmHg or diastolic blood pressure by 5 mmHg reduces the risk of stroke to (35%) and that of ischemic heart disease events to (25%) at age 65 years (124,125).

1.8.2.1.3 Endocrine causes:

Endocrine causes which include hyperthyroidism, hyperparathyroidism, congenital adrenal hyperplasia, Cushing syndrome, primary aldosteronism, primary hyperaldosteronism, pheochromocytoma and other neural crest
tumors such as neuroblastom, ganglioneuroblastoma, ganglioneuroma, diabetic nephropathy and Ladle's syndrome.

1.8.2.1.4 Central nervous system causes:

Central nervous system causes include intracranial mass, hemorrhage, residual damage following brain injury.

1.8.2.2 Chemical poisoning:

Chemical causes include substances such as lead and mercury\(^{(126,127)}\).

1.8.2.3 Sleep-disordered breathing

Sleep-disordered breathing such as sleep apnea have been associated with hypertension in clinical reports since the early 1980\(^{(128)}\).

1.8.2.4 Medications:

Medications such as oral contraceptive pills, non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroid drugs, cyclosporine, erythropoietin and sympathomimetics such as phenylpropanolamine and cold medicines containing pseudoephedrine.

1.8.2.5 Maternal hypertension

Hypertension during pregnancy, especially pre-eclampsia, is associated with increased peri-natal morbidity and mortality and often retards intrauterine growth\(^{(129)}\). There are few data available, however, on the neuro-developmental outcome of preterm infants born to mothers whose pregnancies have been complicated by hypertension.
Early epidemiological studies have suggested that there is an association between maternal hypertension and cerebral palsy, whereas in more recent studies of preterm infants, pre-eclampsia has been associated with a reduced risk of cerebral palsy (129).

1.8.2.6 Physical and mental stress:

Physical and mental stress each elicits physiological responses that are mediated through the autonomic nervous system and endocrine system (84). These responses include increases in blood pressure, heart rate, cardiac output and skeletal muscle blood flow and decreases in renal and splanchnic blood flow (130). It has been found that renal vascular resistance increases, whereas forearm vascular resistance decreases during mental arithmetic (130). These responses act to restrict blood flow to visceral capillary beds and to redirect blood to systems of the body that respond to stressful stimuli, such as the heart, the brain and the skeletal muscle (130). Hormonal changes are also seen during the stress response (130). An increase in epinephrine exerts tissue specific effects, such as vaso-constriction in the splanchnic region and vaso-dilation in skeletal muscle (130).

These actions also aid in redirection blood flow to systems of the body responding to stressful stimuli (130). Activation of the cortisol system via corticotrophin releasing hormone aids in mobilizing energy stores (130).
The actions of the renin angiotensin aldosterone system and vasopressin both contribute to the maintenance of elevated BP \(^{(130)}\).

### 1.9 The Patho-physiology of Hypertension:

There is still much uncertainty about the patho-physiology of hypertension. A small number of patients between (2\%) and (5\%) have an underlying renal or adrenal disease as the cause for their raised blood pressure. In the remainder, however, no clear single identifiable cause is found and their condition is labeled as essential hypertension. A number of physiological mechanisms are involved in the maintenance of normal blood pressure, and their derangement may play a part in the development of essential hypertension.

It is probable that raised blood pressure in hypertensive patients, and their relative roles may differ among individuals. Among the factors that have been intensively studied are salt intake, obesity and insulin resistance, the renin - angiotensin system and the sympathetic nervous system. In the past few years, other factors have been evaluated, including genetics, endothelial dysfunction, as manifested by changes in endothelin and nitric oxide, low birth weight and intrauterine nutrition and neurovascular anomalies. Maintenance of a normal blood pressure is dependent on the balance between the cardiac output and peripheral vascular resistance \(^{(131)}\).
Increased sympathetic tone plays an important role in the development of essential hypertension in adults.

A similar mechanism responsible for persisting high blood pressure in children has recently been proposed but is still controversial. McCrory et al reported that resting plasma nor epinephrine levels were significantly higher in children with borderline and significant hypertension than in healthy control subjects (132,133). Wambach et al, reported that urinary catecholamine levels were significantly higher in adolescents with hypertension compared with normotensive subjects, whereas plasma levels of epinephrine and nor epinephrine were similar (132,133).

Others, however, reported no relationship between blood pressure and plasma nor-epinephrine level or vascular reactivity to sympathetic stimulation (132). The renin - angiotensin system (RAS) is an important regulator of blood pressure. However, angiotensin II (AngII), a principal effector of the (RAS), not only contributes to the pathophysiology of hypertension, through its vaso-constrictive effects, but also mediates growth-promoting and hypertrophic processes in atherosclerosis and enhances the potential for thrombogenesis (134).

Thus, antihypertensive interventions that decrease blood pressure by inhibiting (AngII) would also be expected to have a favorable influence on other pathogenetic consequences of increased (AngII) activity (134).
Multiple actions on the heart, kidneys, vascular system, adrenal gland, central nervous system, and (Ang Π) plays an important part in the pathogenesis of hypertension and heart failure \(^{(134)}\). It stimulates vasoconstriction, either directly via vascular receptors, or indirectly via stimulation of the sympathetic nervous system leading to increases in peripheral resistance. This is achieved by facilitating the release of nor-epinephrine from the prejunctional sympathetic nerve endings and that of epinephrine from the adrenal medulla\(^{(134)}\).

Osmo-regulating and volume regulating effects of (Ang Π), including renal salt and water retention, are mediated through increased production and secretion of aldosterone from the adrenal cortex, or directly by receptor stimulation at various sites in the renal tubules\(^{(134)}\). In addition to these acute central effects of (Ang Π) aimed at blood pressure and volume haemeostasis, tissue (Ang Π) has mitogenic properties and promotes the growth of vascular smooth muscle cells, fibroblasts and cardiac myocytes. These actions lead to structural alterations that contribute to vascular, cardiac and renal pathology, including left ventricular hypertrophy, congestive heart failure, neo-intima formation, post-infarct remodeling and nephrosclerosis\(^{(134)}\).

1.9.1 **The pressure control mechanisms:**

The pressure control mechanisms can be divided into three mechanisms.
1.9.1.1 **Short-term mechanisms:**

The short-term mechanisms are the three nervous feedback control mechanisms: the baroreceptor mechanism, the chemoreceptor, and the (CNS) ischemic feed-back mechanism. Each of these mechanisms begins to act within seconds whenever any disturbance attempts to change the arterial pressure either to a higher or a lower value than its normal level. Therefore, these nervous control mechanisms play an exceedingly important role in preventing the arterial pressure from bouncing to very high values or from falling to very low values from second to second or moment to moment \(^{(135)}\).

1.9.1.2 **Intermediate-term control mechanism:**

Intermediate control mechanisms are represented by stress-relaxation of the vascular, the renin-angiotensin-vasoconstriction mechanism, and the capillary fluid shift mechanism, when a disturbance continues for minutes or hours tending to alter the arterial pressure. All of these mechanisms can help to keep the pressure close to its normal value, though they cannot respond in seconds. Thus, an excess of blood volume leads to slow stress-relaxation of the vasculature or to capillary fluid shift out of the circulation. A prolonged decrease in arterial pressure leads to the formation of angiotensin, and this in turn causes vasoconstriction and elevation of the arterial pressure back towards normal \(^{(135)}\).
1.9.1.3 Long-term arterial pressure control mechanisms:

Long-term arterial pressure control mechanisms are represented by the renal-body fluid pressure control system and by the aldosterone control system. However, the aldosterone system works in conjunction with the renal-body fluid system so that in reality they are part of the same system. The basic mechanism of the renal-body fluid for arterial pressure control involves the following steps:

- An increase in arterial pressure causes the kidneys to excrete increased quantities of fluid.
- Increased loss of fluid through the kidneys reduces both the extra-cellular fluid volume and the blood volume.
- Reduced blood volume reduces venous return of blood to the heart and therefore reduces the cardiac output.
- Reduced cardiac output reduces the arterial pressure back to normal.

Conversely, when the arterial pressure falls too low, the kidneys retain fluid, the blood volume increases, the cardiac output increases and the arterial pressure returns again to normal\(^{(135-137)}\).
1.10 Clinical Manifestations of Hypertension:

The main symptoms are headache, dizziness, changes in vision, seizures and renal problems. Growth failure may occur. Hypertensive encephalopathy is suggested by the presence of vomiting, temperature elevation, ataxia, stupor and seizures. Regardless of the cause of hypertension, cardiac and renal functions deteriorate in the face of marked increases in blood pressure. Young children and infants may develop heart failure or seizures\(^{138}\).

1.11 Methods of Measuring Blood Pressure:

1.11.1 Auscultatory method:

The arterial blood pressure in human is routinely measured by the auscultatory method. An inflatable cuff, Riva-Rocci cuff attached to a mercury manometer, the sphygmomanometer, is wrapped around the arm and a stethoscope is placed over the brachial artery at the elbow. The cuff is rapidly inflated until the pressure in it is well above the expected systolic pressure in the brachial artery.

The artery is occluded by the cuff, and no sound is heard with the stethoscope. The pressure in the cuff is then lowered slowly. At the point at which the systolic pressure in the artery just exceeds the cuff pressure, a spurt of blood passes through with each heart beat and,
synchronously with each beat, a tapping sound is heard below the cuff. The cuff pressure at which the sounds are first heard is the systolic pressure. As the cuff pressure is lowered further, the sounds become louder, then dull and muffled. Finally, in most individuals they disappear. These are the sounds of Korotkoff. When direct and indirect blood pressure measurements are made simultaneously, the diastolic is the pressure at which the sound disappears\(^{(139)}\).

1.11.2 Palpation method:

The systolic pressure can be determined by inflating an arm cuff and then letting the pressure falls and determining pressure at which the radial pulse first becomes palpable. Because of the difficulty in determining exactly when the first beat is felt, pressures obtained by this palpation method are usually 2-5 mmHg lower than those measured by auscultation\(^{(139)}\).

1.12 Devices for Measurement of Blood Pressure:

Blood pressure measuring devices are divided into two broad groups, manual and automated categories:

1.12.1 Manual sphygmomanometers

Manual sphygmomanometers includes mercury and aneroid devices.
1.12.2 Automated sphygmomanometers

Automated sphygmomanometers includes devices for clinical use in hospitals, self measurement of blood pressure, ambulatory blood pressure measurement and for measuring blood pressure in community setting\(^{(140)}\).

1.12.2.1 Automated devices:

Available for self measurement, all of which use the Oscillometric technique. There are three categories available of automated devices that measure blood pressure on the finger, the wrist and the upper arm, as follows\(^{(141)}\):

- Finger devices that measure blood pressure at the finger are not recommended. This is of the inaccuracies caused by measurement distortion with peripheral vaso-constriction, the alteration in blood pressure due to the more distal the site of recording and the effect of limb position on blood pressure.

- Wrist devices that measure blood pressure at the wrist are subject to the latter two problems. Although, more accurate than finger measuring devices, there are strong reservations about the correct use of these devices, especially with regard to the correct placement of the occluding cuff at heart level.

- Upper arm devices are the most recommended automated device to use in measuring blood pressure in general for which
appropriate cuff sizes should be available. It may not be possible to measure blood pressure with automated device in patients with arrhythmias. Moreover there are some patients in whom automated measurement is not possible but the reason is not obvious.\textsuperscript{(141)}.

- Ambulatory blood pressure monitoring (ABPM) is more expensive than conventional blood pressure measurement (CBPM) but the benefits to patients are more and justify the additional expenses.\textsuperscript{(142)} Experience in adults has shown that ambulatory blood pressure is a better predictor of end organ damage than causal readings. It is possible that ambulatory blood pressure in children could provide the basis for easier and earlier recognition of abnormal blood pressure behavior, but interpretation depends on knowledge of normal ranges.\textsuperscript{(143)}

- Some clinical indications for (ABPM) are exclusion of white coat hypertension, deciding diagnosis in borderline hypertension, elderly patients, identification of nocturnal hypertension, hypertensive patients resistant to treatment, as a guide to antihypertensive drug treatment, hypertension of pregnancy and diagnosis of hypotension.\textsuperscript{(142-145)}
Patients with daytime ambulatory pressure lower than 135/85 mmHg have a low risk of subsequent events. A ambulatory pressure of 135/85 mmHg thus represents good control and approximately corresponds to a clinic pressure of 140/90 mmHg\(^{(146,149)}\).

Masked hypertension or isolated ambulatory hypertension, consists of an elevated daytime or awake ambulatory blood pressure in the presence of a normal pressure on conventional blood pressure measurement at the office. In adults, masked hypertension is associated with increased left ventricular mass and a worse cardiovascular prognosis\(^{(150)}\).

1.13 **Technique of Blood Pressure Measurements:**

Blood pressure may be measured by auscultation, palpation, Doppler ultrasound or oscillometric techniques. For correct measurements, the blood pressure cuff must be wide enough to cover two thirds of the arm and the bladder must be long enough to encircle at least half of the arm. Blood pressure may be falsely elevated if the cuff is small or if the measurements are obtained in the lower leg of infants or children who are in a sitting position\(^{(151)}\).

Patients should not have smoked or ingested caffeine within 30 minutes before measurement, seated with their arm at heart level, measurement should begin after 5 minutes of rest, both (SBP) and (DBP)
must be recorded, disappearance of sound fifth Korotkoff is used for the diastolic reading, two or more readings every two or more minutes should be averaged. If two consecutive readings differ by more than 5 mmHg, additional readings should be obtained, measurements should be taken with a mercury sphygmomanometer or recently calibrated aneroid or electronic manometers\(^{(152,153)}\). Report on high blood pressure in children and adolescents recommended use of the fifth Korotkoff sound to determine diastolic blood pressure in children and adolescents rather than the fourth sound\(^{(154)}\). Seated blood pressure recordings are generally sufficient, but standing blood pressure should be measured in elderly or diabetic patients to exclude orthostatic hypotension. Ambulatory blood pressure monitoring may be helpful\(^{(155)}\).

The most accurate devices for measuring blood pressure is intra-arterial catheters but they are not appropriate for routine screening because of their invasiveness, technical limitations and cost. Office sphygmomanometry remains the most appropriate screening test for hypertension in the asymptomatic population\(^{(156)}\).

British Hypertension Society (BHS) protocol recommends the use of two different gold standards namely the Doppler mercury technique as described by de Swiet et al for under 5 years olds and conventional mercury sphygmomanometry for 5-15 years olds\(^{(157)}\).
Cuff dimensions are most important and three cuffs with bladders measuring 4 × 13 cm, 10 × 18 cm and the adult dimensions 12 × 26 cm are required for the range of arm sizes likely to be encountered in the age range 0-14 years \(^{(158)}\). In elderly people considerable blood pressure variability, which can lead to a number of circadian blood pressure patterns that are best identified using ambulatory blood pressure measurement \(^{(158)}\).

### 1.14 Diagnosis of Hypertension in Children:

It is unusual for pediatric hypertension to be diagnosed as a result of the patient's complaint or symptom; most hypertension is clinically silent. For this reason, it is appropriate to measure blood pressure as a part of all routine medical examinations and all patients who have persistent blood pressures greater than the 95\(^{th}\) percentile should be evaluated more thoroughly. Because tracking data suggest that patients whose blood pressure is between the 90\(^{th}\) and 95\(^{th}\) percentile develop overt hypertension at a higher frequency than more normotensive patients, they should be followed carefully \(^{(159)}\).

Many clinicians begin evaluations for patients who have other risk factors, including a history of umbilical catheter lines, recurrent urinary tract infections, diabetes, other cardiovascular disease, or a significant family history \(^{(159)}\). The extent of the evaluation depends on the age of the
child, the severity of the hypertension, the extent of end-organ damage and
the long term risk factors for the individual patient (159).

Personal and family history should include specific questions regarding neonatal course urinary tract infections, other significant medical illnesses or traumas and medication use (159). It should also include family history of hypertension, early cardiovascular, cerebro-vascular events or end-organ renal disease (159).

The physical examination includes evaluation for four extremity specific pulses and blood pressure, bruits, and skin lesions in addition to the standard components. The initial phases of evaluation should characterize the severity of the hypertension and identify common causes that require additional evaluation. Most physicians obtain these investigations complete blood count (CBC), serum electrolytes, urea & creatinin, serum glucose, uric acid, and urinalysis. Lipid profile which includes total cholesterol, low-density lipoprotein (LDH), high-density lipoprotein (HDL) and triglycerides. Renal ultrasonography is helpful in searching for an underlying renal pathology and Doppler ultrasonography for the renal vessels.

Cardiac evaluation is important in the search for causes such as coarctation of the aorta and for defining the extent of end-organ damage, such as left ventricular hypertrophy. Electrocardiography (ECG) and chest radiography have been considered as standard studies for cardiac
evaluations in the past, but they are insensitive. Most clinicians use Echocardiography (ECHO) for more definitive and quantifiable information.

Ophthalmologic evaluation is helpful in determining the long-term effects of hypertension, although children do not suffer from retinal changes as frequently as do hypertensive adults.

Faced with an obese hypertensive adolescent who has a negative medical history, normal laboratory screening results, negative findings on ultrasonography, and positive family history, most clinicians would halt the evaluation. They make an initial diagnosis of essential hypertension and begin considering therapy. Additional evaluation can be undertaken later if the clinical course suggests a secondary cause. More intensive evaluation is warranted, when the initial screening evaluation detects a possible secondary cause, in situation such as the age of the patient rules out essential hypertension, or hypertension is severe.

Measurement of plasma rennin, aldosterone, and thyroid function as well as urine drug screening may be considered, depending on the possible expected diagnosis. Rennin and aldosterone are elevated in renal parenchyma disease and reno vascular disease. The electrolyte abnormalities, usually hypokalemic alkalosis, suggest the possibility of endocrine causes of hypertension.
In the presence of congenital urinary tract anomalies, nuclear imaging with 99m Tc-diethylene triamine pentaacetic acid (DTPA) can evaluate bilateral function and possible obstruction, 99m Tc-dimercaptosuccinic acid scintigraphy (DMSA) or glucoheptonate can identify areas of renal ischemia and scarring, with more accuracy and less radiation than the standard intravenous pyelography, angiography, magnetic resonance imaging (MRI), computed tomography (CT) and angiography for evaluation renal-vascular disease. The evaluation for possible pheochromocytoma requires measurement of timed urinary catecholamines. In these tumors, epinephrine, nor epinephrine, and their metabolites (vanillylmandelic acid and homovanillic acid) are elevated. Ultrasonography and (CT) results can be negative because many of the tumors are small.

However, nuclear imaging with meta iodobenzyl guanidine (MIBG), which is a radio iodinated compound that localizes to storage granules in neural crest cells, is very sensitive and helpful when the tumor is located elsewhere than the traditional adrenal or para-ganglionic positions.\(^{(159)}\)

Measuring blood pressure at home is recommended to distinguish sustained hypertension from white coat hypertension, and to monitor treatment.\(^{(159)}\) Blood pressure measured at home is a better predictor of 24 hour ambulatory blood pressure monitoring, target organ damage, and cardiovascular mortality than that measured by doctors.\(^{(160)}\)
However, some patients of low educational level may have poor reporting accuracy, which may affect the assessment of blood pressure. 

1.15 Management of Hypertension:

Although the decision to treat a child who has severe hypertension and end-organ damage is relatively straightforward, the management of a child or adolescent who has relatively mild hypertension and no end-organ damage remains controversial. In these situations, many clinicians begin with conservative measures, progressing to pharmacologic therapy only when conservative measures fail or the hypertension worsens.

1.15.1 Non pharmacological management of hypertension:

The goal of treatment for pediatric hypertension is to decrease short- and long-term risks of cardiovascular diseases and end-organ diseases that result from high blood pressure.

The most commonly used non pharmacologic measures are salt restriction, weight loss, exercise, and cessation of smoking. Restriction of sodium chloride intake to 4 to 5 g/d will decrease blood pressure by approximately 8 mmHg. There are no current recommendations for the use of supplemental potassium, calcium or magnesium in the treatment of pediatric hypertension.
The associations between obesity and hypertension are strong in some studies, obesity accounts for as much as (45%) of hypertension in adolescents. Therefore, nutritional counseling for weight loss should be a part of the therapeutic strategy for managing hypertension in the overweight child.

The addition of exercise to a hypertensive child’s lifestyle has beneficial effects on both blood pressure and overall health. The current recommendations from the American Academy of Pediatrics limits competitive sports and highly static exercise in patients who have severe hypertension only until their hypertension is under adequate control and there is no evidence of end-organ damage, such as arrhythmia or (ST) segment depression. Dynamic exercise and participation in organized sports is encouraged for all other patients whose hypertension is less severe or is well controlled (161-163).

1.15.2 Pharmacological management of hypertension:

Pharmacological management of hypertension could be categorized in five groups including, angiotensin-converting enzyme inhibitors, beta adrenergic blocking drugs, diuretics, calcium channel blockers and vasodilators.

1.15.2.1 Angiotensin - converting enzyme inhibitors:

Angiotensin converting enzyme inhibitors drugs reduce the production of angiotensin, a chemical substance that causes arteries to
constrict. Angiotensin converting enzyme (ACE) inhibitors are effective and with no adverse effects on plasma lipids or glucose tolerance. They prevent the progression of diabetic nephropathies, and glomerulopathies but appear to be less effective in black patients than in white patients. Patients with high levels of plasma rennin activity may have an excessive hypotensive response to (ACE) inhibitors. In individuals with renal vascular disease and those with single kidney, in whom renal perfusion is maintained by high levels of angiotensin Π, irreversible acute renal failure develops when treated with (ACE) inhibitors.

Drugs commonly used under this category include:

- **Captopril (Capoten)** - prevents conversion of angiotensin I to Angiotensin Π, a potent vasoconstrictor; lower aldosterone secretion.

- **Enalapril / enalaprilat** (Vasotec PO/IV):

  Competitive inhibitor of (ACE), reduces angiotensin Π levels and decreasing aldosterone secretion.

- **Lisinopril** (Prinivil, zestril) - Prevents conversion of angiotensin I to angiotensin Π, a potent vasoconstrictor, resulting in lower aldosterone secretion.
1.15.2.2 Beta-adrenergic blocking drugs:

Beta adrenergic blocking drugs block the effects of adrenaline, thus easing heart's pumping action and widening blood vessels. This category include the following drugs:

- **Propranolol (Inderal, Betachron E-R):**
  
  Non-selective beta-blockers acts on both beta 1 and beta 2 adrenergic receptors, which explains bradycardiac and broncho-spastic effects. Non-selective beta-blockers increase triglyceride levels and decrease high density lipoprotein (HDL) cholesterol.

- **Atenolol (Tenormin):** Selective beta-blocker; has greater effect on beta 1 than on Beta 2 receptors. As a result, has less of a tachycardia and broncho-spastic action than non-selective beta-blockers.

- **Labetalol (Normodyne, Trandate):** combines non-selective adrenergic blockade and sympathomimetic activity with alpha adrenergic receptor blockade. Decreases blood pressure more promptly than other beta-blockers. Equally effective in blacks and whites. Does not affect serum lipid levels.

1.15.2.3 Diuretics

Diuretics exert their antihypertensive effects by promoting salts and water excretion. Diuretics should be considered the first line of treatment for hypertension due to acute post-streptococcal glomerulonephritis.
1.15.2.3.1 Thiazide diuretics

- Chlorothiazide (Diuril) inhibits re-absorption of sodium in distal tubules, causing increased excretion of sodium and water as well as potassium and hydrogen ions.

- Hydrochlorothiazide: (Esidrix, HydroDIURIL) inhibits re-absorption of sodium in distal convoluted tubules, causing increased excretion of sodium and water as well as potassium and hydrogen ions.

1.15.2.3.2 Loop diuretics

- Furosemide (Lasix). Inhibits sodium chloride reabsorption in the thick ascending limb of Henle loop.

1.15.2.3.3 Potassium-sparing diuretics:

- Spironolactone (Aldacton) which is used for management of hypertension, may block effects of aldosterone on arteriolar smooth muscles.

1.15.2.4 Calcium-channel blockers:

Calcium channel blockers agents inhibit calcium movement into vascular smooth muscle, thereby inhibiting vasoconstriction.

- Diltiazem (Cardizem, Dilacor, Tiamate, Tiazac) which help decrease the contractions of the heart and widen blood vessels.

- Nifedipine (Adalat, Procardia): relaxes coronary smooth muscle and produces coronary vasodilatation, which, in turn, improve myocardial oxygen delivery. Used for hypertensive emergencies.
• Verapamil (Calan, Isoptin) during depolarization, inhibits calcium ion from entering slow channels or voltage-sensitive areas of vascular smooth muscle and myocardium.

1.15.2.5 Vasodilators:
Vasodilators agents which act to widen blood vessels, are often used in combination with a diuretic or a beta-blocker. They are almost never used alone by themselves.

Representative vasodilators include hydralazine (Apresoline), Clonidine (Catapress, available in tablets or as a skin patch) and Minoxidil (Loniten). Some of these drugs should be used with caution or not at all in people with angina or who have had a heart attack.\(^{164}\)

1.16 Complications of Hypertension:
The natural history of hypertension is dictated by pathological changes that occur in the cardiovascular system.

1.16.1 In blood vessels:
Pathology of hypertension is complex and involves remodeling and other structural changes in the wall. These changes vary according to the severity of hypertension and whether the vascular system is influenced by other risk factors, particularly smoking and abnormal lipids. In patients with lipid abnormalities, hypertension accelerates atherosclerotic disease.
In mild to moderate hypertension, the lumen size of small blood vessels is reduced as a consequence of rearrangement of smooth muscle cells within the vessel wall and hypertrophy, together with evidence of tissue rarefaction.

In moderate hypertension, degenerative changes in the vessel wall lead to hyaline deposition and obliteration of the blood supply to vital tissues such as the kidney and the brain. With more severe hypertension and the development of the malignant phase, there is fibrinoid necrosis. Degenerative changes occur in the vessel wall with fibrin deposits in small arterioles leading to intra-vascular thrombosis and tissue ischemia.

Remodeling of the vascular wall occurs as hypertrophy, in which the smooth muscle cells enlarge in response to elevations in arterial pressure. Growth factors, either circulating or locally synthesized may also be involved in the hypertrophic response.

Changes in the larger vessels are also associated with a reduction in lumen size, a loss of wall compliance and in many sites, an increased propensity for the formation of atheroma. When hypertension coexists with dyslipidemia, the injury to the vascular endothelium stimulates enhancement of deposition of lipids within the vascular wall.
1.16.2 In the brain:

Hypertensive vascular changes produce a spectrum of disease including haemorrhagic and thrombotic strokes. In some hypertensive populations, notably those of Afro-Caribbean origin, small-vessel disease leads to multi-infarct dementia. In the malignant phase hypertension, the small vessel disease produces the syndrome of hypertensive encephalopathy with multi-focal neurological deficit.

1.16.3 In the heart:

Vascular changes lead to a progressive reduction in coronary reserve. The left ventricle enlarges as a consequence of raised arterial pressure. In the early stages, this may be seen as a protective adaptation to higher levels of pressure. With sustained hypertension, there is enlargement of cardiac myocytes and increased deposition of extracellular collagen matrix, which contributes to the loss of compliance of the ventricle and progressive left ventricular dysfunction. The combination of worsening left ventricular compliance and hypertension-associated coronary artery disease leads to cardiac failure, unless the process is interrupted by the treatment.

1.16.4 In the kidney:

In milder forms of hypertension, renal function is preserved, but as pressures rise or hypertension is not adequately controlled, hypertensive vascular disease progressively impairs renal function\(^{(165-167)}\).
1.16.5 In the bone:

Hypertension increases the elimination of calcium in urine that may lead to loss of bone mineral density, a significant risk factor for fractures, particularly in elderly women. In one study of English women, those with the highest blood pressure lost bone density at nearly twice the rate of those in the lowest range. It is not clear whether this effect occurs in men or white women.

1.16.6 Sexual dysfunction:

Some form of sexual dysfunction occurs in about a quarter of hypertensive men. It is often caused by medications that treat high blood pressure. One study suggested, however, that impotence in hypertensive men most likely occurs as a consequence of the blood-pressure-lowering effects of antihypertensive drugs rather than specific actions in the drugs themselves, blocked arteries which are common in people with hypertension, or both. Impotence related to hypertension is treatable.\(^ {165-167}\).

1.16.7 In the eyes:

Optic fundi: grade III-IV are hallmarks of malignant hypertension.

- Can present with impairment of vision ranging from blurring to blindness.
- Loss of auto-regulation of retinal vessels due to hypertension, resulting in development of areas of narrowing and dilatation in the
vessels.

- Retinal hemorrhages due to necrosis of capillary and pre-capillary arteriolar walls.

- Hard exudates due to endothelial damage leading to leakage and deposition of plasma proteins in the posterior retina. In the macular region, this may form a radiating pattern called the macula stare.

- Soft exudates due to ischemic infarct of the nerve fibers.

- Papilledema due to swelling of the optic disc with obliteration of the cup. Early signs include overfilling of veins, loss of venous pulsation, hyperemia of the nerve head and blurring of the disc margins. With treatment of hypertension, retinal lesions can be reversed and vision often returns to normal (166-168).

1.17 PROGNOSIS:

The detection of high blood pressure during childhood is of potential value in identifying those children who are at increased risk of primary hypertension as adults and who might benefit from earlier intervention and follow-up. Hypertensive vascular and end organ damage may begin in childhood. A relatively high proportion of children with hypertension have secondary, potentially curable forms (156). Early detection and treatment of hypertension have shown the value in
reducing the incidence of congestive heart failure, renal failure, stroke and death (138).
Chapter two

2. JUSTIFICATIONS AND OBJECTIVES

2.1 Justifications:

2.1.1 Hypertension is one of the most common diseases affecting humans worldwide. Because of the associated morbidity and mortality as well as cost to the society, hypertension is an important public health challenge.

2.1.2 Hypertension is classified as a major risk factor for developing irreversible macro and micro-angiopathies affecting the cardiovascular, renal, central nervous systems, eyes and other systems. These effects of hypertension may begin during childhood.

2.1.3 Identifying associated factors in children with hypertension can give valuable information for prevention, by developing suitable modifications such as modifying lifestyle and macro and microenvironment of the child.

2.1.4 Change of life style in Yemen with rapid socio-demographic changes and urbanization will lead to an increase in life style organic disorders.

2.1.5 No similar studies were done in Yemen addressing hypertension in childhood.
2.2 **OBJECTIVES:**

2.2.1 **General Objectives:**

To identify the patterns of blood pressure in primary and secondary school children in Aden Governorate

2.2.2 **Specific Objectives:**

2.2.2.1 To determine the prevalence and types of high blood pressure in these children.

2.2.2.2 To explore the main possible associated risk factors in those with high blood pressure.
Chapter Three

3- MATERIAL AND METHODS

3.1 Nature of the Study:

This is a cross sectional, community based study.

3.2 Study Area:

The study was conducted in Aden Governorate in which there are eight districts which include 69 primary schools and 22 secondary schools. Aden total population is 721,620 inhabitants, while the number of children aged 6-16 years, is 114,987 of whom 87.5% are enrolled in schools.

Thirty-two schools were approached in Aden Governorate, all agreed to participate in the study. Eighteen were primary and fourteen were secondary. Seven districts of Aden Governorate were included: Carater, Maala, Twahi, Khormakser, Al-Mansora, Al-sheikh Othman and Dar Saad.

3.3 Duration of the Study:

A school-based screening was performed during the period from November 2002 through to April 2004.
3.4 Study Population and Sampling Technique:

3.4.1 Study population:

The study population considered a total of 10,082 male and female students from 1st to 9th classes of primary schools and 1st class of secondary schools.

3.4.2 Sample size

The sample size was calculated applying the following statistical equation:

\[ N = \frac{Z^2 \times pq}{d^2} \]

Where \( Z \) = Statistical certainty.

\( P \) = Prevalence of hypertension

\( q \) = 1 - \( p \)

\( d \) = Margin of error

\[ 1.96^2 \times 0.03(1-0.03) = 3.8416 \times 0.0291 \]

\[ \frac{3.8416 \times 0.0291}{(0.005)^2} = 4471 \]

While the sample size in the study is 10,082 students.

3.4.3 Sample technique:

We had selected randomly the 1st class from each level to be studied in each school. All the participant students in the first screen were
given a questionnaire to be filled by the parents and a consent form. The questionnaire included personal data such as name of students, age, sex, date of birth, address, telephone number. It also included the past history such as sore-throat, skin infection, macroscopic hematuria and others. The family history included the fathers' and the mothers' diseases such as cardiovascular diseases, hypertension, kidney diseases, diabetic mellitus, obesity and others, along with consanguinity and number of siblings.

The social history included father's and mother's education and occupation and the family monthly income. The social habits included if the father and / or mother and the student is a smoker or chewing Kat.

The other questionnaire was filled by the author and other trained doctors which included personal data such as student name, school name and other personal data. The present history included symptoms such as headache, dizziness, changes in vision, palpitation, fatigability and others. The past history included childhood infection, (UTI), other renal problems, skin lesions, Rheumatic Fever and others.

The physical examination, included anthropometric examination such as height and weight. Systemic examination included respiratory system signs and cardiovascular system signs, blood pressure (BP), while abdominal findings included signs as liver, spleen, kidney sizes, other masses, central nervous system (CNS) examination and ophthalmologic examination.
Age was determined based on the date of birth registered in the first screening, weight was measured in each student by electronic scale DC9V = 0.2W, made in Japan. Height was measured using tape measure and student standing to wall looking straight without shoes.

Body mass index (BMI) was calculated as weight (kg) / height (m)². The most current pediatric anthropometric reference data specific for gender and age was used to established height, weight and (BMI) percentile for each subjects.

Techniques for checking blood pressure, (BP) measurements were made throughout the regular school day in a quite isolated room. Blood pressure was determined by using a stethoscope and standardized mercury sphygmomanometers with appropriate cuff, covering two-thirds of the upper left arm. The student should be seated for five minutes rest with their arm supported at the level of heart and cuff adjusted for arm circumference and then deflated at 2 mmHg /sec and (BP) measured to the nearest 2 mmHg. Systolic blood pressure (SBP) was taken upon hearing the first sound while diastolic blood pressure (DBP) was taken upon complete disappearance of Korotkoff sounds (phase V). We record two (BP) measurements, with two minutes interval between each measurement. The participants were categorized into normal blood pressure (SBP and / or DBP) < 90th percentile, high normal blood pressure (SBP and / or DBP) at 90th - 95th.
percentile and hypertension (SBP and/or DBP) > 95th percentile for gender, age and height according to the Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents.

SPSS program was used for data processing, data analysis and statistical analysis.

3.5 Ethical Issues:

Prior to the survey, the following permissions were obtained.

- Permission from the local Authorities.
- Permission from the School Headmaster.
- Consent from the Child and his Parents.

3.6 Inclusion Criteria:

Students, aged 6-16 years, in the selected schools were included in the study.

3.7 Exclusion Criteria:

Those children and/or parents who refused to be included in the study or to perform the required investigations were excluded from the study.
3.8 Statistics:

Data collected and the variable results were analyzed in the computer, using SPSS (statistical package for social sciences) Software, for sample tabulation and statistical analysis, Chi-square test \( (x^2) \) was used to (95%) significance level. P value of < 0.05 was considered as a finding of statistically significant difference.

3.9 Difficulties:

- Some of the schools covered by the survey were undergoing maintenance which jeopardized the collection of data.
- Transfer of some of the selected students to schools in other cities following their families transfer.
- Refusal of some students and/or their parents to be involved in the survey.
- Difficulties in conducting tests to some of the selected girl students due to some socio-cultural restrictions which do not allow partial taking of girl clothes for medical checkup even by female doctors.
- Non abidance of some selected students to come to school without taking breakfast made it difficult to conduct the fasting blood sugar tests. The same problem was
encountered for students who attended afternoon schools. This had been replaced by random blood sugar test.

- Refusal of the parents to allow their children to undergo Chest X Ray and Electrocardiography (ECG) in the Hospital.
Chapter Four

4· RESULTS

4.1 General Characteristic of the Study Group:

4.1.1 Age and gender:

10,082 students were enrolled in this study during the period from November 2002 to April 2004, in different schools in Aden Governorate. Males constituted 4766 (47.3 %) while females constituted 5316 (52.7 %), that gave a female to male ratio of 1.1: 1, (Figure 1).

The age of the study population ranged between 6 -16 years with age mean $11.6 \pm 2.94$ S.D. The distribution of students in the first screen, age group 6 - < 9 years, was 1937 students (19.2%) of whom 962 males (9.5 %) and 975 females (9.7 %). Age group 9 - < 13 years was 3854 students (38.2 %) of whom 1756 males (17.4 %) and 2098 females (20.8 %). While age group 13-16 years was 4291 students (42.6 %) of whom 2048 males (20.3 %) and 2243 females (22.3%) as shown in (Figure 2).

Among male students, 4161 (87.3%) had normal blood pressure while high blood pressure and hypertension were found in 433 (9.1%) and 172 (3.6%) respectively. In female students normal blood pressure was observed in 4426 (83.3%) while high blood pressure and hypertension were observed in 617 students (11.6%) and 273 students (5.1%), respectively (Figure 3).

The prevalence of high blood pressure and hypertension was
higher in females than in males and the overall prevalence of hypertension was found in 445 students (4.4%) after the first screen. From the 445 students with hypertension found in the first screening, 412 students (92.6%) were enrolled in the second screening, the remaining thirty three students were excluded from the study because of their transfer to other cities. Normal blood pressure, high blood pressure and sustained hypertension were observed in 71 students (17.2%), 141 students (34.2%) and 200 students (48.6%), respectively (Table 1).

The prevalence of hypertension decreased in the second screen from 445 students (4.4%) to 200 students (2%). The frequency of hypertension in the first screen had shown sharp fluctuation for different ages, could be due to anxiety of the students being exposed for the first time to blood pressure measurements. However, results of the second screen shows systematic increases of hypertension with age (Figure 4). Age related hypertension in second screen in males was relatively high among age group 14-15 years while in females it was higher among age group 13-15 years (Figure 5).

4.1.2 Origin:

All the students covered by the study were from Aden Governorate, the second largest city and the economic capital of Yemen. The frequency of hypertension according to the districts of origin was also observed. The number of students in Crater district was 1501 (14.9%) including 718 male students (47.8%) among whom only five students (0.33%) were
found to be hypertensive and 783 female students (52.2%) of whom eight students (0.54%) had hypertension. Therefore, a total of 13 students had hypertension constituting (0.87%). In Maala district the total number of students was 960 (9.6%) including 384 males (40%) and 576 females (60%), of whom ten students were found to have hypertension, six males (0.62%) and four females (0.42%) which constituted (1.04%). In Twahi district, the total number of students was 1782 (17.73%) including 870 males (48.8%) and 912 females (51.2%) and hypertension was observed among 28 students (1.57%), seven males (0.39%) and 21 females (1.18%). In Khormakser district the number of students was 1661 (16.53%) including 772 males (46.5%) and 889 females (53.5%) with a total number of hypertensive students found to be 38 (2.29%), eight males (0.48%) and 30 females (1.81%). In Mansora district the number of students was 2388 (23.76%) including 957 males (40.1%) and 1431 females (59.9%) and hypertension was detected in 87 students which constituted (3.64%), 38 males (1.59%) and 49 females (2.05%). In Sheikh-Othman district the number of students was 1315 (13.09%) including 731 males (55.6%) and 584 females (44.4%) with a total number of hypertensive students found to be 19 which constituted (1.44%), nine males (0.68%) and ten females (0.76%). In Dar-Sad district the number of students was 442 (4.40%) including 318 males (71.9%) and 124 females (28.1%) and hypertension was observed in five students (1.13%), all of them were males.
The prevalence of hypertension according to districts was (3.64 %) in Mansora, followed by Khormakser, Twahi, Sheikh-Othman, Dar-Sad, Maalla and Crater which was (2.29 %), (1.57 %), (1.44 %), (1.13%), (1.04%), (0.87 %), respectively (Figure 6).

4.2 Blood Pressure and Clinical Findings of the study population:

4.2.1 Pattern of blood pressure in relation to age and gender percentiles:

Four thousand four hundred and eighty seven male students (96.0%) had systolic blood pressures (SBP) at the 50th percentile and 185 students (4.0 %) at the 90th-95th percentile. The number of male students with high systolic blood pressure was more at ages of 8, 9, 11, 13 and 14 years (Table 2). Four thousand three hundred and eight male students (92.2 %) had diastolic blood pressure (DBP) at the 50th percentile, 364 male students (7.8%) at the 90th –95th percentile. The number of male students with high (DBP) was more at ages 7 and 13-16 years (Table 3).

Four thousand eight hundred seventy nine female students (94.2 %) had systolic blood pressure at the 50th percentile while 298 female students (5.8%) at 90th – 95th percentile. The number of female students with high (SBP) was more at ages of 9 and 12-15 years (Table 4). Regarding the diastolic blood pressure among females, it was found that 4635 female
students (89.5%) had diastolic blood pressure at the 50th percentile, while 542 (10.5%) were at the 90th – 95th percentile. The number of female students with high (DBP) was more among ages 13-16 years (Table 5).

The mean (SBP) and (DBP) in male and female students in this study were less than those observed in a similar study done in Jordan. The comparison between the two studies is shown in tables (Table 6, 7).

4.2.2 Pattern of blood pressure and body mass index (BMI):

One-thousand eight hundred and sixty students had a (BMI) lower than 5th percentile (underweight), of whom 1854 students (99.68%) had normal blood pressure and only six students (0.32%) had hypertension. Seven thousand and ninety eight students had (BMI) at the 5th - 85th percentile (normal weight), of whom 6999 students (98.61%) had normal blood pressure, and only 99 students (1.39%) had hypertension. Eight hundred and eight students had (BMI) at the 85th-95th percentile (high risk), of whom 751 students (92.95%) had normal blood pressure and 57 students (7.05%) had hypertension. Two hundred and eighty three students had (BMI) greater than 95th percentile (over weight), of whom 245 students (86.57%) had normal blood pressure, while 38 students (13.43%) had hypertension with (P value<0.0000) which is statistically significant.

Among underweight students, only (0.32%) had hypertension, while 1.39%, 7.05% and 13.43% had hypertension in those students who had normal weight, high risk weight and overweight, respectively (Figure 7).
4.2.3 Grades of severity of hypertension:

The number of students who had stage 1 hypertension were 57 males and 76 females, while those with stage 2 hypertension were only 21 males and 46 females. These results show that stage 1 hypertension was more prevalence among males (73.1%) compared to females (62.3%). On the other hand stage 2 hypertension was more prevalent among females (37.7%) compared to males (26.9%) (Figure 8). Stage 2 hypertension was not detected in children less than eight years, however it was found in children from eight years of age with the highest prevalence being at age nine years (66.7%) (Figure 9).

Regarding types of hypertension, systolic hypertension was more frequent, constituting (51.0%) of all hypertensive students, followed by systo-diastolic hypertension (45.0%) and diastolic hypertension (4.0%) consequently (Figure 10).

At age group 6 -11 years values of height, weight and (BMI) were found nearly equal in both sexes, while in age group 12 –14 years the females values of height, weight, and (BMI) were more than those of males. At the age group 15-16 years male values of height were more than those of females. The mean (SBP) and (DBP) values of females were more than those of males in age group 7-16 years (Table 8,9).
4.2.4 Other clinical findings:

Chest examination was found to be normal in all male students, while 48 female students (0.9%) had abnormal chest findings such as wheezes and crepitations.

Cardiovascular examination showed that four males (0.08%) and 14 females (0.3%) had first grade murmur which was mostly soft and localized. Among male students (96.1%) had normal pulse rate and only (3.9%) had tachycardia, while in female students (88.6%) had normal pulse rate and (11.4%) had tachycardia (Figure 11).

Concerning abdominal examination, four male (0.08%) and five female students (0.09%) had a just palpable liver. Two male students (0.04%) had palpable spleen while no female students had palpable spleen and no other masses were palpable for all. Regarding central nervous system and ophthalmologic examination, all students were found within normal.

4.3 Clinical Symptoms of the Study Group:

Two thousand five hundred and twenty six students had headache without hypertension which constituted (25.6%) of non hypertensive students while 62 students had headache with hypertension which constituted (31%) of hypertensive students. Among the students who had no hypertension, 1715 students (17.41%) had dizziness, 1433 students (14.55%) had changes in vision, 207 students (2.10%) had palpitations and
575 students (5.84%) had fatigability. On the other hand, among the hypertensive students, 37 students (18.5%) had dizziness, 39 students (19.5%) had changes in vision, four students (2.0%) had palpitation and 13 students (6.5%) had fatigability with (P value = 0.1, 0.8, 0.06, 0.9, 0.8) respectively which is statistically not significant (Figure 12).

4.4 Past Medical History of the Children:

Among the students 9849 who had no hypertension, 3163 students (32.1%) had past history of tonsillitis, 78 students (0.79%) had past history of passing red urine, 494 students (5.02%) had childhood infections, 278 students (2.82%) had other renal problems, 954 students (9.69%) had urinary tract infections and 416 students (4.22%) had skin infections. On the other hand among the 200 hypertensive students, 62 students (31%) had past history of tonsillitis, three students (1.5%) had past history of passing red urine, 17 students (8.5%) had past history of childhood infections, nine students (4.5%) had past history of other renal problems, 24 students (12%) had urinary tract infections and eleven students (5.5%) had past history of skin lesions with (P value = 0.8, 0.5, 0.04, 0.23, 0.33, 0.48), respectively which is statistically not significant (Figure 13).
4.5 Relevant Family History:

4.5.1 Parents' health:

The family history of diseases and hypertension was obtained, including history of hypertension, diabetes mellitus and obesity.

Hypertension, diabetes mellitus and obesity of the fathers were found to be positively related to hypertension among their children and this is statistically significant (P value < 0.000, 0.000 and 0.04), respectively.

Regarding the mothers' side, history of hypertension, diabetes mellitus also had a positive relation with the students' hypertension which is statistically significant (P value < 0.000, 0.02) respectively. The other family history of diseases such as father's heart diseases and kidney diseases, statistically, had no significant relation to students' hypertension, with (P values = 0.8 and 0.9), respectively. From the mother's side, heart diseases, kidney diseases and obesity, statistically, had no significant relation to students' hypertension with (P values = 0.9, 0.2 and 0.2), respectively (Table 10).

4.5.2 Consanguinity:

Among 2690 students whose parents were consanguineous, 57 students (2.1%) had hypertension while among the 7359 students whose parents had no consanguinity, 143 students (1.9%) had hypertension. Parents consanguinity had, statistically, no significant relationship to students hypertension with (P value = 0.31) as shown in (Figure 14).
4.5.3 Number of siblings, brothers and sisters in relation to hypertension:

Five thousand one hundred and sixty five students had 1-4 siblings and from those, 100 students (1.9%) had hypertension. From the 3278 students with 5-7 siblings, 65 students (2.0%) had hypertension. From the 1229 students with 8-10 siblings, 26 students (2.1%) had hypertension, while from 377 students with more than ten siblings, nine students (2.4%) had hypertension, with (P value = 0.923) which is statistically not significant (Figure 15).

4.5.4 Family history of hypertension:

Eight thousand seven hundred and thirty one students had no family history of hypertension, and from those only 126 students (1.4%) had hypertension. Out of 561 students whose fathers had hypertension, 534 students (95.2%) had no hypertension while 27 students (4.8%) had hypertension. Among 577 students whose mother's had hypertension, 544 students (94.3%) had no hypertension while 33 students (5.7%) had hypertension. Out of 180 students whose both parents had hypertension, 166 students (92.2%) had no hypertension while 14 students (7.8%) had hypertension as shown in (Figure 16).
4.6 The Socioeconomic Status of the Families of the Children in the Study Group:

4.6.1 Parents' education and occupation:

Among 625 students whose fathers were illiterate, only eight students (1.28%) had hypertension. While among 2401 students whose fathers had primary school education, only 44 students (1.83%) had hypertension. Among 3886 students whose fathers had secondary school education, only 80 students (2.06%) had hypertension and among 3137 students whose fathers had university education, 68 students (2.17%) had hypertension. The rate of hypertension increased among students of fathers with secondary and university education levels, although it is statistically not significant (P = 0.471).

Among 2843 students whose mothers were illiterate, only 62 students (2.18%) had hypertension while 3273 students whose mothers had primary school education, only sixty students (1.83%) had hypertension. Among 2832 students whose mothers had secondary school education, only 50 students (1.77%) had hypertension. Out of 1101 students whose mothers had university education, 28 students (2.54%) had hypertension. The rate of hypertension increased among students of mothers with university education and those who were illiterate, although it is statistically not significant (P = 0.334) as shown in (Figure 17).
The rate of hypertension was higher among students whose fathers were professionals, business-man, simple laborers and skilled laborers, (3.98, 2.99, 2.09 and 2.03) respectively with (P value = 0.457) which is statistically not significant. The rate of hypertension was higher among students whose mother's occupation is professional, skilled laborers and unemployed (5.13, 4.0, 2.0) respectively with (P value = 0.711) which is statistically not significant (Figure 18).

4.6.2 Parents' income:

Among 6334 students whose families had low income, only 114 students (1.8 %) had hypertension. While among 2847 students whose families income was moderate, only 66 students (2.3 %) had hypertension. Out of 868 students whose families had a high income, only 20 students (2.3 %) had hypertension. Consequently the rate of hypertension was higher among those whom parents income was higher, with (P value = 0.203) which is statistically not significant (Table 11).

4.6.3 Social habits:

Among 4266 students whose fathers smoked, only 77 students (1.8%) had hypertension. Among 6512 students whose fathers chewed Kat only 119 students (1.8%) had hypertension. Out of 140 students whose mothers smoked, only two students (1.4%) had hypertension while among the 459 students whose mothers chewed Kat, only 12 students (2.6%) had
hypertension. Among 18 students who smoked, one student (5.6%) had hypertension. Among 64 students who chewed Kat, four students (6.3%) had hypertension with (P values = 0.28, 0.13, 0.9, 0.4, 0.8, 0.8) respectively, which are statistically not significant (Table 12).

4.7 Investigations Performed:

In this study, from the 200 students with hypertension, 170 students (85%) took part in the investigations and 30 students refused and/or their parents did not allow them to do any investigations. The laboratory investigations done included routine urinalysis, hematological investigations such as hemoglobin (Hb), white blood cells (WBC) and erythrocytes sedimentation rate (ESR). Biochemical investigations, such as serum urea, creatinine, uric acid, sodium, potassium, cholesterol, random blood sugar and triglyceride. And other investigations were carried as required such as urine culture and sensitivity and abdominal ultrasound.

4.7.1 Routine investigations:

4.7.1.1 Routine urine and microscopy findings:

Routine urine and microscopic investigations were done for 165 students (82.5%) while five students refused to do the investigation. 107 students (64.8%) had normal routine urine analysis while 58 students (35.2%) had abnormal routine urine analysis.
From the group of students with stage 1 hypertension, 73 students (65.2%) had normal results of urine analysis while 39 students (34.8%) had abnormal results of routine urine analysis. Among students with stage 2 hypertension, 34 students (64.2%) and 19 students (35.8%) had normal and abnormal results of routine urine analysis respectively (Figure 19).

4.7.2 Hematological investigations:

4.7.2.1 Hemoglobin:-

The results of hemoglobin of 170 students ranged between 5.10 – 14.10 g / dl, with a mean of 10.82 ± 1.46 g / dl. One hundred and forty five students (85.3%) had low hemoglobin results while 25 students (14.7%) had normal results.

Among the students with stage 1 hypertension, 103 students (88.8%) had low hemoglobin and 13 students (11.2%) had normal hemoglobin. While among students with stage 2 hypertension, 42 students (77.8%) and 12 students (22.2%) had low and normal hemoglobin results respectively with (P value = 0.052) which is statistically not significant (Figure 20).

Underweight students were 37, from those 34 students (91.9%) had low hemoglobin levels while three students (8.1%) had normal results. Students with normal weight were 65, from those 54 students (83.1%) had low results of hemoglobin while 11 students (16.9%) had normal results. While among high risk weight and overweight students, 30 students (88.2%)
and 27 students (79.4%) had low results of hemoglobin while four students (11.8%) and seven students (20.6%) had normal results of hemoglobin respectively with (P value = 0.438) which is statistically not significant (Figure 21).

4.7.2.2- Blood Leukocytes:-

Blood leukocytes of 170 students ranged between 2200-8200 cells/m³, with a mean of 4064.12 ± 1056.26 cells/m³. One hundred and twenty six students (74.1%) had low white blood cells count while 44 students (25.9%) had normal results.

The students who had stage 1 hypertension, 84 students (72.4%), had low (WBC) level and 32 students (27.6%) had normal (WBC) level. The students with stage 2 hypertension, 42 students (77.8%), had low and 12 students (22.2%) had normal results of (WBC) level with (P = value 0.292) which is statistically not significant (Figure 22).

Students with abnormal routine urine analysis were 58 of whom 45 students (77.6%) had low (WBC) results while 13 students (22.4%) had normal results. Students who had positive urine culture were 28 of whom 21 students (75%) had low (WBC) results while seven students (25%) had normal results. Those students with abnormal ultrasound were 23 students, 15 students (65.2%) had low results while eight students (34.8%) had normal results. Most of the students with renal problems had low results of (WBC) with (P values = 0.182, 0.408, 0.258) which is statistically not significant.
7.2.3 Erythrocyte sedimentation rate:

Erythrocyte sedimentation rate (ESR) of 170 students ranged between 10 - 82 mm / 1 first hour (Westergren), with a mean of 30.29 ± 14.40 mm / 1 first hour. 132 students (77.6%) had high results while 38 students (22.4%) had normal results.

The students who had stage 1 hypertension, 27 students (23.3%), had normal (ESR) level and 89 students (76.7%) had high (ESR) level. The students with stage 2 hypertension, 11 students (20.4%), had normal (ESR) level and 43 students (79.6%) had high results of (ESR) level with (P value = 0.416) which is statistically not significant (Figure 23).

The students with abnormal routine urine analysis were 58, nine students (15.5%) had normal (ESR) results while 49 students (84.5%) had high (ESR) results with (P value = 0.290) which is statistically not significant. Students with positive urine cultures, 21 students (75%) had high results of (ESR), while seven students (25%) had normal results of (ESR). Those with abnormal results of abdominal ultrasound, 16 students (69.6%) had high results of (ESR) while seven students (30.4%) had normal results with (P value = 0.034) which is statistically significant.

4.7.3 Biochemical investigations:

4.7.3.1 Serum urea:

Serum urea nitrogen of 170 students ranged between 19 - 42 mg/dl, with a mean of 28.36 ± 5.79 mg/dl and all students had high results.
4.7.3.2  Serum creatinine:

Serum creatinine of 170 students ranged between 0.24 - 0.99 mg/dl with a mean of 0.55 ± 0.20 mg/dl. Ninety seven students (57.1%) had low results while 67 students (39.4%) had normal results and only six students (3.5%) had high results.

Among the students with stage 1 hypertension, 68 (58.6%) and 44 students (37.9%) had low and normal results of serum creatinine, respectively. While among students with stage 2 hypertension, 29 students (53.7%) and 23 students (42.6%) had low and normal results of serum creatinine, respectively. Those with high results were only four students (3.5%) and two students (3.7%) with stage 1 and stage 2 hypertension, respectively with (P value =0.833) which is statistically not significant (Figure 24).

4.7.3.3 Serum uric acid:

Serum uric acid of 170 students ranged between 2.30-7.30 mg/dl with a mean of 4.66 ± 0.97 mg/dl. One hundred and fifty six students (91.8%) had normal results. Thirteen students (7.6%) had high results while only one student (0.6%) had low results.

Among the students with stage 1 hypertension, 106 students (91.4%) had normal results of serum uric acid, while nine students (7.7%) had high results and one student (0.9%) had low results of uric acid. Among students with stage 2 hypertension, 50 students (92.6%) had normal results of serum uric acid and four students (7.4%) had high results of uric acid.
with (P value = 0.788) which is statistically not significant (Figure 25).

4.7.3.4 Serum sodium:

Serum sodium of 170 students ranged between 110.00-180.00 mg/dl with a mean of 134.07 ± 9.31 mg/dl. Ninety six students (56.5%) had low results, while 59 students (34.7%) had normal results and only 15 students (8.8%) had high results.

Among the students with stage 1 hypertension, 67 students (57.8%) had low serum sodium level and 40 students (34.5%) had normal results of serum sodium. While among students with stage 2 hypertension, 29 students (53.7%) had low serum sodium and 19 students (35.2%) had normal results of serum sodium. Those students with high results were 15 students, nine of them (7.7%) had stage 1 hypertension and six students (11.1%) had stage 2 hypertension with (P value = 0.748) which is statistically not significant (Figure 26).

Among 85 students with normal weight, 44 students (51.8%) had low results of serum sodium. While 33 students (38.8%) and eight students (9.4%) had normal and high results of serum sodium, respectively. Out of 51 students at greater than 85th-95th percentile, 28 students (54.9%) had low results of serum sodium. While 17 students (33.3%) and six students (11.8%) had normal and high results of serum sodium. Among 34 students at greater than 95th percentile, 24 students (70.6%) had low results of serum sodium. While nine students (26.5%) and one student (2.9%) had normal and high
results of serum sodium, respectively, with (P value = 0.483) which is statistically not significant (*Figure 27*).

### 4.7.3.5 Serum potassium:

Serum potassium of the study group ranged between 2.10-6.00mg/dl with a mean of 3.31±0.71 mg/dl. One hundred and thirty nine students (81.8%) had low results, thirty students (17.6%) had normal results while only one student (0.6%) had high results.

Students with stage 1 hypertension who had low and normal results of serum potassium were 95 students (81.9%) and 20 students (17.2%), respectively. While students with stage 2 hypertension who had low and normal results were 44 students (81.5%) and ten students (18.5%) respectively. Only one student (0.9%) with high results, had stage 1 hypertension with (P value = 0.779) which is statistically not significant (*Figure 28*).

Eighty five students at <5th-85th percentile, of whom 70 students (82.3%) had low results of serum potassium while 14 students (16.5%) and one student (1.2%) had normal and high results of serum potassium, respectively. Out of 51 students at > 85th-95th percentile, 42 students (82.4%) had low result while nine students (17.6%) had normal results. Among 34 students at > 95th percentile, 27 students (79.4%) had low results of serum potassium and seven (20.6%) had normal results with (P value = 0.851) which is statistically not significant (*Figure 29*).
4.7.3.6 Serum cholesterol:

Serum cholesterol of the investigated group ranged between 133.00-231.00 mg/dl with a mean of 170.84 ± 22.32 mg / dl . One hundred and fifty five students (91.2%) had normal results, 15 students (8.8 %) had high results while no one had low results . Among students with normal results, 107 students (92.2%) and 48 students (88.9%), had stage 1 and stage 2 hypertension, respectively . Out of the students with high results, nine students (7.8%) and six students (11.1%) had stage 1 and stage 2 hypertension, respectively with (P value = 0.326) which is statistically not significant (Figure 30).

The association of serum cholesterol with (BMI) showed that at <5th-85th percentile, 81 students (95.3%) and four students (4.7%) had normal and high results of serum cholesterol, respectively. Fifty one students were at >85th-95th percentile of whom 47 students (92.2%) and four students (7.8%) had normal and high results of serum cholesterol, respectively. While out of the 34 students at >95th percentile, 27 students (79.4 %), and seven students (20.6%) had normal and high results of serum cholesterol, respectively with (P value = 0.049) which is statistically significant (Figure 31).
4.7.3.7 Serum triglyceride:

Serum triglyceride of the investigated students ranged between 60.00 – 173.00 mg / dl with a mean of 103.90 ± 24.04 mg/dl. One hundred and forty nine students (87.6 %) had normal results, 21 student (12.4%) had high results and no one found with low results. Students with normal results were 105 students (90.5%) and 44 students (81.5%), with stage 1 and stage 2 hypertension, respectively. From students with high results, 11 students (9.5%) and ten students (18.5%) had stage 1 and stage 2 hypertension, respectively with (P value = 0.081) which is statistically not significant (Figure 32).

Eighty five students were at <5th -95th percentile, of whom 77 students (90.6%) and eight students (9.4%) with normal and high results, respectively. While 51 students were at >85th -95th percentile, of whom 40 students (78.4%) and 11 students (21.6%) had normal and high results of serum triglyceride level, respectively. Out of 34 students at >95th percentile, 32 students (94.1%) and two students (5.9%) had normal and high results, respectively with (P value= 0.089) which is statistically not significant (Figure 33).

4.7.3.8 Serum sugar:

Serum sugar of 170 students ranged between 75.00-115.00 mg/dl with a mean of 91.50 ± 11.20 mg/dl. All the students had normal results.
4.7.4 Investigations performed when required:

4.7.4.1 Bacteriological investigations:

4.7.4.1.1 Urine culture and sensitivity:

Fifty-eight students (35.2%) had abnormal results of routine urine analysis. Urine culture analysis was done for 49 students (84.5%) while nine students (15.5%) refused to do it. Urine culture results of twenty one students (42.9%) were found sterile while 28 students (57.1%) had positive bacterial growth in their urine culture. The students with stage 1 hypertension were 33, of whom 13 students (39.4%) had normal results of urine culture while 20 students (60.6%) had positive bacterial growth. The students with stage 2 hypertension were 16, of whom eight students (50%) had normal results while the other eight students (50%) had positive bacterial growth with (P value = 0.768) which is statistically not significant (Figure 34).

4.7.4.2 Abdominal ultrasound:

Fifty eight students (35.2%) had urine routine and microscopic examinations which showed abnormal results. Abdominal ultrasound was done for 50 students (86.2%) while eight students (13.8%) refused to do it. Results showed that 27 students (54%) had normal abdominal ultrasound results while 23 students (46%), the results of their abdominal ultrasound show chronic glomerulonephritis. Students with stage 1 hypertension were
35 students, of whom 19 students (54.3%) had abnormal ultrasound results (chronic glomerulonephritis) while 16 students (45.7%) had normal results. Students with stage 2 hypertension were 15 students, of whom four students (26.7%) had abnormal ultrasound results (chronic glomerulonephritis) while eleven students (73.3%) had normal results with (P value = 0.199) which is statistically not significant (Figure 35).

4.7.3 Radiological examination:

The parents refused to do the radiological investigations because they considered their children do not need to have such an investigations.

4.8 Medical Advice and Treatment Offered:

All students who had sustained hypertension after the second screen were referred to Aden General or Al-wahda hospitals or private clinics according to the parents request for advice and treatments.
Chapter Five

5- Discussion

5.1 General Characteristic of the Study Group:

5.1.1 Age and gender:

High blood pressure is often thought of as a disease of adults, but it can also be a problem in children and adolescents. This study was done on healthy school children from Aden Governorate, age 6-16 years with mean age 11.6 ± 2.94 years. It included 4766 male students (47.3%) and 5316 female students (52.7%) who were enrolled in the first screen.

The distribution of blood pressure in the first screen according to age, gender and height showed that in males, 4161 students (87.3%) had normal blood pressure, 433 students (9.1%) had high blood pressure and 172 students (3.6%) had hypertension. In females, 4426 students (83.3%) had normal blood pressure, 617 students (11.6%) had high blood pressure and 273 students (5.1%) had hypertension. The prevalence of high blood pressure and hypertension was higher in females than males. These findings are similar to a study done in Gassim, Saudi Arabia \(^{(169)}\). Other studies reported that hypertension is slightly higher in females than males, from age six years until puberty \(^{(42)}\).
The overall prevalence of hypertension in the first screen was 445 (4.4%) while in the second screen was 200 (2%) . The prevalence of hypertension in the second screen was less than in the first screen which is similar to a study done in the Muscatine . It showed that the prevalence decreased from (13%) to (1%) and in Dallas study from (9%) to (2%) , while in Barbacena from (16.6%) to (2.5%) , suggesting that the anxiety and fear observed among the students raised the blood pressure values as mentioned by Garcia et al and by Moura et al (170,171) . In the present study, this fact was also observed, perhaps, because most of the students had never undergone blood pressure measurement before.

The prevalence of definite hypertension in Yemeni school children was (2 %) which is similar to the findings of a study done in the United States among children aged 4-15 years, in whom hypertension was 1.5-2%(42). Sinaiko et al found the prevalence of hypertension to be (2 %) among 14,000 school children aged 10-15 years (172) . Another study done in Israeli Arab children found the prevalence of hypertension to be 2.18 % (173) . However, our findings were lower than those reported in Saudi Arabia, Kuwait, Sudan, Jordan, India and Pakistan (29, 30, 33, 34, 38, 39) .

Unfortunately, no records of previous studies on the prevalence of systemic hypertension in Yemeni school children exist, which do not allow an
assessment of the evolution of that parameter over time. The studies done were only on adult patients.

5.1.2 Present residence:

The prevalence of hypertension in Crater, Maala, Twahi, Khormakser, Mansora, Shekh-Othman and Dar-Saad districts were (0.87 %), (1.04 %), (1.57 %), (2.29 %), (3.64 %), (1.44 %) and (1.13 %) respectively. The prevalence of hypertension was higher in Mansora (3.64 %) followed by Khormakser (2.29 %). Similarly, the prevalence of obesity in Mansora and Khormakser was higher than other districts (11.8 %) and (12.5 %), respectively. The obese children had higher blood pressures than the lean children. The association between obesity and hypertension in children has been reported in numerous studies among a variety of ethnic and racial groups, with virtually all studies reporting higher prevalence of high blood pressures and/or hypertension in obese children compared to lean children (67, 70, 174-177). Studies within populations have demonstrated that, regardless of genetic background, blood pressures were lowest in individuals who had healthy lifestyle with appropriate diets, normal (BMI), low alcohol consumption and those who exercise regularly (13).
5.1.3 Origin:

All students who participated in this study were from different districts of Aden Governorate. A number of epidemiologic studies had shown that individual blood pressure levels result from both genetic predisposition and environmental factors. The genetic component of blood pressure had been documented in familial and in twin studies such as those performed in Montreal, where blood pressure levels were documented in families with natural and adopted children. The results suggested that approximately (30%) of the variation in blood pressure was attributable to genetic factors and (50%) to environmental influences \( ^{(12)} \). Genetic factors, environmental factors as well as individual lifestyles play important roles in the development of hypertension as mentioned in the literature \( ^{(52, 53, 13)} \).

5.2 Blood Pressure and Clinical Findings of the Study Group:

5.2.1 Pattern of blood pressure in relation to the percentile, age and gender:

The study results were compatible with the findings reported in the literature, which showed that (SBP) and (DBP) were positively associated with age and height \( ^{(178-180)} \). For each year of life an increase from 0.9 to 2 mmHg in systolic blood pressure and of 0.5-1 mmHg in the
diastolic blood pressure. Other studies reported that age was an important factor and was related to blood pressure levels. Voors et al reported that for each year of life an increase from 1.2 to 1.7 mmHg occurs in systolic blood pressure and of 1mmHg in diastolic blood pressure (170). In another study by Santo Andre reported that blood pressure increase was observed with age (170). Bastos et al, reported that blood pressure gradually increased with age in both sexes until growth is completed by the age of 18-20 years (170). The findings emphasize that height and age offer more precision in detection of high (BP) in children and adolescents. They are also supportive to the recommendations of the updated report on the 1987 American Task Force. It is well known that blood pressure increases consistently from infancy to adolescence (2,5).

In this study (67.5%) of the students had body weight less than 25th percentile. This might well be one of the reasons for lower level of normative values of systolic and diastolic blood pressure compared to studies done in Jordan, Karnataka and Ethiopia (34,179,181). Decrease in body weight by one kg resulted in a reduction of (SBP) and (DBP) by 1.2 mmHg and 1 mmHg, respectively (67,70).

5.2.2 Pattern of blood pressure and body mass index (BMI):

The anthropometric measurements, body mass index (BMI) and blood pressure characteristics in apparently healthy students with normal blood
pressure values, increased with the increase of the ages. This finding is similar to the study done in Belgian Luxembourg Child Study (182). In this study, at age 6-11 years, height, weight and (BMI) were nearly equal in both sexes. At age 12-14 years the female values of height, weight and (BMI) were higher than males. At age 15-16 years only (BMI) was higher in females compared to males. These differences in height, weight and (BMI) between females and males were related to the changes of body physiology due to hormonal changes. Maturation begins earlier in females and menarche at this age is associated with increased anxiety and subsequent rise in (SBP) values. De Cesaris et al in their study reported that increase in (BP) was positively related to menarche (34).

Other studies in children showed positive relationship between (BMI) and (SBP) also between obesity and hypertension (180). In this study (0.32%) of the students with (BMI) at <5th percentile had hypertension, (1.39%) of the students with (BMI) at 5th - 85th percentile had hypertension while (7.05%) and (13.43%) of students with body mass index at >85th-95th percentile and at >95th percentile had hypertension.

Sorof J. et al found that the prevalence of hypertension increased progressively from (2%) to (11%) as the (BMI) percentile increased from ≤ 5th percentile to ≥ 95th percentile (71). The association between obesity and hypertension in children had been reported in numerous studies among
a variety of ethnic and racial groups. Virtually all studies found higher blood pressure and/or higher prevalence of hypertension in obese children compared to lean children \(^{(54,68-70,174-177)}\).

**5.2.3 Grades of severity of hypertension:**

In this study the number of students at stage 1 hypertension were 133 students which constituted (66.5\%) of the cases with hypertension, while at stage 2 hypertension the number was 67 students which constituted (33.5\%). These results showed that the rate of stage 1 hypertension was higher than the rate of stage 2 hypertension, a finding which corresponds to the results of similar studies.

Primary hypertension in childhood is usually characterized by mild or stage 1 hypertension and is often associated with a family history of hypertension or cardiovascular disease. Usually, children and adolescents with primary hypertension are overweight \(^{(13)}\). The prevalence of hypertension in male and female students at age group 14-16 years was found higher compared to other age groups which is similar to other studies which found increase in prevalence of hypertension at this age group \(^{(179)}\). Adolescence begins at this age group during which the physiologic changes occur and stresses increase during this period, this most likely accounts for the increases in blood pressure among this age group.
Regarding the type of hypertension, isolated systolic hypertension was more frequent, constituting (51.0 %) of all hypertensive children. This was followed by systo-diastolic hypertension which was (45.0 %) while isolated diastolic hypertension was only (4%). The results of isolated systolic hypertension were similar to the results of other studies done in Gassim, Saudi Arabia and Kuwait \(^{(29,30)}\).

Systo-diastolic and isolated diastolic hypertension showed a different result in such studies. Isolated systolic hypertension is a definite risk factor for stroke, ischemic heart disease and renal damage \(^{(169,183)}\).

**5.2.4 Other clinical findings:**

All male students had chest examination with normal findings. However, among female students, 48 had wheezes but none of them had hypertension. This was, most likely, due to allergic conditions.

Heart examination of male and female students showed that only four males and 14 females had grade one systolic murmur with no other heart abnormal findings. Of these, only four had hypertension as well as low hemoglobin levels without any other findings. The grade one murmur in these students might be explained by the anemia leading to hyper-dynamic circulation and hence the soft ejection systolic murmur. Severe anemia also leads to tachycardia and cardiac dilatation \(^{(138)}\).
Forty students with hypertension (20.0%) had tachycardia and (62%) were found having high risk weight and overweight. In this study, it was found that overweight hypertensive students had faster heart rates compared to those students with hypertension but had no overweight, which is due to the various metabolic derangements in the obese.

Sorof et al. documented the early association of faster heart rate and higher blood pressure with overweight in a group of school age children. They view tachycardia as a sign of enhanced sympathetic tone and speculate about the mechanism by which sympathetic over-activity could eventually lead to sustained hypertension (70, 184).

Abdominal examination of male and female students showed that four male and five female students had palpable liver and two male students had palpable spleen while no female students had palpable spleen. No other masses were palpable for all and none of them had hypertension. This splenomegally can be explained by the anemia which lead to an increase in extramedullary activity or other associated diseases in the children. The spleen is usually enlarged on palpation in (10-15%) of patients with severe anemia (138).
5.3 Clinical Symptoms of the Study Group:

It is unusual for pediatric hypertension to be diagnosed as a result of patient complaints or symptoms; most of the hypertensive cases are clinically silent. In this study the percentage of students with hypertension who had headache, dizziness, visual changes, palpitations, and fatigability were (31%), (18.5%), (19.5%), (2.0%), and (6.5%), respectively. For this reason, it is appropriate to measure blood pressure as a part of all routine medical examinations and moreover, all patients who have persistent blood pressure higher than the 95th percentile should be evaluated more thoroughly. It must be noted that the hypertensive students who are symptomatic usually have moderate to severe hypertension.

5.4 Past Medical History of the Children:

Among the hypertensive group of children enrolled in this study, (31%) had past history of recurrent tonsillitis, (1.5%) history of passing red urine, (8.5%) history of childhood infections, (4.5%) mild renal problems, (12%) urinary tract infections and (5.5%) had past history of skin infections. It is well recognized that renal involvement may lead to hypertension secondary to renal parenchymal disease. Renal problems in the past history of patients may lead to
chronic glomerulonephritis which is the main cause of secondary hypertension in childhood \(^{(138)}\).

5.5 Relevant Family History:

5.5.1 Parents' health:

The family history of diseases such as fathers' diabetes mellitus and obesity and mothers' diabetes mellitus had a positive relation in hypertensive students with \((p \text{ values } = 0.000, 0.04, 0.02)\) respectively which is statistically significant. However, in this study no positive relation was found between, the history of other family diseases such as heart diseases and kidney diseases to the student's hypertension. This finding is not similar to other studies which showed significant correlations in blood pressure and cardiovascular risk factors, between parents and their children \(^{(10)}\). This difference could be due to the fact that these diseases were not yet diagnosed in parents and this study scope had not catered to investigating them.

5.5.2 Consanguinity:

Regarding consanguinity among parents, \((2.1\%)\) of students, whose parent's were consanguineous, had hypertension. On the other hand, \((1.9\%)\) of hypertensive students had no consanguinity among their parents. This means that, genetic factors play a role in the pathogenesis of hypertension.
However, it was observed in another study which found that the most common cause of essential hypertension was genetic, accounting for 30-60% \((56, 12)\).

5.5.3 Number of siblings:

Families with a number of children, 1-4, 5-7, 8-10, >10 had hypertensive students in the ratio of (1.9%), (2.0%), (2.1%), (2.4%) respectively. The frequency of hypertension was found positively associated with increase in the number of siblings. Stress is one of the causes of hypertension, and the increase in the number of children per family and the resultant overcrowding may cause stress\(^{13, 31}\).

5.5.4 Family history of hypertension:

1.4% of the students, whose parents had no history of hypertension, had hypertension while (4.8%) of hypertensive students, their fathers had hypertension. While (5.7%) of hypertensive students, their mothers had hypertension and (7.8%) of hypertensive students, both parents had hypertension. This means that the risk increases when the mothers are hypertensive and further increases when both parents are hypertensive. Similar findings were reported by other studies which showed that children of hypertensive parents are not only more likely to develop hypertension, but also have their blood pressure measurements along the upper percentiles compared to children from normotensive families\(^{185}\). It was also observed
that there is greater correlation in blood pressures between mothers and their children than between fathers and their children\textsuperscript{(186,187)}.

5.6 The Socioeconomic Status of the Families of the Children in the Study Group:

5.6.1 Parents' education and occupation:

The frequency of hypertension found higher among students whose fathers and mothers are of higher levels of education and occupation. This was also found associated with increased frequency of high risk weight and overweight, among those students with (P value < 0.006, 0.006, 0.000, 0.045), respectively, which is statistically significant. Obesity is considered as a risk factor for cardiovascular disease, hypertension and type 2 diabetes mellitus, as mentioned in the literature. These results are different from the results reported by Kaplan and Keil which showed that a low level of education is associated with high prevalence of hypertension, and another study done by Dekkers J C et al which reported that socioeconomic status is inversely related with blood pressure\textsuperscript{(188,189)}.

5.6.2 Parents' Income:

The frequency of hypertension and obesity found higher among
students with higher parent's income, (9.8%), (12.3%), (13.6%), with (P value < 0.000), which could be due to change in lifestyle and diet imbalance of these families. These results were similar to the results of a study done in the United Arab Emirates, which reported that hypertension is significantly associated with obesity, medium/high income, history of diabetes, low physical activity and having three or more children (31).

5.6.3 Social habits:

The frequency of hypertensive students whose fathers or mothers were smokers found to be (1.8%) and (1.4%), respectively. While the frequency of hypertensive students whose fathers or mothers were Kat chewers found to be (1.8%) and (2.6%), respectively. The prevalence of hypertension among students who smoked or chewed Kat was (5.6%), (6.3%) respectively. Smoking leads to an acute elevation of blood pressure, though the effect usually subsides within 15 minutes of finishing a cigarette (13). Smoking is considered as a cardiovascular risk factor which increases the percentage of the intimal surface involved with fibrous plaques in the aorta (190). Al Qirbi and Sheiban reported that the continuous alteration of blood vessel condition (vasoconstriction, vasodilatation) as a result of sympathetic and parasympathetic dysfunction, induced by the Kat active ingredients, may be an important factor in potentiating hypertension in genetically predisposed individuals (191).
5.7 **Investigations Performed:**

In this study among 200 students with hypertension, 170 students (85%) took part in the investigations. However, 30 students (15%) refused and/or their parents did not allow them to do any investigations. The following laboratory investigations were done:

**5.7.1 Routine investigations:**

*5.7.1.1 Routine urine and microscopic findings:*

The routine urine and microscopic investigations done for 165 students, showed normal results for 107 students while 58 students (35.2%), had renal problems and were considered as having secondary hypertension. While (64.8%) who had shown no underlying clear causes were considered as having essential hypertension. This is similar to findings in literature, which reported (30%) to (60%) of hypertensive children having an identifiable etiology. The most common causes were renal parenchymal diseases, which account 60-70% of secondary causes of hypertension. Forty percent to 70% of hypertensive children did not have an identifiable etiology and were diagnosed as having primary or essential hypertension. Thirty nine students (67.2%) had stage 1 hypertension while 19 students (32.8%) had stage 2 hypertension.
5.7.2 **Hematological investigations:**

5.7.2.1 **Hemoglobin:**

The results of hemoglobin of 170 students (85%) ranged between 5.10 - 14.10 g/dl, with a mean of 10.82 ± 1.46 g / dl. One hundred and forty five students (85.3%) had low hemoglobin (<110 g/l) while 25 students (14.7%) had normal results. Students with low hemoglobin results were 145 students, of whom 103 students (71.0%) had stage 1 hypertension while 42 students (29.0%) had stage 2 hypertension. The cause of low hemoglobin in these children may be either due to lack of iron in nutrition, renal infections which is the main cause of hypertension or deterioration of renal function as result of hypertension or other causes not related to hypertension. However, it seems that there is no direct relation between the anemia and hypertension. Renal infection is a well known cause of anemia and hypertension in children.

5.7.2.2 **Blood leukocytes:**

Serum leukocytes of 170 students (85%) ranged between 2200 - 8200 cells / m³, with a mean of 4064.12 ± 1056.26 cells/m³. One hundred and twenty six students (74.1%) had low (WBC) results of the total students. Eighty four students (66.7%), had stage 1 hypertension while 42 students (33.3%) had stage 2 hypertension. However, the low (WBC) results may be
due to chronic renal infection or other causes. We did not find any explanation for the low (WBC) results with relation to hypertension.

5.7.2.3 Erythrocyte sedimentation rate:

The erythrocyte sedimentation rate of 170 students (85%) ranged between 10-82 mm / 1 first hour (Westergren), with a mean of 30.29 ± 14.40 mm/1 first hour. One hundred and thirty two students (77.6%) had high results of (ESR) and 38 students (22.4%) had normal results. Regarding the students with high results of (ESR), 89 students (67.4%) had stage 1 hypertension and 43 students (32.6%) had stage 2 hypertension. Concerning students with high (ESR) results, 111 students (84%) of them had mild to moderate anemia. It is well recognized that high (ESR) is associated with anemia. One study done in Tanzania, found a strong association between the (ESR) level and anemia, even after controlling malaria and other infections, the mean (ESR) level in the sample was high (193). The cause of high (ESR) results among the children of the study group are mainly due to anemia and renal infections. However, it seems that there is no direct relation between the high level of the (ESR) and hypertension.
5.7.3 Biochemical investigations:

5.7.3.1 Serum urea:

Serum urea nitrogen of 170 students (85%) ranged between 19-42 mg/dl, with a mean of 28.36 ± 5.79 mg/dl. All of the students had high results of serum urea levels. This is unexpected since renal damage leading to rises in urea level happen in late stages of hypertension. However, it seems that there is no direct relation between the high level of the serum urea and hypertension. The samples were taken while the children were not fasting. Fasting urea may have showed slight rise in hypertensive students as urea is synthesized in the liver and its production is strongly influenced by food intake.

5.7.3.2 Serum creatinine:

Serum creatinine of the study group ranged between 0.24-0.99 mg/dl with a mean of 0.55±0.20 mg/dl. Ninety seven students (57.1%) had low results, 67 students (39.4%) had normal results and only six students (3.5%) had high results. Only two students (33.3%) who had high results serum creatinine, had stage 2 hypertension, while four students (66.7%) had stage 1 hypertension. In renal infections such as glomerulonephritis, the glomerular filtration rate decreases and stimulates renin angiotensin aldosterone system which results in hypertension. The glomerular filtration rate might be estimated.
by measurement of the serum creatinine level. Hypertensive vascular disease progressively impairs renal function\textsuperscript{(138)}.

5.7.3.3- Serum uric acid:

Serum uric acid of the study group ranged between 2.30-7.30 mg/dl with a mean of 4.66 ± 0.97 mg/dl. Only one student (0.6%) had a low result, 156 students (91.8%) had normal results, while 13 students (7.6%) had high results. The students with high results of uric acid, nine of them (69.2%) had stage 1 hypertension while four students (30.8%) had stage 2 hypertension. Several studies found that hyperuricemia predicts the development of, and is an independent risk factor for hypertension. Serum uric acid is strongly correlated with (BP) in childhood primary hypertension\textsuperscript{(194,195)}. Two large studies, the Moscow Children's Hypertension Study and (NHANES 111), had reported an association of serum uric acid with hypertension in children. The Hungarian Children's Health Study also reported that an elevated serum uric acid could predict the development of hypertension in children. Decreased renal blood flow, which is a characteristic finding in subjects with hypertension, might result in increased urate re-absorption and an elevation in serum uric acid. Hence, one might postulate that an elevated uric acid level might simply reflect the severity of hypertension, rather than contribute to it pathogenetically. Increased serum uric acid further causes an
increase in juxtaglomerular renin production and a decrease in macula densa neuronal nitric oxide synthase expression and these two processes lead directly to increased blood pressure\(^{(196)}\).

**5.7.3.4 Serum sodium:**

Serum sodium of 170 students (85\%) ranged between 110.00-180.00 mg / dl with a mean of 134.07 ± 9.31 mg / dl. Ninety six students (56.5\%) had low results, 59 students (34.7\%) had normal results while only 15 students (8.8 \%) had high results. Of those students with high results of serum sodium, nine students (60\%) had stage 1 hypertension while six students (40\%) had stage 2 hypertension. The cause of high results of serum sodium in these students might be due to increased dietary intake and / or renal problems. Obesity also plays a role in retention of sodium through the effect of high level of insulin which is usually high in obese children\(^{(65)}\). Data on the relation between dietary sodium and blood pressure were mainly based on adult populations. Significant correlations had not been shown between sodium intake and blood pressure in children and adolescents. However, the usual dietary intake of sodium in children and adolescents, well exceeds nutritional requirements and current dietary patterns suggest that sodium consumption among the young might be increasing. In addition, certain groups of adolescents demonstrate blood pressure sensitivity to sodium. It is unlikely
that sodium contributes to the development of hypertension as an isolated factor, but blood pressure sensitivity to sodium might have an association with race, family history and obesity (197). A large number of adult patients with essential hypertension appear to be especially sensitive to salt intake. The mechanism of salt sensitivity is not clear. A subgroup of salt sensitive individuals appear to have impaired ability for urinary excretion of a sodium load (138).

5.7.3.5 Serum potassium:

Serum potassium of the study group ranged between 2.10-6.00mg/dl with a mean of 3.31 ± 0.71 mg / dl. One hundred and thirty nine students (81.8%) had low results, 30 students (17.6%) had normal results while only one student (0.6 %) had a high result.

The low level of potassium of these students is most likely due to diets deficient in fruits and vegetables which are the main source of potassium. The diet rich in fruits and vegetables which is the main source of potassium, is now recommended as an important step in managing blood pressure (42). Increased potassium intake suppresses production and release of rennin and induces natriuresis, thus decreasing blood pressure (42).
5.7.3.6 Serum cholesterol:

Serum cholesterol of 170 students (85%), ranged between 133.00 - 231.00 mg/dl with a mean of 170.84 ± 22.32 mg/dl. One hundred and fifty five students (91.2%) had normal results, Fifteen students (8.8%) had high results while no one had a low result. Students with high results, nine of them (60%) had stage 1 hypertension and six students (40%) had stage 2 hypertension. Usually hypercholesterolemia is more common in children with family history of hypercholesterolemia, while in this study the parents were not investigated. In fact, it is unusual that hypercholesterolemia contributes to the development of hypertension as an isolated factor. However, the cause of hypercholesterolemia in these students, could probably be due to familial, obesity or imbalance diet which contains high fat. Hypertension, obesity and hypercholesterolemia have been identified as risk factors for cardiovascular and total mortality. Overweight children of both genders had higher cholesterol levels than the result of the overall youth population of the Bogalusa Heart Study (197).

5.7.3.7 Serum triglyceride:

Serum triglyceride of 170 students (85%) ranged between 60.00-173.00 mg/dl with a mean of 103.90 ± 24.04 mg/dl. One hundred and forty nine students (87.6%) had normal results, 21 students (12.4%) had high results
while no one had a low result. Of those students with high results of triglyceride, eleven students (52.4%) and ten students (47.6%) had stage 1 and stage 2 hypertension respectively. Much of the hypertriglyceridemia seen in clinical practice is secondary to exogenous factors or underlying clinical disorders but not an isolated risk factor for the development of hypertension. Hypertriglyceridemia is considered to be a risk factor for early development of atherosclerosis and coronary heart disease. Many over-weight students who had elevated blood pressure also had elevated plasma triglyceride. Increased serum triglyceride in hypertensive students is a risk factor for cardiovascular disease and the risk increases more when associated with obesity.

5.7.3.8 Serum sugar:

Serum sugar of the investigated students ranged between 75.00-115.00 mg / dl with a mean of 91.50 ± 11.20 mg/dl. All the students had normal results. Raised blood pressure is more common in people with type 2 diabetes than in the general population. In people without diabetes it is a major risk factors for myocardial infarction and stroke.
5.7.4 Investigations performed when required:

5.7.4.1 Bacteriological investigations:

- Urine culture and sensitivity:

Urine culture and sensitivity were done for 49 students (84.5%) of the total 58 students who had positive results of routine urine analysis. Twenty-eight of these students (57.1%) showed positive bacterial growth. This might be due to renal infection (UTI) which is the most likely cause of secondary hypertension. Pruitt A. W. found that approximately (75-80%) of children with secondary hypertension had a renal abnormality. Urinary tract infection was present in (25-50%) of those patients and was often related to an obstructive lesion of the urinary tract\(^{(138)}\).

5.7.4.2 Abdominal ultrasound:

Ultrasound was done for 50 students (86.2%) of the total 58 students who had positive results of routine urine investigation. Twenty-three students (46%) showed renal involvement such as chronic glomerulonephritis, no other abnormalities while the others were normal.

Renal diseases are the main cause of secondary hypertension. The renal parenchymal lesions such as acute and chronic
glomerulonephritis, lead to reduced glomerular filtration rate in patients with nephritis resulting in salt and water accumulation and hypertension\(^{(138)}\). These patients with renal problems need detailed investigations to clarify the underlying causes.

**5.7.4.3 Radiological examination:**

Parents refused to do the radiological investigation as they considered their children were not ill and did not need such an investigation.

**5.8 Medical Advice and Treatment Offered:**

All students who had sustained hypertension after the second screen were referred to Aden or Alwahda Hospital or private clinics according to the parents request for further advice and treatment.
CONCLUSION

- The overall prevalence of high blood pressure and hypertension was higher in females than males.
- The prevalence of the definite hypertension in school Yemeni children was (2%).
- The prevalence of hypertension was higher in Mansora followed by Khormakser. This was found to have a close relation with a higher prevalence of obesity in Mansora and Khormakser.
- Increment in systolic and diastolic blood pressures were found to be associated with age and increase in age is associated with increases in blood pressure.
- Primary hypertension was more common among overweight and obese children.
- Stage 1 hypertension was found to be more prevalent than stage 2 hypertension.
- Primary hypertension was usually characterized by mild (stage 1) hypertension and was often associated with positive family history of hypertension or cardiovascular disease.
• Isolated systolic hypertension was the most common type of hypertension among children of the study group, this was followed by systo-diastolic hypertension.

• Overweight hypertensive students had faster heart rates than their lean hypertensive counterparts.

• Most of the hypertensive children were asymptomatic while only few were symptomatic.

• Some of the students who had past history of renal problems developed hypertension.

• Family history of chronic diseases in parents such as hypertension, diabetes mellitus as well as family history of obesity had a great association with the development of hypertension.

• Hypertension was more common among students coming from larger households and who had more siblings as well as among those whose parents were consanguineous.

• Higher socioeconomic status was associated with a higher prevalence of hypertension.

• Hypertension was more common among students who smoked or chewed Kat.
• Most hypertension cases were primary, while secondary hypertension was less common. Renal problems were found to be the main cause of secondary hypertension accounting for (35.2%) of these students.

• Most of the students were anemic and having high (ESR) results which were not related to hypertension. Serum electrolyte analysis such as serum sodium, cholesterol and triglyceride were higher among hypertensive obese children than their lean hypertensive counterparts.

• Serum potassium was low in hypertensive children, which might be due to lack of fruits and vegetables in diets, resulting in low potassium intake. Usually increased potassium intake suppresses production and release of renin and induces natriuresis, thus decreasing blood pressure.
RECOMMENDATIONS

- Blood pressure should be checked during health maintenance visits in all children three years of age and older.
- Children and adolescents should have their blood pressure measured at least once per year.
- The best way to reduce the prevalence of high blood pressure is to create national and international programs that concentrate on healthy lifestyle.
- Health policymakers need to have their attention drawn to the problem of hypertension. They should promote for exclusive breast feeding, increased duration of breast feeding and a balanced diet for infants. Encourage a low-sodium diet, more physical activity and adequate fruits and vegetables intake.
- Improve mother and child health centers to efficiently follow all pregnant women for nutrition and pre-eclampsia.
- Encourage physical activity and increase educational programs to avoid over weight and obesity in school children.
- More efforts are to be made to detect and properly manage medical problems which may lead to hypertension.
• Proper management and follow up for children with hypertension.

• Further studies need to be conducted about hypertension among children.

• Children with high risk factors, obese children, high blood pressure and children whose parents had history of hypertension, cardiovascular diseases, renal diseases and obesity, should be followed regularly.
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