UNIVERSITY OF CAPE COAST

EFFECTS OF WEALTH AND EXERCISE ON BLOOD PRESSURE: EVIDENCE FROM GHANA

PETER YELTULME MWINLAARU

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BY

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DECLARATION

Candidates Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature ………………………………. Date ………………………

Name: Peter Yeltulme Mwinlaaru

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature……………………. Date ………………………

Name: Prof. Samuel Kobina Annim

Co-Supervisor's Signature…………………………. Date ………………………

Name: Dr. Camara Obeng

ABSTRACT

This study determines whether or not the effect of physical exercise on blood pressure is only direct as most studies posit or is also mediated by some socioeconomic factors, including the wealth status of the household. The study used data on 13,784 individuals from the 2014 Ghana Demographic and Health Survey (GDHS) and employed two models, namely the multinomial logit and the multiple regression models. The multinomial model was used to determine, while controlling for other variables, the likelihood of individuals being hypertensive or prehypertensive, given that they exercise. It was found that exercising reduces the likelihood of an individual becoming systolic hypertensive or prehypertensive relative to having a normal blood pressure. The study also found that physical exercise helps reduce the systolic blood pressure of individuals directly. The effect of physical exercise on both systolic and diastolic blood pressure is also found to be mediated by the wealth status of the individual. The wealthy who exercise are found to have their systolic blood pressure fall by 5.786 mmHg higher than the poor. While physical exercise does not directly affect the diastolic blood pressure of an individual, its effect on diastolic blood pressure is mediated by the wealth status of the individual. Just as in the case of systolic blood pressure, wealthy individuals who exercise benefit from a greater fall in their diastolic blood pressure by 2.158 mmHg than the poor who exercise. The study, thus, concluded that while all individuals benefit from exercising, the wealthy in society benefits the most. It is, therefore, recommended that all individuals in the quest to decrease the risk of becoming hypertensive should exercise. This is truer for the wealthy in society.

KEY WORDS

Blood Pressure

Ghana

Hypertension

Physical Exercise

Socioeconomic status

Wealth

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DEDICATION

To my father, Mr. Charles Vendogfu Mwinlaaru; My mother, Mrs. Clotilda Vendogfu; and my brother, Isaac Nuokyaa-Ire Mwinlaaru

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
ATP	Adenosine Triphosphate
BMI	Body Mass Index
BP	Blood Pressure
BPAM	Blood Pressure Ambulatorial Monitoring
CDC	Center for Disease Control and Prevention
CHD	Coronary Heart Disease
COPD	Chronic Obstructive Pulmonary Disease
CVD	Cardiovascular Disease
DALYs	Disability Adjusted Life Years
DBP	Diastolic Blood Pressure
DHS	Demographic and Health Surveys
GCM	Global Coordination Mechanism
GDHS	Ghana Demographic Health Survey
GDP	Gross Domestic Product
GHS	Ghana Health Service
GLM	Generalized Linear Model
GLSS	Ghana Living Standards Survey
GSS	Ghana Statistical Service

HIAPA	Health in All Policy Approach
HMS	Harvard Medical School
IDH	Isolated Diastolic Hypertension
ISH	Isolated Systolic Hypertension
JNC	Joint National Committee
MoH	Ministry of Health
MRC	Medical Research Council
NCD	Non-Communicable Disease
NGOs	Non-Governmental Organisations
NHANES	Nutrition Examination Surveys
NPHRL	National Public Health Reference Laboratory
QOF	Quality and Outcomes Framework
SBP	Systolic Blood Pressure
SES	Socioeconomic Status
SOA	Super Output Area
SDGs	Sustainable Development Goals
UK	United Kingdom
USA	United State of America
VO2max	Maximum Volume of Oxygen
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION

Background to the Study

Health and disease patterns change over time in societies depending mainly on the degree of changes in population structure and the rate of economic growth and development. This is referred to as epidemiological transition. As societies develop, although communicable diseases such as tuberculosis prevail, non-communicable diseases become more prevalent, particularly in urban populations (Karar, Alam, & Streatfield, 2009). Non-communicable diseases (NCDs) are the leading killer today and are on the increase. Non-communicable diseases are diseases that cannot be spread from person to person. Examples are cancer, heart disease, rickets, etc. Opie and Seedat (2005) defined NCDs as diseases of long duration, generally slow progression and they are the major cause of adult mortality and morbidity worldwide.

NCDs are not only a health problem but a development challenge as well. In China, up to 71 percent of patients who had experienced an acute stroke were found to face catastrophic health expenditure, while 37 percent of them fell below the poverty line of US$ 1 per day after paying for their health care, 39 percent fell below the poverty line when it was increased to US$2 per day after paying for their health care (Heeley et al., 2009). The indirect cost for diabetes patients and their caregivers in India was 28.76 percent of the total treatment cost. Similarly, Arrossi et al. (2007) found that in Argentina, 39 percent of households with a member suffering from cervical cancer lost family income, partially or totally. The loss of income borne by patients suffering from NCDs is mainly due to self-reported absenteeism from usual economic activity. In fact, the treatment of NCDs usually requires repetitive visits to health facilities in addition to the inability to work due to their poor health. This lead to additional losses of working time both for patients and caregivers. Obi and Ozumba (2008) found in Nigeria that all patients suffering from cervical cancer and their relatives lost income from workplaces due to absenteeism, disengagement from work and missing business appointments.

NCDs undermine social and economic development throughout the world and threaten the achievement of internationally agreed development goals. The reduction in economic growth is estimated at 0.5 percent for every 10 percent increase in NCD-related mortality (Kolbe-Alexander, 2013). Kolbe-Alexander (2013) added that worksites and companies are also directly affected by NCD's due to reduced employee productivity, increased absenteeism and increased likelihood of disability. NCDs and their risk factors lead to increased burdens on individuals, families and communities, including impoverishment from long-term treatment and care costs, and to a loss of productivity that threatens household income and leads to productivity loss for individuals and their families, and to the economies of countries. This make NCDs a contributing factor to poverty and hunger, which may have a direct impact on the achievement of the Millennium Development Goals (World Health Organisation [WHO], 2015).

In 2011, world leaders assembled at the United Nations General Assembly in New York, and acknowledged that the global burden and threat of noncommunicable diseases constitutes one of the major challenges for development in the twenty-first century, which undermines social and economic development throughout the world and threatens the achievement of internationally agreed development goals. World leaders noted with grave concern the vicious cycle whereby NCDs and their risk factors worsen poverty, while poverty contributes to rising rates of NCDs, posing a threat to public health and economic and social development (WHO, 2014). They added that a report from the African Union in April 2013 underscored the fact that the exorbitant costs of NCDs are forcing 100 million people in Africa into poverty annually, stifling development (WHO, 2014).

To visualize the importance of NCD to development and to get prepared to the implementation of the new Sustainable Development Goals (SDGs) the World Health Organisation Global Coordination Mechanism (WHO GCM) on NCD was mandated to create a web site on NCD poverty and development in 2014. The WHO GCM was also asked to organize a multi - stakeholder dialog on how to encourage the continued inclusion of NCDs in development cooperation agendas and initiatives, internationally agreed development goals, economic development policies, sustainable development frameworks and poverty reduction strategies (Mikkelsen, 2015) which was latter organized in April, 2015 in Geneva (WHO, 2015)

The loss in national income due to NCD's is substantial. During 2011–2025, cumulative economic losses estimates due to the four major NCDs in low- and middle-income countries have been estimated at US$ 7trillion according to a 2011 study conducted by the Harvard School of Public Health and the World Economic

Forum (Mikkelsen, 2015). The annual loss of approximately US$500 billion amounted to approximately four (4) per cent of gross domestic product (GDP) for developing countries in 2010 (WHO, 2014). The estimated cost of the five main NCDs in China and India were US$ 27.8 trillion and US$ 6.2 trillion respectively (Bloom et al., 2013). The projected loss in income from 2005 to 2015 in countries with emerging economies similar to South Africa, range from 49.2 billion dollars in Brazil to 236.6 billion dollars in India (Kolbe-Alexander, 2013). Therefore, countries, worksites and individuals are likely to incur higher medical expenditures and reduced productivity due to NCD's.

All the above instances show that NCDs can force a drastic cut in spending on food and education and even lead to the liquidation of family assets and a loss of care and investment in children. NCDs and their risk factors often prevent people from working or seeking employment, thus robbing families of income. It is stated in Jha et al's. (2006) that each 10 percent rise in NCDs is associated with 0.5 percent lower rate of annual economic growth. NCDs account for 48 percent of the healthy life years lost in the world (Murray et al., 2010).

NCDs also compromise future economic and human development because poverty and ill-health are often passed down from one generation to the next; what is referred to as 'Barker Hypothesis'. The hypothesis suggests that fetal growth adaptations occur relative to biological conditions in utero and that the mother's physiological condition may influence the health trajectory of the newborn, potentially predisposing the child to adult diseases such as coronary heart disease, stroke, hypertension and diabetes later in life (De Boo & Harding, 2006; Paneth & Susser, 1995).

Four main diseases are generally considered to be dominant in NCD mortality and morbidity. They are cardiovascular diseases (including heart disease and stroke), diabetes, cancer and chronic respiratory diseases (including chronic obstructive pulmonary disease and asthma). The leading causes of NCD deaths in 2015 were: cardiovascular diseases (17 million deaths, or 48 percent of NCD deaths); cancers (7.6 million, or 21 percent of NCD deaths); and respiratory diseases, including asthma and chronic obstructive pulmonary disease (COPD), (4.2 million). Globally, cardiovascular diseases are the number one cause of death and they are projected to remain so (Kuh & Shlomo, 2004). It was estimated that over a ten-year period (i.e. 2006 to 2015), China lost $558 billion in foregone national income due to the combination of heart disease, stroke and diabetes (Wu, Fu, Yang, Zhang, & Han, 2009).

Hypertension, otherwise known as high blood pressure, is a leading cause of cardiovascular disease (CVD) worldwide (Chobanian et al., 2003). When the heart pumps blood through the blood vessels, the blood pushes against the walls of the blood vessels. This creates blood pressure. The body needs blood pressure to move the blood throughout the body, so every part of the body can get the oxygen it needs. Healthy arteries (the blood vessels that carry oxygen-rich blood from the heart to the rest of the body) are elastic. They can stretch to allow more blood to push through them. How much they stretch depends on how hard the blood pushes against the artery walls. For arteries to stay healthy, it’s important that blood pressure be within a healthy range (Fagard, 2001). Table 1 shows healthy and unhealthy blood pressure ranges as recognized by the WHO and American Heart Association.

Table 1: Blood Pressure Level Staging

Blood Pressure Category	**Systolic (Upper #)**		**Diastolic (Lower #)**
Normal	Less than 120	And	Less than 80
Prehypertension	120-139	Or	80-89
High Blood Pressure (Hypertension) - Grade 1 (Mild)	140-159	Or	90-99
High Blood Pressure (Hypertension) - Grade 2 (Moderate)	160-179	Or	100-109
High Blood Pressure (Hypertension) - Grade 3 (Severe)	Higher than 180	Or	Higher than 110

Source: Arbor pharmaceuticals (2014)

Hypertension burdens a lot of individuals and countries in the world. The proportion of the global burden of disease attributable to hypertension has significantly increased from about 4.5 percent (nearly one billion adults) in 2000 (Kearney et al., 2005), to 7 percent in 2010 (Lozano et al., 2013). This makes hypertension the single most serious cause of morbidity and mortality globally and highlights the urgent need of action to address the problem. Hypertension had always been regarded as a disease of the affluence but this has changed drastically in the last two decades with average blood pressures now higher in Africa than in

Europe and USA and the prevalence increasing among poor sections of society. Ng et al. (2014), in their report, stated that hypertension is the number one risk factor for cardiovascular disease (CVD) in Africa and consequently, CVD has taken over as number one cause of death in Africa and the total numbers will further increase in the next decades reflecting the growing urbanization and related lifestyle changes. According to them, almost three out of every four people with hypertension will be living in low and middle-income countries by 2025.

High blood pressure cannot be cured. It can, however, be managed very effectively through lifestyle changes and, when needed, medication. In most cases, the cause of high blood pressure is not known. In fact, high blood pressure usually does not have symptoms. This is why it is sometimes called 'the silent killer'. According to Addo, Smeeth and Leon (2007), hypertension is of public health importance in sub-Saharan Africa, particularly in urban areas, with evidence of considerable under-diagnosis, treatment, and control. They noted that there is an urgent need to develop strategies to prevent, detect, treat, and control hypertension effectively in the African region. There were approximately 80 million adults with hypertension in sub-Saharan Africa in 2000 and projections based on current epidemiological data suggest that this figure will rise to 150 million by 2025 (Mayosi et al., 2007).

In the case of Ghana, it is reported that the prevalence of hypertension has been increasing and that in some urban centres, about half of all adults have hypertension (MoH, 2012). The reported outpatient hypertension in public and mission facilities other than teaching hospitals increased 11-fold from about 60,000 cases in 1990 to about 700,000 cases in 2010 (MoH, 2012). This shows how pervasive the problem is. The increase in the incidence of hypertension and its related burden on people pushes one to ask whether or not hypertension can be prevented or controlled.

There are known risk factors for high blood pressure. These are conditions that are known to increase the risk for getting high blood pressure. Risk factors for high blood pressure falls into two categories: those one can control, and those that are out of one's control (Arbor pharmaceuticals, 2014). Some of the risk factors that are out of one's control are family history, age, gender, and race. Risk factors that one can control includes lack of physical activities, unhealthy diet, overweight and obesity, drinking too much alcohol, smoking and tobacco use, stress and sleep apnea. Thus, hypertension can be prevented and controlled if one minimises those risk factors that are within one's control.

Prevention and/or control of hypertension and hence CVD are not only of public health importance, but will also have a big economic impact. That is, these diseases make a significant proportion of the productive population chronically ill or die, leaving their families in poverty. It is, therefore, essential to develop and share best practices for affordable and effective community-based programs in screening and treatment of hypertension. In order to prevent and control hypertension in the population, Africa needs policies developed and implemented through a multi-sectoral approach involving the Ministries of Health and other sectors, including transport, work and industry, finance and economic affairs, sports and recreation among others. That is to say Government must do well to adopt the

Health in All Policy Approach (HIAPA) in dealing with the problem of hypertension. That is, humans do not live in a vacuum and hence their behaviour, values, culture and environment might influence their health and quality of life. Therefore, in trying to look for ways to control blood pressure and thus reduce hypertension in humankind, what people do, why they do what they do, their behaviour in a given environment and his environment as a whole should be looked at with a critical eye. All Government and private agencies should, therefore, incorporate in their policies ways to control any activity of humankind that potentially put them at risk of becoming hypertensive. Example, food and standard authority can give guidelines as to the highest amount of cholesterol or sugar or salt a food processing company can use in its production. The ministry of sports can organize interesting sporting and physical exercise based programmes in communities and so forth. This can go a long way to control and prevent CVDs and their related burdens on society.

Statement of the Problem

In most cases, the cause of high blood pressure is not known (Arbor pharmaceuticals, 2014; Kofi, 2011). However, there are some known risk factors for high blood pressure. These are conditions that are known to increase the risk for getting high blood pressure. These risk factors are either biological or behavioural in nature. Studies have shown that biological factors such as gender and age as well as behavioural factors such as exercising, desisting from alcohol and no smoking, consumption of fruits and vegetables, loss of weight or obesity can help prevent or control high blood pressure in people (Wilcox, Bennett, Brown, & Macdonald, 1982; Halbert et al., 1997; Cristine Bündchen, de Castro Schenkel, dos Santos, & de Carvalho, 2013; Fagard, 2001; Cornelissen & Smart, 2013; and Meltzer & Jena, 2011).

Humankind, a social being, does not live in a vacuum. Individuals exist in a multiple, multi-layered and interacting context, each of which is a domain of social relations and environmental health risk and protection. Hence the environment or society influences people's health. Studies have, therefore, shown that socioeconomic factors such as education, wealth and so on influences the state of health of an individual (Yew, Chin, Azlan, & Noor, 2014; Armenakis & Kiefer, 2007; Woolf & Aron, 2013; Feinstein, Sabates, Anderson, Sorhaindo, & Hammond, 2006; and WHO, 2014). It is, therefore, possible for the socioeconomic state and culture of an individual to affect his/her blood pressure.

The curiosity on the part of researchers to determine the effect of socioeconomic status (SES) on an individual's blood pressure gave rise to a number of studies. For instance, studies conducted by Ulijaszek (2003); Lam (2011); Colhoun, Hemingway, and Poulter (1998); and Ashworth, Medina, and Morgan (2008) show that socioeconomic factors such as level of education, income, marital status, and urbanization affects the blood pressure of an individual. These studies however, only looked at only the direct impact of these socioeconomic variables on hypertension.

An extensive research conducted by Feinstein et al. (2006) however, shows that education, for instance, does not only directly affect health but also affects health through certain behavioural factors like tobacco use, alcohol consumption, overweight, fruit and vegetable intake, physical activity, illicit drugs, and unsafe sex. That is, SES of an individual might not only directly affect blood pressure; but might also affect it through one or more of these lifestyle behaviours. WHO (2014) mentioned, though vaguely, in a study they conducted on 'social determinants of mental health' that among other factors the geographic area of residence of an individual can influence his/her health. This is reinforced by Feinstein et al. (2006) who mentioned that the context of self; such as family, neighbourhood, country, culture are some determinants of health. However, studies on effects of socioeconomic factors on blood pressure and risk of hypertension failed to assess this.

This study, thus, tried to look at how some socioecomic variables directly and indirectly – through exercising – affects blood pressure and hence the risk of being hypertensive. A question which then comes to mind is, why exercise and not the other behavioural risk factors of hypertension? Physical exercise because, (1) physical inactivity is widely recognized as a major risk factor for NCDs including hypertension (Kolbe-Alexander, 2013) and (2) the distribution of the various risk factors of hypertension in Ghana is such that on the average most individuals have developed positive habits in the other controllable behaviours on which data is available (smoking, fruit intake). This is not so when it comes to exercising (evidence of this can be seen in Appendix A). Thus, it seems most people still have not got the message on the importance of physical exercise on their health. This informed the decision to revisit the story of exercise and blood pressure in Ghana.

Purpose of the Study

The study examines how some socioecomic variables directly and indirectly – through exercising – affects blood pressure and hence the risk of being hypertensive. That is, whether or not the effect of physical exercise on blood pressure is only direct as most studies posit or is mediated by some socioeconomic factors or determinants of blood pressure.

Research Objectives

The main objective of the study is to determine socioeconomic factors that mediate the effect exercise has on blood pressure. The specific objectives of the study are to:

1. examine the relationship between exercise and blood pressure status.
2. Investigate the effect of wealth status on the relationship between exercise and blood pressure.

Research Hypotheses

1. $H_{O:}$ There is no relationship between exercise and blood pressure.

   H_A: There is a relationship between exercise and blood pressure.
2. H_O: Wealth status does not affect the relationship between exercise and blood pressure.

   H_A: Wealth status affects the relationship between exercise and blood pressure.

Significance of the Study

The outcome of the study will be beneficial to, first, the Ministry of Health and, for that matter the Government of Ghana. The study will inform the Government that the fight to combat hypertension and thus reduces its economic burden on the citizens of the country and the Ghanaian macroeconomy at large, it should enact a health education policy that will let Ghanaians know the risk factors of hypertension and hence promote positive lifestyle practices. To be specific, Government will be motivated to encourage all its citizens to take physical exercise seriously and also target people who physical exercise reduces their risk of being hypertensive the most. The Government will again be encouraged to provide facilities like gyms, recreational parks, and so on in each and every community to entice people to be physically active. It can also make a national policy to provide runways by all roads that run through communities in Ghana.

The study will also help health facilities in Ghana to make it set programmes to encourage and help people develop the habit of exercising. Health facilities will also give special attention to people whose social and economic conditions makes them more susceptible to be hypertensive and hence recommend exercising to them especially those who, given their socioeconomic condition, will benefit most from physical exercise.

Also, the study will give guidance to Non-Governmental Organisations (NGOs) who aim at helping countries and societies fight against hypertension to focus their attention not only on antihypertensive drugs, but also to go to the societies to provide primary health education on the consequence of some lifestyle behaviours and health in general and on blood pressure to be specific. NGOs will also be motivated to channel most of their resources to promoting physical activity, which is a preventive measure of hypertension; than channeling resources to provide curative assistance.

Lastly, the outcome of this study will benefit all individuals globally and more especially citizens of the republic of Ghana. However, this study will benefit individuals whose socioeconomic conditions put them at high risk of being hypertensive but the degree to which this risk reduces by being physically active is highest. Thus, people will tend to develop positive lifestyle and control their blood pressure positively.

Delimitation of the Study

The study is delimited to Ghana. Also, males and females who are 15 to 49 years and 15 to 59 years respectively were used for the study. Again, the study only used observable behaviours and socioeconomic conditions to determine the behaviour of blood pressure. That is, the medical conditions of subjects and some other factors that may determine blood pressure were not considered.

Limitation of the Study

According to WHO, the risk factors of high blood pressure or, in other words, the determinants of blood pressure that can be controlled are physical activity (exercise), sodium(salt), overweight and obesity, alcohol intake, smoking and tobacco use, stress and sleep apnea. The 2014 Ghana Demographic Health Survey (GDHS), where data for the present study is extracted, does not have data on alcohol intake, sodium (salt) intake, stress and sleep apnea. Hence these variables, which are also determinants of blood pressure, were not used during this study. Omission of these variables might bias the magnitudes of effects on blood pressure obtained from this study. Though the methodologies employed cannot correct for these biases, the signs of estimate coefficients rightly predict the directional effect of the independent variables used on blood pressure. Also exercise, which is the main variable of concern, was captured as dummy (i.e. whether one exercises or not). That is, the type of exercise one engages in and the number of days or times an individual exercise per week and the duration of exercise per session were not captured. This incapacitates the study to delve deep to explain the effect of exercise on blood pressure. Exercise as captured in the 2014 GDHS and used in this study comprises any physical activity a person does. Also, since the 2014 GDHS does not involve the aged in their study, results are only limited to the middle age group of Ghanaians. Since blood pressure among the aged is said to be relatively high, it is believed that if they were included in the study, the results obtained could be different. Also, the health history and medical conditions of subjects which are important determinants of blood pressure, were not considered in this study. Finally, the bi-causal relationship between physical activity and level of blood pressure can lead to endogeneity in the models' estimation. However, the researcher found no appropriate method to solve this problem. This could also have consequences on the parameter estimates.

Organization of the Study

This study is organised into five chapters. Chapter one introduces the study. It contains the background of the study, the statement of the problem, purpose of the study, objectives of the study, research hypotheses, significance of the study, delimitation of the study, limitation of the study and, finally, the organization of the study. Literature related to the study is reviewed in chapter two. Both theoretical and empirical literature are reviewed. Chapter three discusses the methodology of the study. It gives a detailed description of the scope of the study, the theory on which the foundation of the study stands, the variables used for the study, and the econometric model used for the study. Results obtained from the study are presented and discussed in chapter four. Finally, the study is concluded in chapter five. It also presents a summary of findings and makes recommendations from the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

Epidemiological studies suggest that regular physical activity may be beneficial for both prevention and treatment of hypertension. It will enable one lose weight, maintain functional health status, and diminish causes of morbidity and risk of cardiovascular disease. This study, thus, looks at the effect of physical exercise on blood pressure and how this effect is influenced by social and economic variables. In this chapter, theoretical and empirical literature related to the study is reviewed. The chapter starts with the presentation of arguments on which of the blood pressure components (systolic or diastolic blood pressure) should be given more importance in the diagnosis of an individual's blood pressure status. This is immediately followed by a presentation on how physical exercise influences one's health in general and is used to treat hypertension. The chapter also gives empirical evidence of the effect of exercise on blood pressure. Lastly, literature on socioecomic determinants of blood pressure is reviewed.

Theoretical Literature

Theories related to the study are presented under this section. It presents arguments on how blood pressure status should be diagnosed. It also presents literature on how physical exercise influences health.

Diastolic and Systolic Blood Pressure

Blood is carried around the body in tubes called blood vessels. The pumping of the heart keeps blood moving through the blood vessels. Blood pressure is the measurement of the pressure in the walls of bigger blood vessels called arteries (National Heart Lung and Blood, 2016). That is to say, blood pressure is the force of blood pushing against blood vessel walls. Blood pressure is written as two numbers. These numbers are written in a form of a fraction. The top number is called systolic blood pressure. It is the pressure when the heart beats. The bottom number, diastolic blood pressure is the pressure when the heart rests between beats (National Heart Lung and Blood, 2016).

Blood pressure can be measured by using a device called a blood pressure monitor. The systolic blood pressure (the "upper" number) tells how much pressure blood is exerting against the artery walls while the heart is pumping blood. The diastolic blood pressure (the "lower" number) tells how much pressure blood is exerting against the artery walls while the heart is resting between beats. Blood pressure is measured in units of millimeters of mercury, or mmHg. For example, a blood pressure reading might be 120/80 mmHg. A healthy blood pressure is under 120/80 mmHg. A blood pressure reading of 120-139 systolic or 80-89 diastolic is defined as "prehypertension." This means that the blood pressure is not high enough to be called high blood pressure (hypertension), but that it is higher than normal. If systolic blood pressure is 140 or greater, or diastolic blood pressure is 90 or greater, it's high blood pressure (Arbor pharmaceuticals, 2014). One needs more than one high reading to confirm whether or not the person has high blood pressure. When a patient's systolic and diastolic blood pressure levels fall within different categories, the higher diagnostic category and recommended actions apply (National Heart Foundation of Australia, 2016).

The medical term for high blood pressure is hypertension. High blood pressure is dangerous because it makes the heart work too hard and contributes to atherosclerosis (hardening of the arteries). It increases the risk of heart disease and stroke. High blood pressure also can result in other conditions, such as congestive heart failure, kidney disease, and blindness. People who do not have high blood pressure at age 55 face a 90 percent chance of developing it during their lifetimes. Both numbers in a blood pressure test are important, but for people who are aged 50 or older, systolic pressure gives the most accurate diagnosis of high blood pressure (U.S. Department of Health and Human Services, 2003).

Tin, Beevers and Lip (2002), however, in a paper titled 'Systolic vs diastolic blood pressure and the burden of hypertension' mentioned that it is still uncertain how hypertension is defined. According to them it is not clear whether hypertension is better defined either as a systolic blood pressure, a diastolic blood pressure, or both. They added that applying either criteria or both, implies the existence of different types of hypertension, such as systolic-diastolic hypertension (i.e. SBP≥140 mmHg and DBP≥90 mmHg), isolated systolic hypertension (SBP≥140 mmHg) or isolated diastolic hypertension (DBP≥90 mmHg). An added sub-definition is the 'stage' of hypertension. Tin et al. (2002) cited that the 1997 United States Joint National Committee (JNC) on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure report and the 1999 WHO guidelines which classified hypertension into stages, based on levels of SBP and DBP, recommend that when an individual's SBP and DBP fall into separate stages that they be classified into the higher stage, referred to as 'upstaging'.

However, studies from the United States suggest that systolic hypertension is the main factor in determining staging. For a long time, guidelines, clinical trials and clinical practice have based greater importance on DBP levels as the basis for detecting whether or not one is hypertensive. That is, no matter the level of systolic blood pressure, it was the corresponding level of diastolic blood pressure that was used as basis for the diagnosis and treatment of hypertension. The first JNC report in 1977 defined DBP as the basis for detection and treatment of hypertension. For example, an individual with blood pressure of 180/85 mmHg was not eligible for treatment under the old guidelines. In fact, it was felt that systolic hypertension, due to hardening and loss of elasticity of the major arteries was an unavoidable consequence of aging and augmented by hypertension, in contrast to DBP which was thought to be a function of peripheral resistance. Therefore, SBP continues to rise with advancing age while DBP stabilizes or declines giving rise to isolated systolic hypertension (ISH) (Tin, Beevers & Lip, 2002). Older trials, as reported by Tin et al., which showed benefits of treating diastolic hypertension, such as the Veterans Administration Study on Antihypertensive Agents, did not take into account the effect of elevated systolic hypertension.

In 1969 however, the Framingham heart study first noted that systolic hypertension was related to increased cardiovascular risk (Tin et al., 2002). It was probably not possible to 'dissect out' the relative importance of SBP verses DBP until the use of statistical methods such as the Cox proportional hazards analysis and multivariate analyses, on the appropriate computer software/hardware. Prior to this study, it was globally accepted that it is the diastolic blood pressure of people that matter. Indeed, it was not until the publication of the 5th JNC guidelines in 1993 that SBP was incorporated into blood pressure staging.

In a meta-analysis of outcome trials in hypertension consisting of patients over 60 years, Staessen et al. (2000) using a multiple Cox regression with stratification for trial with sex, age, and systolic and diastolic blood pressures at baseline as explanatory variables found that total mortality was positively correlated with systolic blood pressure at entry, whereas the association with diastolic blood pressure was negative. These findings highlight the importance of pulse pressure as a risk factor. Indeed, at any given level of systolic blood pressure, a lower diastolic blood pressure was associated with a higher death rate. By the use of the same stratified and adjusted Cox model as for total mortality, the relative hazard rates associated with a 10 mmHg increase in the baseline systolic blood pressure were 1.12 for stroke, but only 1.04 for coronary events. Diastolic blood pressure at baseline tended to be inversely correlated with cardiovascular mortality; the relative hazard rate associated with a 5-mmHg increase was 0.95. However, diastolic blood pressure was not significantly associated with outcome, if fatal and non-fatal events were combined.

Similarly, the meta-analysis of several prospective cohort studies by He & Whelton (1999) indicated that the association between SBP and risk of coronary heart disease, stroke and end-stage renal disease was continuous, graded, and independent. They also posit that the association of SBP with these outcomes is stronger than that of DBP. Pooling of the data available from randomized controlled trials indicates that an average reduction of 12–13 mmHg in SBP over 4 years of follow-up was associated with a 21 percent reduction in coronary heart disease, a 37 percent reduction in stroke, a 25 percent reduction in total cardiovascular mortality, and a 13 percent reduction in all-cause mortality.

Examination of data from Framingham and Framingham Offspring studies showed that DBP vastly underestimates the number of patients requiring treatment. For example, Lloyd-jones et al. (1999) evaluated the effect of disparate levels of SBP and DBP on blood pressure staging and eligibility for therapy. They examined 4962 Framingham Heart Study subjects between 1990 and 1995 and determined blood pressure stages on the basis of SBP alone, DBP alone, or both. After the exclusion of subjects on antihypertensive therapy (51306 of them), 3656 subjects were eligible. In this sample, 64.6 percent of subjects had congruent stages of SBP and DBP, 31.6 percent were up-staged on the basis of SBP, and 3.8 percent on the basis of DBP; thus, SBP alone correctly classified JNC-VI stage in 96 percent of the subjects. Of 1488 subjects with high-normal blood pressure or hypertension, who were potentially eligible for drug therapy, 13.0 percent had congruent elevations of SBP and DBP, 77.7 percent were up-staged on the basis of SBP, and 9.3 percent were up-staged on the basis of DBP; SBP alone correctly classified 91 percent, whereas DBP alone correctly classified only 22 percent.

SBP elevation out of proportion to DBP is common in middle-aged and older persons. Lloyd-jones et al. (1999), thus stated that SBP appears to play a greater role in the determination of JNC-VI blood pressure stage and eligibility for therapy. Lloyd-jones et al. (1999) recommends future guidelines should consider a greater role for SBP than for DBP in determining the presence of hypertension, risk of cardiovascular events, eligibility for therapy, and benefits of treatment. Due to the overwhelming evidence of the importance of systolic hypertension, it has even been suggested that one should not even bother measuring DBP. The Copenhagen Heart Study for instance, did not find an association between IDH and risk of stroke after a 12-year follow-up of 6545 patients. The Multiple Risk Factor Intervention Trial found that for any level of DBP, SBP was the major determinant of cardiovascular risk. It has to be noted that in both these studies most of the study subjects were white Caucasians and in the Copenhagen Heart Study, subjects were over 50 years of age. Given all these arguments about which of the two numbers in the blood pressure measure should be considered more important during staging, the WHO still recommends that (as mentioned earlier) if a patient's systolic and diastolic blood pressure levels falls within different categories, the higher diagnostic category and recommended actions apply.

Physical activity and Health

Physical activity is described as body movement that expends energy and raises the heart rate. Inactivity is classed as less than 30 minutes of physical activity a week, and sedentary time means time spent in low-energy postures, e.g. sitting or lying. Globally, physical inactivity is the fourth leading risk factor for mortality (accounting for 6 percent of deaths). This follows high blood pressure (13%), tobacco use (9%) and high blood glucose (6%). In the UK, physical inactivity directly contributes to one in six deaths. Evidence suggests that sedentary behaviour is independently bad for health and that regular physical activity helps prevent and manage over 20 chronic conditions including coronary heart disease, stroke, type II diabetes, cancer, obesity, mental health problems and musculoskeletal conditions (House of Commons Health Committee, 2015). Evidence also shows there is a link between physical activity and good mental wellbeing (House of Commons Health Comsmittee, 2015). Monteiro and Filho (2004) defines physical exercise as an activity presenting systematic repetitions of oriented movements feature with consequent increase on the oxygen intake due to muscular demand, thus generating work.

Exercise represents a subgroup of physical activity designed with the objective of maintaining the physical conditioning. It may also be defined as any muscular activity that generates strength and interrupts homeostasis. The physical exercise causes a series of physiological responses in the body systems, particularly in the cardiovascular system. With the objective of maintaining the cellular homeostasy in face of the increase on the metabolic demands, some mechanisms are set into action. These mechanisms function under the form of reflex arches composed of receptors, afferent pathways, integrator centers, efferent pathways and effectors and many stages of these mechanisms have not yet been fully elucidated.

Furthermore, the chronic effects, also called adaptations, resulting from the frequent and regular exposure to physical exercise distinguish an individual who is physically trained from an untrained individual. Regular physical exercises promote important autonomic and hemodynamic adaptations that will influence the cardiovascular system with the objective of maintaining the cellular homeostasis in face of the increment of the metabolic demands. There are increases on the cardiac debt; redistribution on the blood flow and elevation on the circulatory perfusion into muscles in activity. The systolic blood pressure (SBP) increases directly proportional to the increase on the cardiac debt. The diastolic blood pressure reflects the efficiency of the local vasodilator mechanism of the muscles in activity, which is as high as the local capillary density. The vasodilatation of the skeletal muscle reduces the peripheral resistance to the blood flow and the sympathetically induced concomitant vasoconstriction occurring in nonexercised tissues compensates this vasodilatation. Hence, the total resistance to the blood flow drops significantly when the exercise starts, reaching a minimum value around 75 percent of the VO2max. The tensional levels increase during physical exercise and during effort predominantly static, and intra-arterial pressure levels above 400/250 mmHg with no health damage has been verified in young and healthy individuals. In short, one may say that during an exercise period, the human body undergoes cardiovascular and respiratory adaptations in order to attend the increased demands of the active muscles and, as these adaptations are repeated, modifications in these muscles are verified, allowing the organism to improve its performance.

Physiological and metabolic processes optimize the oxygen distribution throughout tissues in activity. Therefore, the mechanisms that guide the post-physical training blood pressure drop are related to hemodynamic, humoral and neural factors. Modern living, according to Hegde (2003) has, however, robbed most of the “civilised” world of the many benefits of an active lifestyle (Hegde, 2003). Hedge continues that humankind has become sedentary because of the available of gadgets that can do works that previously would have been done by man. Even housewives have become more or less sedentary. This is a curse on human health and longevity. What goes on inside the body when one pedals a bike or takes a stroll? These activities set off complicated physical processes that affect nearly every organ system. When one exercises several times a week or more, the body adapts so that he is able to do so more efficiently (Minter-Jordan, Davis, & Arany, 2013). Knowing about this process will help one understand why physical activity has so many benefits.

Physical exercise helps the body to burn energy. Like all machinery, the muscles must have fuel. This fuel comes from the food we eat and the body's reserves of fat and glucose. The catch is that nutrients from food cannot be turned directly into usable energy for the trillions of cells in the body. According to Minter-Jordan, Davis and Arany each cell has one primary source of energy: a molecule called adenosine triphosphate (ATP). The body's ability to create ATP is critical because it determines its capacity for physical exertion. And the reverse is also true: one's physical conditioning influences how well the body can generate ATP. The food we eat contains energy stored in a variety of forms — proteins, fats, and carbohydrates. The body needs to extract this energy and capture it in the form of ATP. To do this, the stomach and small intestine break the food into millions of tiny molecules, which enter the bloodstream and find their way to every cell in the body. There, in small cell structures called mitochondria, the food molecules undergo a series of chemical reactions that ultimately lead to the creation of ATP.

The body stores only a small amount of ATP, but makes it as quickly as is needed. When demand increases- such as when one is exercising- the body must churn out more. To do this, it taps into glucose stored in the muscle and liver and fats from various places in the body. These substances make their way through the bloodstream to the muscles. Stored glucose (also known as glycogen) and fat can be broken down for ATP production in two ways: aerobic (requiring oxygen) and anaerobic (requiring no oxygen). Aerobic processes produce more ATP, but grind to a halt without oxygen.

When the body is working so hard that it is unable to deliver enough oxygen to support aerobic metabolism of food for fuel, it switches to anaerobic production of ATP, which creates a byproduct known as lactic acid. The lactic acid enters the bloodstream, creating an acid imbalance. To compensate this imbalance, breathing speeds up to take in more oxygen and the heart beats faster to move that oxygen to the muscles. But anaerobic activity cannot be sustained. The lungs and heart reach their maximum work efforts, and the body can only neutralize the resulting acid imbalance for a short time. The lactic acid generated from the anaerobic process also leaves muscles feeling fatigued. Hence one need to slow down when exercising to a particular level. By doing so, one is able to take in enough oxygen that once again he can be relied primarily on for aerobic production of ATP. Thus, Lactic acid production stops, the muscles start to recover, and the body restores normal acid balance. Level of fitness determines how swiftly this happens. Regular exercise conditions the lungs, heart, and blood vessels, enabling them to deliver oxygen to muscle cells more quickly and efficiently. Walking up a hill with a fitter friend illustrates this nicely. While the less fit individual is still huffing, and puffing, the fitter one will not be struggling to catch breath.

Intensity of exercise needed for physical fitness and bodybuilding is often confused with that needed for health benefits and longevity. The two are totally different. Physical fitness may not be the same as health life without physical illnesses. The emphasis is changing from encouraging an increase in fitness to encouraging an increase in total energy expenditure. This new approach comes from the recognition that there is a genetic component to fitness and that health benefits are achieved by activities that do not necessarily produce large gains in fitness. Regular physical activity decreases the likelihood of premature deaths. Very heavy physical exercise is sometimes associated with sudden death, but regular exercise, not of the vigorous type, more than compensates for this extra risk by the overall reduced risk at all other times. Routine exercise does confer many benefits like better exercise tolerance, lower body weight, lower blood pressure both systolic and diastolic, better control of blood sugar and cholesterol, lowered cardiovascular morbidity and mortality, lowered stroke risk, diminished accident rates, better social acceptability, strengthened bones in postmenopausal women, significantly reduced cancer risk of all types, better respiratory reserve, lesser incidence of viral infections, lowered risk of depression and most of all, a good night's rest at the end of the day. There are reports of well controlled studies that even show longer life expectancy in those that are active compared to couch potatoes. Although sudden death is more common during or immediately after a bout of vigorous exercise, it is not seen in people who regularly exercise. Regular exercise programmes do protect one from the risks of an acute exertional episode, which might be a necessity in an emergency.

The question that would be asked by many patients and lay people is at what age does the exercise regime benefit most? Recent work has clearly shown that exercise started even in those past the middle age would bestow its benefits, irrespective of the previous state of health. Hegde (2003), in his paper 'Health Benefits of Exercise' cited that a small number of young men (five) aged 20 years in 1966, were studied extensively for their aerobic power-body's ability to use oxygen. They were given three weeks of complete bed rest. At the end of the bed rest they were again tested to show that their aerobic capacity had declined significantly at the end of three weeks bed rest. Now in their late 50s they were completely reexamined to see the effect of ageing on their systems. They had lost their aerobic power by 11 percent, their body fat had almost doubled and their muscle mass was reduced significantly. Their cardiovascular capacity had declined significantly. They were then given a period of exercise- none of which was vigorous and there were no weight exercises. Most of the exercises were walking, bike riding or swimming. All of them started gradually and built up slowly to achieve, at the end of the month, moderate exercise for forty minutes a day for, at least, five days in a week. Six months later a repeat assessment showed that all the men had regained their aerobic capacity by 15 percent, their cardiovascular health had returned to normal, and they had less fat and bulkier muscles. They were fitter in every respect and felt a lot better. Three weeks of bed rest at the age of 20, had made them much worse than at their age of 56 years. Six months of moderate exercise got them back to their physical health of their younger days at age 20. Hegde (2003) concluded that “it is never too late to get back to shape” p. 297.

Health related articles in lay press give mostly misleading ideas about the health benefits of exercise while goading the population to do vigorous exercise to get into shape. The exercise outfits industry is a multi-billion-dollar industry, anyway. It would have its say through these write-ups and advertisements. Vigorous exercise is not only not needed, as the benefits gained by mild-moderate exercise are as good, if not better than that gained by vigorous exercise; but moderate exercise avoids the possible risk of sudden death during or immediately after a bout of exercise-- more so in the elderly. It is worth saying that physical fitness and good health are two different phenomena, although both could be simultaneously present in an occasional lucky individual. Various types of exercise have been scientifically studied in the past, including walking, running, cycle ergometer, calisthenics, and restrictive exercises. Although all of them do good to the human system, the best of the lot seems to be walking. The latter does not need any special sports gears, could be done in any place and weather, and most importantly, by anybody at any age. Even the very old have been shown to benefit by walking. Added advantage being the mental alertness in that age group, in addition to all other benefits of other age groups. Standard advice has been to recommend exercise durations ranging from 20-40 minutes a day for at least four to five days in a week. If done daily it is still better. Physical activity needs to be continuous. Studies have shown that the benefit of lower blood pressure due to exercise disappears if one stops the activity for more than two weeks. Industrialised countries could benefit a lot by making regular exercise popular among all their sedentary people. The benefits by way of deaths avoided and premature morbidity could be very substantial both from the economic point of view and that of manpower conservation. People with even modest motivation should be encouraged to gain important benefits of increasing their physical capacity. Avoiding premature death seems to be the single most important bonus of increased physical activity in the population.

Although the physiological mechanisms of many of the good effects of exercise are not clearly understood, the benefits are very well studied and documented by now. The study gives the right message for the elderly who missed out on their younger days on being active. They could catch up at any time and get back to good health and avoid physical disability and premature mortality. In addition to the regular exercise mentioned above, people should also be encouraged to be as mobile as possible even in their work places. “Catch them young” would be the best way to do this. Started early in life the benefits could be lifelong and longevity could be enhanced significantly. The byproduct of this would be to distract the adolescents from the bad effects of drugs abuse, television obsession, and many other criminal activities. Physical exercise confers the added bonus of a tranquil mind that reduces hatred, jealousy, and anger-the three devils, that have been shown to be most important risk factors for major killers like heart attacks, brain attacks and cancer. One bad habit that delays starting of an exercise habit at any age is the temptation to postpone exercise to a near future date. People put it off to the next day and that tomorrow might never come.

Many people spend more than half their waking hours sitting down. And activities that don't enhance health account for quite a lot of the remainder. This growing trend may cause more trouble than most people realize. Observational studies suggest habitual inactivity raises risks for obesity, diabetes, cardiovascular disease, deep-vein thrombosis, and metabolic syndrome. In fact, one study that followed more than 50,000 middle-aged women for six years found that even among women who were avid exercisers, the more television they watched, the more likely they were to gain weight or develop diabetes — regardless of how much physical activity they did. For every two hours, the women spent watching television each day, they had a 23 percent greater risk of becoming obese and a 14 percent greater risk of developing diabetes. Sitting at work for many hours also heightened their risks for obesity and diabetes (Minter-Jordan et al., 2013). When planning the day, it may be beneficial not only to increase the time for exercising but also to try to reduce "sitting time." The case for exercise is strong. Decades of solid science confirm that adding as little as half an hour of moderately intense exercise to the day improves health and extends life. Minter-Jordan et al. (2013)gave quick snapshot of the benefits exercise provides- not just while one is engaging in the exercise, but also over the long term. According to them exercise: (1) lessens the likelihood of getting heart disease, the number one killer of both women and men in America, (2) helps prevent plaque buildup by striking a healthier balance of blood lipids, helps arteries retain resilience despite the effects of aging, and bumps up the number of blood vessels feeding the heart, (3) reduces inflammation and discourages the formation of blood clots that can block coronary arteries, (4) lowers chances of dying from it and (5) lowers blood pressure, a boon for many body systems.

Long-term hypertension (high blood pressure) doubles or triples the odds of developing heart failure and paves the way to other kinds of heart disease, stroke, aortic aneurysms, and kidney disease or failure. Physical exercise helps prevent diabetes by paring off excess weight, modestly lowering blood sugar levels, and boosting sensitivity to insulin so that less is needed to transport glucose into cells. If one has diabetes, exercise helps control his/her blood sugar. Exercising also reduces the risk for developing colon and breast cancers, and possibly cancers of the endometrium (uterine lining) and lung. To attain a healthy weight, exercise lessens the risk for cancers in which obesity is a factor.

Furthermore, exercising helps shore up bones. When combined with calcium, vitamin D, and bone-saving medications if necessary, weight-bearing exercise like walking, running, and strength training helps ward off age-related bone loss (Minter-Jordan et al., 2013). And balance-enhancing activities, including tai chi and yoga, help prevent falls that may end in fractures. It also protects joints by easing swelling, pain, and fatigue and by keeping cartilage healthy. Strong muscles support joints and lighten the load upon them. Activities that boost flexibility, such as stretching, yoga, and tai chi, extend the range of motion, may limit and even reverse knee problems by helping to control weight — quite a bang for the buck, since every pound of weight lost reduces the load on the knee by four pounds. Exercising again lifts spirits by releasing mood-lifting hormones and relieving stress. In some studies, exercising regularly has helped ease mild to moderate depression as effectively as medications; combining exercise with medications, therapy, and social engagement is even better.

Physical exercise adds years to one's life. In the long-running Framingham Heart Study, moderate activity tacked on 1.3 years of life for men and 1.5 years of life for women versus low activity. Raising the bar to high activity added 3.7 years for men and 3.5 years for women. In a conference paper published by the Harvard Medical School, Jake Miller, one of the speakers reported a statement given by Huseyin Naci, an HMS visiting fellow in population medicine at the Harvard Pilgrim Health Care Institute, and a graduate student at the London School of Economics. He said "We were surprised to find that exercise seems to have such powerful life-saving effects for people with serious chronic conditions. It was also surprising to find that so little is known about the potential benefits of physical activity for health in so many other illnesses" (Minter-Jordan et al., 2013, pp. 24).

The study, conducted in collaboration with John Ioannidis, C.F. Rehnborg Professor in Disease Prevention and Director, Stanford Prevention Research Center, Stanford School of Medicine, found only four conditions where the effects of exercise on reducing mortality had been studied: prevention of severe illness in patients with coronary heart disease, rehabilitation from stroke, treatment of heart failure and prevention of diabetes. In addition to providing guidance for patients and clinicians about the importance of discussing the potential benefits of exercise, the researchers highlighted the importance of continuing to research the value of exercise for health. The researchers argue that more trials comparing the effectiveness of exercise and drugs are urgently needed to help doctors and patients make the best treatment decisions. In the meantime, they say exercise "should be considered as a viable alternative to, or alongside, drug therapy" (Minter-Jordan et al., 2013, pp. 24). This does not suggest people who have had a stroke should go off their medication and head to the gym, but having a conversation with a physician about incorporating exercise into treatment might be beneficial in many cases.

In the United States, 80 percent of people 18 and older failed to meet the recommended levels of aerobic and muscle-strengthening physical activity in 2011, according to the Center for Disease Control and Prevention (CDC). Also, the average number of retail prescriptions per capita for calendar year 2011 was 12.1, according to the Kaiser Family Foundation (Minter-Jordan et al., 2013). For the current study, the researchers analyzed the results of 305 randomized controlled trials involving 339,274 individuals and found no statistically detectable differences between exercise and drug interventions for secondary prevention of heart disease and prevention of diabetes. Among stroke patients, exercise was more effective than drug treatment, while in congestive heart failure diuretic drugs were more effective than all other types of treatment, including exercise. It was pointed out that the amount of trial evidence on the mortality benefits of exercise is considerably smaller than that on the benefits of drugs, and this may have had an impact on their results. Of the nearly 340,000 cases analyzed, only 15,000 patients had had exercise-based interventions. What people do not know about the benefits of exercise may be hurting. In many common diseases, physical activity is as effective as taking drugs at reducing the risk of death. Physical activity is potentially as effective as many drug interventions for patients with existing cardiovascular diseases and other chronic conditions. In the few conditions where the life-saving benefits of exercise have been studied, physical activity was often found to be as effective as drugs at reducing the risk of death, according to the first study to aggregate and assess the comparative benefits of drugs and exercise for reducing mortality in a wide range of illnesses.

Physical Exercise and Hypertension Treatment

Randomized studies showed the undesirable effects of the pharmacological treatment in a subgroup of patients with systemic arterial hypertension, suggesting a change on the treatment approach of these individuals. The effect of the physical exercise on the rest levels of the blood pressure from light to moderate degree is especially important, once the hypertensive patient may reduce the dosage of his anti-hypertensive remedies or even to control his blood pressure without the adoption of pharmacological measures (Monteiro & Filho, 2004).

The trend of the early use of pharmacological measures has been replaced by non-pharmacological agents, among them, the aerobic physical exercise has been recommended for the treatment of the light systemic blood pressure hypertension (Monteiro & Filho, 2004). Monteiro and Filho (2004) continued that the systemic arterial hypertension is a polygenic syndrome, being influenced by the genetic inheritance and only 75 percent of the hypertensive patients are responsive to physical training. The search for an explanation for the effect of the exercise on the blood pressure of normal blood pressure individuals and especially hypertensive individuals has encouraged many researches in the last decades, and the reduction on the rest diastolic blood pressure after training is the topic most widely studied.

The mechanisms that guide the post-physical training pressure drop are related to hemodynamic, humoral and neural factors. Among the hemodynamic factors, it was verified that both in rats spontaneously hypertensive and in humans, physical exercises reduce blood pressure due to the reduction on the cardiac debt, which is associated with the reduction of the cardiac frequency, once no alterations on the systolic volume were observed (Monteiro & Filho, 2004). The drop on the systemic vascular resistance and hence on the blood pressure would be another alternative mechanism proposed in order to explain the post-exercise blood pressure drop. A significant reduction on the pressure levels is obtained with low intensity training (50 percent of the peak oxygen intake). Thus, low intensity physical exercises reduce the blood pressure because they cause reduction on the cardiac debt, what may be explained due to the decrease on the rest cardiac frequency and the decrease on the sympathetic tonus in the heart as result of a lower sympathetic intensification and higher vagal nerve removal.

Some authors attribute reduction of blood pressure after the practice of physical exercises in hypertensive individuals to humoral alterations related to the production of vasoactive substances. Grassi, Seravalle, Calhoun and Mancia (1994) studied young normal blood pressure individuals and verified that after 10 weeks of physical exercise, the systolic and diastolic blood pressure of the respondents reduced significant. With regard to the acute effect of the exercise on the 24-hour blood pressure curve in patients evaluated through the blood pressure ambulatorial monitoring (BPAM); Marceau, Kouame, Lacourciere and Cleroux (1993) demonstrated that individuals trained at 50 percent and at 70 percent of the VO2max presented different pressure curve profiles; the individuals trained at 50 percent of the VO2max maintained reduction exclusively during the wake period, while the individuals trained at 70 percent of the VO2max maintained reduction even during the sleep period. Ishikawa, Ohta, Zhang, Hashimoto and Tanaka (1999) studied 109 hypertensive individuals in stages I and II who performed mild exercise training for eight weeks in sports academies. They verified a significant reduction on the blood pressure in all of them, where the elder individuals presented lower reduction on the blood pressure levels if compared to the younger individuals. No influence of the genders on the results was verified.

More recently, Takata, Ohta, and Tanaka (2003) submitted 207 individuals with essential hypertension of degrees 1 and 2 to a physical exercise program for eight weeks. The individuals were divided into five groups according to the exercise weekly duration and frequency (control group- inactive individuals, 30-60 minutes/week, 61-90, 91-120 and above 120 minutes/week). They verified that the rest diastolic blood pressure did not change for the control group; however, a significant reduction on the rest systolic and diastolic blood pressure was verified in the four groups submitted to the exercises. The reduction on the systolic blood pressure was higher for the group of 60-90 minutes/week, when compared to the group of 30- 60 minutes/week. No higher reduction with the increase on the exercise volume was verified. The reduction on the diastolic blood pressure was not significantly different in the four groups. There was no obvious relation between the weekly exercise frequency and the magnitude of the decrease on the blood pressure cause by exercises. Hypertensive individuals maintain the most intense reduction on the blood pressure in the 24 hours after exercise. Blood pressure evaluations in 25 and 45-minutes sessions after physical exercise at 50 percent of the maximal oxygen intake demonstrated more intense reductions after the 45-minutes sessions. In this case, it is possible that the blood pressure drop is due to the decrease on the peripheral vascular resistance, and this fact may even be related to the vasodilatation in the active and inactive musculature caused by physical exercise as result of the accumulation of muscular metabolites (potassium, lactate and adenosine) or due to the dissipation of the heat produced by the physical exercise. Alternatively, the increase on the blood flow may be a result of the reduction on the sympathetic tonus and the consequent increase on the peripheral vasodilatation, which seems to be related to the increase on secretion of endogen opioids caused by exercise, presenting direct vasodilator effect.

Cardiopulmonary and blood pressure receptors functional alterations such as the increase on its sensibility and the modification on its activation point and the recovery time may also contribute to the post-exercise vasodilator effect. The reduction on the alpha-adrenergic vasoconstrictor response verified in the recovery period- “down regulation” of the alpha-adrenergic receptors could also explain the higher post-exercise muscular blood flow. And yet, humoral factors such as adrenalin, the natriuretic atrial factors and the nitric oxide have been cited as factors involved in the post-exercise vasodilatation. Surprisingly, studies with rats spontaneously hypertensive showed that the decrease on the total peripheral vascular resistance was not the hemodynamic mechanism responsible for the decrease on the blood pressure after low intensity training, but rather a reduction on the cardiac debt.

The Brazilian Cardiology Society recommends that hypertensive individuals start programs of regular physical exercise since submitted to previous clinical evaluation. The exercises must be of mild intensity, from three to six times a week in sessions of 30-60 minutes duration, performed with cardiac frequency between 60 percent and 80 percent of the maximum or between 50 percent and 70 percent of the VO2max. With slight modifications, these recommendations are in agreement with the recommendations of other international entities.

Empirical Literature

This section presents empirical evidence of some determinants of blood pressure status. Literature on the effect of physical activity on blood pressure is reviewed. Literature on the socioeconomic factors that affect blood pressure are also reviewed under the section.

Physical Activity and Blood Pressure

Studies around the globe have shown that one of the risk factors of hypertension and thus, CVD is physical inactivity. In the study conducted by Sturtevant (2005) on the effects of exercise on reaction time, the heart rate, blood pressure, and reaction time of thirty (30) respondents were measured before and after they performed a five-minute acute-intense exercise. Participant’s heart rate, blood pressure, and reaction time were taken via Pulse Ox Monitor, Sphygmomanometer, and Reaction Timer, respectively, and were measured to have baseline statistics. In order to assess the effect of exercise on participant's heart rate and blood pressure, both variables were measured before and after the occurrence of exercise. They observed that on the average both heart rate and systolic blood pressure of respondents increased immediately after exercise. The results also indicated that both increased heart rate and blood pressure during exercise independently had an impact on decreasing reaction time. That is, immediately after exercising, the blood pressure of the individual increases. This study did not look at how blood pressure behaves after one has rested from exercising.

In an experiment conducted by Tuxworth et al, (1986) on health, fitness, physical activity, and morbidity of middle aged male factory workers; they administered questionnaires to and performed test on **e**very man aged between 35 and 60 years. The medical questionnaire asked about previous significant medical history and current medication and treatment. Each participant was examined by a physician immediately before testing. The physical examination consisted of assessments of the heart, lungs, heart rate, and blood pressure. submaximal bicycle ergometric procedures were used to predict maximum oxygen consumption. A total of 1394 subjects were included in the study. They concluded that most subjects with mild hypertension would have little to lose, and might benefit greatly, from increased physical activity rather than drug treatment. They added that this would especially apply to the men in the sub-mild hypertension group approaching 90 mmHg. In one of the trials, resting diastolic blood pressure was reduced from 99 mmHg to 88 mmHg over a four months period of physical training. They stated in the concluding part of their study that of even greater importance perhaps was the substantial reduction in both systolic and diastolic pressure during exercise, thereby reducing the risk normally encountered by hypertensive subjects during unaccustomed exertion. They then concluded that relative fitness is associated with improved health status through lower blood pressures and less body fat. That is, exercising over a long period of time can help reduce blood pressure

In a semi-experimental study by Assarzadeh, Beni and Khoubi (2012) to investigate and compare the effect of four types of sub-maximal aerobic exercises (front crawl swimming, running, bicycle riding and rhythmic movements) on the variations of systolic and diastolic blood pressure during and after exercise in middle-aged males with hypertension among 16 middle-aged male patients (40 to 55 years old) with drug-dependent mild hypertension, they found a significant difference between systolic blood pressure during and after front crawl swimming, running, bicycle riding and rhythmic movements. Thus, swimming, running, bicycle riding and rhythmic exercises cause variation in systolic blood pressure during and after exercises. Also, there was a significant difference between their diastolic pressure during and after swimming, running, bicycle riding and rhythmic exercises; therefore, swimming, running, bicycle riding and rhythmic exercises also affect diastolic pressure during the exercise. But, no significant difference existed between their diastolic blood pressure before and after swimming and running exercises while a significant difference existed between their diastolic pressure before and after bicycle riding and rhythmic movements. The participants used medications under the supervision of a physician and they did not have any cardiac or diabetic diseases. All four types of single-session sub-maximal aerobic exercises were carried out with 60-70 percent of their maximal heart rate for about 20 min. The time interval between each exercise was 2 days. Investigation of the obtained results demonstrated that all the four types of selected exercises caused considerable variations in systolic and diastolic blood pressure during and after exercises. Systolic blood pressure during and after bicycle riding had the least variation relative to other exercises while systolic blood pressure during and after the rhythmic movements had the largest variation relative to other exercises. Variations of systolic blood pressure during and after running and front crawl were in an average range compared with other exercises. In all four types of exercises conducted in their study, there was a significant decrease in the diastolic blood pressure during the exercise and this pressure drop was almost the same among all the exercises. Diastolic pressure drops after stopping exercises in the running exercise and rhythmic movements was lower and higher than other exercises, respectively. the study investigated within-group differences using Analysis of Variance (ANOVA) with repeated measures. The significance of the within group differences in means were tested using the dependent t-test. Moreover, one-way Analysis of Variance (ANOVA) was applied for investigating between-group differences and, in the case of any significant differences, post-hoc Scheffe test was used for determining the location of the between-group difference. The study suggests all forms of exercising can help reduce systolic blood pressure while rigorous exercise is important in controlling blood pressure. The one-way ANOVA, which was used for the study however makes it impossible to control for other factors that influences blood pressure. That is, the results of the study might have been different if a more rigorous statistical tool had been used for the study.

Ewing (2005) studied how physical environment influences physical activity levels. His study was founded on a study conducted for Smart Growth America. Smart Growth America analyzed relationships between sprawl and various travel outcomes, including some related to physical activity. According to them, the percentages of workers walking and taking public transportation to work proved significantly related to the metropolitan sprawl index. They acknowledged that walk trips to work involve significant amounts of physical activity, because work trips tend to be longer than trips for other purposes. It was also noted that public transportation trips are less obviously related to physical activity, but are still classified as active travel, because they almost always require a walk at one or both ends of the trip. The study thus, concluded that the more sprawling the area, the less physical activity residents get through active travel. In Ewing (2005) study, he returned to the metropolitan sprawl database to compute elasticities of walk and transit-mode shares with respect to the metropolitan sprawl index. To Ewing (2005), the elasticity of walk-mode share with respect to the sprawl index was computed to be 0.93, whereas the elasticity of transit-mode share with respect to the sprawl index was an even higher 1.78. These elasticities suggest that for every 1 percent increase of the index, the percentage of commute trips made on foot increases by 0.93 percent, and the percentage made by public transportation increases by 1.78 percent. The way the index was constructed, lower values correspond to more sprawling areas, and higher values to more compact areas. So, this relationship is in the expected direction. The first study linking the built environment to health outcomes appeared in late 2003. Health data for more than 200,000 American adults were extracted from BRFSS. These data were matched to Smart Growth America's county sprawl index (described above) using county geocodes from BRFSS. Obesity, body mass index (BMI), hypertension, diabetes, and coronary heart disease (CHD) were modeled in terms of individual characteristics and the county sprawl index. After controlling for age, education, fruit and vegetable consumption, and other sociodemographic and behavioural covariates, residents of sprawling counties weighed more, were more likely to be obese, and were more likely to have high blood pressure than were their counterparts living in compact counties (Ewing, 2005). The study concluded that there is relatively strong evidence of association between metropolitan development patterns and use of active travel modes such as walking and transit, and between neighborhood design and active travel choices. Whether the environment is actually determining travel choices, how the environment relates to overall physical activity, and how the environment affects downstream weight and health remain issues for future research.

Even more recently studies have been carried out into the influence of the physical environment (Bolívar, Daponte, Rodríguez, & Sánchez, 2010). In the literature, the concept of physical environment has been defined as the existence of and physical accessibility to centres such as gyms, swimming pools and leisure centres; ―informal spaces that form part of a neighbourhood's facilities such as open public spaces, and the layout and use of buildings; or aspects regarding traffic, safety and attractiveness of neighbourhoods and local areas. These studies have not simply used objective measurements such as the existence, accessibility or proximity of such facilities.

In a study conducted by Bolívar et al. (2010) on the influence of individual, social and physical environment factors on physical activity in the adult population in Spain, it was found that rates of physical activity are influenced by the social and physical environment. According to them, the influence of social class means that members of disadvantaged groups are less likely to engage in physical activity. Furthermore, they found that women are less active than men. Also, the presence of green spaces in neighbourhoods is an influences physical activity. The study was a cross-sectional study using 6,425 men and 6,768 women (aged 16 and over) living in Andalusia, excluding people living in care, collected by the Andalusia Health Survey in 1999 and 2003. These studies, thus, show that if the physical environment is not physically-active-friendly, people are more likely to be sedentary and hence develop all the risk that comes with it.

Socioeconomic Conditions and Blood Pressure

As mentioned earlier, high blood pressure is the single most important risk factor worldwide of cardiovascular disease, being accountable for about half of all cases of strokes, ischaemic heart disease, and heart failure. High blood pressure appears to be a more powerful cardiovascular risk factor than indicated by earlier studies. Its control can, therefore, help prevent and reduce the prevalence of various CVDs. However, gains in health outcomes must be set against the considerable costs involved. Over the past two decades, several countries have conducted community surveys on blood pressure detection and control. Literature already reviewed above have shown how various authors and organisations have made efforts to find various means by which various ailments including hypertension can be prevented or controlled. These studies however, neglected an important fact that the social and economic factors of persons and societies affect their health. In more recent times, studies have also come up to close this gap and, thus, determine the social and economic determinants of hypertension.

In 2004, the contract for all UK general practitioners was revised to include a pay for performance system accounting for up to a quarter of total annual income. This system, termed the quality and outcomes framework (QOF), has provided new performance data aggregated at practice level. So too is the achievement of blood pressure target levels for all patients with any of five chronic conditions that are included in the QOF - hypertension, coronary heart disease, stroke and transient ischaemic attacks, diabetes, and chronic kidney disease. The linkage of financial incentives to performance targets was intended to drive up the standards of primary care. It has also been observed that health inequalities between different population groups may be diminished as overall collective achievement increases.

Within a few years, however, practices in deprived areas had caught up, resulting in an eventual reduction in inequality based on social deprivation. This phenomenon has been termed the inverse equity hypothesis. Ashworth et al. (2008) decided to use the data available through the QOF to provide a current perspective on two measures— national rates of blood pressure monitoring in primary care patients and the achievement of blood pressure control targets in patients with chronic conditions. Ashworth et al. (2008) described the effect of any changes over time on health inequalities between general practices in deprived and less deprived communities. QOF data covering three years from April 2004 to March 2007 for all general practices in England was used for the study. Analysis was confined to the following: (1) the proportion of all registered patients aged 45 years or more who had had their blood pressure taken within the preceding five years, (2) the prevalence of five chronic conditions (hypertension, coronary heart disease, stroke and transient ischaemic attacks, diabetes, and chronic kidney disease) and the achievement of blood pressure targets for each of these conditions.

The denominator for the analysis of all QOF data was the total population of patients on the respective disease registers for each practice. This method of analysis precludes the process of "exception reporting," whereby general practitioners are permitted to omit certain patients from their performance data on the grounds of unsuitability (for example, patients who are already receiving the maximum tolerated hypotensive drug dose, who fail to attend the surgery in spite of three invitations, or who are terminally ill). A detailed summary of practice characteristics was obtained. Variables included were practice list size, a breakdown of the registered population by age and sex, the number of full time equivalent general practitioners, and training practice status. Data from the 2001 national UK census was obtained based on the lower layer super output area (SOA) for each practice. Each such area consists of about 1500 people within a defined geographical locality. Census data based on the home address of all patients registered at a general practice were not available in England, so the SOA in which a general practice was used as a proxy for the registered population at each practice. The SOA formed the basis for calculating the index of multiple deprivation, 2004, which consisted of seven domains of social deprivation, mostly derived from census data in 2001 but with some domains (such as education, housing, and crime) updated more recently (Ashworth et al., 2008). They therefore obtained and analysed deprivation data at practice level rather than patient level.

Like most commonly used deprivation indices, the index of multiple deprivation did not include a measure of ethnicity. These data were available from the 2001 national census, and was added to their dataset, again aggregated at the level of SOA. They then constructed a dataset for all general practices in England containing data from the QOF, the practice, and census data for the surrounding SOA. Practices that were no longer independent at the end of the study year or had a list size of less than 750 patients or less than 500 per full time general practitioner were removed on the grounds that these practices were likely to be newly formed or about to be closed. The final dataset used for the study consisted of 8515 practices (99.3 percent of the total) in year 1, with 8480 of these practices linked to the 2004 index of multiple deprivation; 8264 practices (98.3 percent of the total) in year 2, all linked to the deprivation index; and 8192 (97.8 percent of the total) in year 3, with 7831 linked to the deprivation index. Firstly, the study explored the relationship between social deprivation and the achievement of the six QOF indicators related to blood pressure that were included in the study. This analysis was conducted by comparing the achievement of practices located in the most deprived fifth of super output areas in the country with the achievement of practices in the least deprived fifth. Mean values were calculated for each of the blood pressure related variables in all practices and then recalculated as weighted means (based on the number of registered patients) in order to adjust for the effect of practice size.

To enable comparison of mean values in the most deprived and least deprived areas, Ashworth et al. (2008) estimated the 95 percent confidence intervals of the means. Possible confounding variables were then searched for using multivariate analysis and a forward stepwise method; variables were entered into the equation if the significance of the association on univariate analysis, P, was less than 0.1. The study found that blood pressure monitoring levels of all adult patients (aged ≥45 years) registered at general practices in England rose by 5 percent over the three years during which QOF data have been available such that, by 2007, 88 percent of the adult population have had their blood pressure measured in the preceding five years. Also, it was observed that when blood pressure monitoring data first became available through the QOF dataset, there was a difference in blood pressure monitoring between most and least deprived areas.

However, as overall blood pressure monitoring levels increased, this inequality narrowed over the three years such that, by 2007, the difference was negligible (0.2%). Ashworth et al. (2008) also found marked differences between practices in least and most deprived areas. On multivariate analysis conducted by Ashworth, Medina and Morgan (2008), practices found to be performing less well in terms of blood pressure monitoring were those with higher proportions of black or black British residents in the local population, were situated in less deprived areas, had larger numbers of general practitioners, and had larger list sizes per general practitioner. Hence, in the third year of QOF, social deprivation was no longer having a negative effect on blood pressure monitoring and, once corrected for confounding, had a weakly positive effect. The strongest confounding effect was the proportion of black or black British people in the local community.

For all five conditions used for the study, the achievement of target blood pressure targets had improved substantially over the three-year study period. The greatest increase over time was observed for blood pressure control in diabetics in the most deprived practices, which improved by over 10 percent, with 79 percent achieving target blood pressure levels by 2007. Just as for overall blood pressure screening in the adult population, the improvements in achievement of blood pressure targets in chronic conditions have resulted in almost complete disappearance of the differences between least and most deprived areas. In 2005, the shortfall in the achievement of blood pressure targets in most deprived areas compared with the least deprived ranged from 2.1 percent to 4.3 percent. By 2007, the differences in achievement ranged from 1.3 to −0.6 (mean blood pressure control was slightly better in diabetic patients in deprived areas). They observed ethnicity played a role in determining the level of blood pressure monitoring by general practitioners but not in the control of high blood pressure. The is to say that improved blood pressure monitoring is crucial in detecting and controlling for hypertension among all societies. The study however did not look at what causes the most deprived to record higher values of blood pressure than the less deprived areas.

In the case of America, Meltzer and Jena (2011) developed and tested a simple model of exercise behaviour that incorporates the time cost of exercise, the disutility associated with intense exercise, and the utility gains from exercise-induced improvements in health. According to them the benefits of exercise for improved longevity and health are well known. Walking for half an hour a day, five days a week, has been reported to increase life expectancy by 1.5 years while more intense exercise may double these gains. Despite the potential for such benefits, more than 60 percent of Americans do not meet these recommended guidelines for moderate physical activity. Knowledge about why this occurs is limited, they added. Meltzer and Jena (2011) continued that there is no evidence that people fail to recognize the health benefits of exercise. However, there is good evidence that many people simply do not enjoy exercise, and especially intense exercise.

Another major barrier to exercise is the time required. Intensity of exercise is interesting in this regard since increased intensity can allow a given amount of total exercise to be accomplished with lower time requirements. This is especially important since the time required for exercise is one of the most commonly reported barriers to regular exercise. However, since increasing the intensity of exercise can be unpleasant and increase the rate of injury, increasing the intensity of exercise has limited capacity to reduce the time costs of exercise. Thus, while the time costs and dislike of exercise are both likely to be important independent barriers to higher levels of exercise, they are also related. When wages are high and time is costly, how does exercise behaviour, i.e. the length and intensity of exercise, change? The main prediction of Meltzer and Jena (2011) model is that as wages increase, individuals will shift towards less time-intensive, but more physically-intensive, forms of exercise. While the overall time exercised may increase if health is a sufficiently normal good, that time will be spent more intensively as wages rise. The main implications, then, are that increasing intensity may be an important strategy for reducing the time costs of exercise and, more generally, that factors which influence the time costs of exercise, such as intensity, may be important concerns in the design of interventions to promote exercise.

To assess the association between measures of income and exercise intensity, Meltzer and Jena (2011) combined data from three cycles of the National Health and Nutrition Examination Surveys (NHANES) conducted in 1999–2000, 2001–2002, and 2003–2004. These nationally representative surveys used a combination of questionnaires, on-site examinations, and laboratory testing to collect detailed information on the health status and health habits of a nationally representative sample of Americans. The Survey collected increasingly detailed information on the physical activities of its respondents. In particular, for each activity an individual information is collected on the nature of that physical activity (i.e. basketball, running, yoga, etc.), the duration (i.e. hours spent in the past month), and the level of exertion (i.e. moderate versus rigorous) they have done in the past month. Because the primary emphasis of the study was on individuals in the labor force, only individuals older than 25 years with a family annual income exceeding $5,000 were used for the study. The total sample size of 10,853 individuals were, thus, used for the study.

From Meltzer and Jena (2011) study, an association between income and exercise intensity was identified; that is consistent with the hypothesis that people respond to increased time costs of exercise by increasing intensity. They however, acknowledged that the association observed may not necessarily reflect a causal association. They added that if one accepts the idea that increases in the opportunity cost of time encourage greater intensity of exercise, such preferences may also have implications for understanding variations in exercise patterns across demographic groups and for designing health promotion efforts. This suggest that physician recommendations for regular low intensity exercise (such as walking) may be unlikely to result in a sustainable exercise regimen for persons with high costs of time, unless such walking can be incorporated into required daily activities, such as commuting. In contrast, recommendations to undertake more intense exercise regimens may be of greater value to such individuals. This suggests that high wage individuals may be willing to make large investments in order to increase the intensity of exercise. The contribution of Meltzer and Jena (2011) paper to the blood pressure control is that while physical exercise has a lot of benefit for mankind, the time used in exercising is an economic resource and has a higher opportunity cost to the rich in society than the poor. The way around it for the wealthy, therefore is to increase the intensity of exercise to be able to benefit from it within the shortest possible time.

In Ulijaszek's (2003) study, a comparison is made between blood pressure of the Rarotonga population in 1996 with the values obtained for this population by Prior et al. (1968) in 1964, and the extent to which education and occupation, as markers of modernization, associate with blood pressure (taking into account the use of anti-hypertensive drugs by a subset of the sample) and island of origin is examined. The 1964 sample comprised 455 Cook Islander volunteers aged 20 to 82 years, living in Avarua, the urban center of Rarotonga. Blood pressure was measured using a sphygmomanometer with the subject seated, at the fourth phase of Korotkoff sounds. The 1996 sample on the other hand, comprised 425 Cook Islanders aged 22 to 86 years, who were recruited by means of a radio and television campaign, on Rarotonga, the Cook Islands, forming a volunteer sample of the total adult population. Subjects who agreed to take part in the survey were seen at six different clinic sites representative of the demographic and socio-economic distributions of the adult Rarotongan population. Systolic (SBP) and diastolic (DBP) blood pressures were measured in a lying position after 15 minutes rest, using a sphygmomanometer. The fourth phase of Korotkoff sounds was recorded. The blood pressure data used for the study is the average of two readings taken one minute apart. Mean values for SBP and DBP were calculated by age group and sex using SPSS-PC for Windows. Relationships between the blood pressure variables and place of origin were examined using one way analysis of covariance and allowing for age and relative weight (BMI) as confounding factors. This gave values for blood pressure adjusted for BMI. The generalized linear model (GLM), using logit-link function where appropriate, was used to test associations between place of origin and socio-economic factors (education and occupation), age, BMI, and the blood pressure variables SBP and DBP. The GLM model allowed analysis of the net effect of the place of origin on individual variables included in the model, and neutralized the effect of having subjects who were using antihypertension medication included in the sample. It was found that island of origin is a significant predictor of blood pressure, irrespective of occupation, use of antihypertension medication, age and BMI. The study also found island of origin is associated with level of education for the females, but not for the males. Also, island of birth has significant associated with DBP for males, and with education and SBP for the females, but was independent of use of anti-hypertension medication in both sexes. This is to say that the environment of people and their place of birth relatively determines their blood pressure. Thus, in controlling for blood pressure, one must pay more attention to societies who by virtue of their environment are more susceptible to risk.

Lam (2011) on his part acknowledged that SES is a known risk factor for cardiovascular disease. He however added that unlike traditional Framingham risk factors, SES does not directly impact the cardiovascular system but exerts its cardiovascular effects via a complex interaction of biobehavioural factors, such as exercise and diet. To understand the role of mediating factors in the association between SES and hypertension, Brummett et al. (2011) conducted a large cross-sectional study using data from Wave IV (2007–2009) of the National Longitudinal Study of Adolescent Health. Using path models, they found that, in 14,299 Americans aged 24 to 35 years; higher household income and being married were independently associated with lower systolic blood pressure. Also, using a multivariate model, they observed that older age, male sex, black ethnicity, higher body mass index, greater waist circumference, smoking, and higher alcohol intake were also independently associated with higher systolic blood pressure. Again, higher household income was found to be associated with lower systolic blood pressure by way of lower resting heart rate (offsetting the SBP-raising effects of increased alcohol consumption) and remained inversely associated with systolic blood pressure even after adjusting for all measured covariates.

More importantly, Brummett et al. (2011) showed that each $50 000 increase of household income was related to a decrease in systolic blood pressure of 0.61 mmHg. Finally, Brummett et al. (2011) found that higher education level was also associated with lower systolic blood pressure by way of lower BMI, smaller waist circumference, and lower resting heart rate, but was no longer significantly related to systolic blood pressure after accounting for these indirect effects. The authors concluded that increased BMI, particularly central obesity, and higher resting heart rate were important mediators of the association between lower SES and higher systolic blood pressure. Obesity emerged as a chief link between lower educational status and higher systolic blood pressure. Lam (2011) stated that the study by Brummett et al. (2011) may not be surprising at first glance-- the association of lower SES with higher BMI and higher SBP has been observed in other developed countries and has been attributed to lack of knowledge regarding dietary choices, lack of access to healthy foods in lower SES areas, poorer weight management skills, or differing social norms related to body size. Furthermore, longitudinal studies have demonstrated that lower SES exerts long-term effects on both obesity and SBP. These data underscore the urgency to address the “epidemic” of obesity in the young, particularly central obesity, which may be part of the metabolic syndrome, where focused efforts in the socially disadvantaged may help to reduce the burden of hypertension and address cardiovascular health disparities in later adulthood. Higher heart rate was identified by Brummett et al. (2011) as another important link between lower SES and higher SBP. Higher heart rate may be a surrogate measure of increased psychosocial stress or reduced physical fitness.

A host of adverse psychosocial factors have been found to be increased in lower SES groups, including hostility, depression, and social isolation, and these stressors may lead to higher resting heart rates and increased SBP via sympathetic over activity. Although psychosocial factors were not directly measured in the current study, the "protective" effect of being married suggested a role for social support, and previous studies have shown that perceived stress and depression were significant mediators of the association between lower SES and increased SBP. The significance of these findings lies in the potential for preventive interventions, such as promoting healthy stress coping skills and regular aerobic exercise. Taken together, it is tempting to oversimplify the association between SES and SBP as such: socially disadvantaged individuals face job and neighborhood stressors, which, coupled with lack of knowledge and limited resources, drive these individuals to low-cost, high-calorie fast food options, resulting in obesity, the metabolic syndrome, and hypertension; chronic ill health may then limit job opportunities, creating even more stress and perpetuating the vicious cycle. Lam (2011) stated strongly that the association may not, however, be that straightforward for the following reasons. Firstly, the SES-obesity-SBP link can change in its direction of association–in undeveloped or developing countries, BMI increases with higher SES and contributes to a direct association between higher SES and higher SBP. Obesity is not, therefore, an inevitable consequence of social deprivation, and much depends on the state of development of the country. Second, variations in SES may have different effects depending on sex and ethnicity. The relationship between lower SES and higher SBP is stronger in women than in men. Among women alone, SES-SBP inverse associations are stronger in black Americans than in Mexican Americans. Third, even if SES disparities were eliminated among sexes and ethnicities, the prevalence of hypertension would still be greater in black than in white Americans, suggesting inherent genetic predisposition or other and effective means to address social disparities in outcomes among hypertensive individuals.

Colhoun et al. (1998) reviewed evidence for the existence of SES differences in BP. To do this, literature for epidemiological studies were searched. This was performed using MEDLINE from 1966–1996, restricted to the English language and using the terms: hypertension, BP, systolic BP, diastolic BP, income, education, socio-economic status, socio-economic grade, occupation, ethnic group, psycho-social and social class. Manual searching of the bibliographies of retrieved references provided additional material. Studies were included in the review if they contained data which quantified the relationship between any measure of SES and any measure of BP. Few of the papers had this relationship as the main focus and none was originally designed to investigate it. Since the studies selected represented widely differing populations and methods, a quantitative overview of the studies was not considered appropriate.

If SES gradient in BP does exist it does not necessarily follow that the direction of this gradient will be the same in all cultures. For example, in some African countries mortality from cardiovascular disease shows the opposite SES gradient to that seen in developed countries, and it is reasonable to expect that the distribution of risk factors for cardiovascular disease may differ also. Therefore, studies of populations in developing as well as developed countries were included. Since the effect of ethnicity on BP was not a focus of the study, it was ignored except insofar as it may confound the SES-BP relationship. SES was typically measured using education, income and occupation. It was observed that cardiovascular disease was inversely associated with SES regardless of which of these three measures was used.

Colhoun et al. (1998) found 57 studies from developed countries reporting on SES differences in BP. Almost all these studies were cross-sectional and in only four were trends over time in SES differences in BP examined. In 10 studies, no adjustment for age was made but three of those were birth cohorts so no adjustment for age was required. Of those studies where age adjustment was made or not required eight reported no age-adjusted association between SES and BP. The remainder reported an inverse association between some measure of BP and some measure of SES in one or both sexes. None of the studies reported a positive association. Almost all of the reported studies from the USA and Canada found higher mean BPs or prevalence of hypertension with lower SES, regardless of the measure of SES used. In Australia, a review of three surveys between 1980–1989 showed a more consistent education gradient in women than men, for both mean systolic BP and hypertension prevalence. No change in the gradient over time was reported. An inverse association between hypertension and education was found in white South African men and women and an inverse association with income was found only in women.

In Japan, the prevalence of hypertension was higher in executives than in manual workers, whereas in China there was an inverse association between systolic BP and physical workload, but not education. In the region of Europe, an inverse association of SES with BP and hypertension have been reported in some parts of Sweden but not others, in Norway, Paris, the Netherlands and in Ireland. In Finland, the association among men was not present in 1972 but has emerged recently and an inverse gradient in obesity in men emerged over the same period. In former West Germany, inverse SES-BP associations were found in women only, whereas a later survey found an inverse association among both men and women in West and East Germany. The reports from UK studies show a less consistent association between SES and BP than those from other countries. A small inverse gradient in systolic BP with occupational status was reported in male, but not female civil servants in the Whitehall II Study.

In the Medical Research Council (MRC) National Survey of Health and Development, (a cohort born in 1946), parental social class was inversely associated with systolic BP in men and women whereas education and own social class was associated with systolic BP in men only, in keeping with the Whitehall findings. Men who had attained a higher social class than their parents had higher pressures than those who retained the social class of their parents. In the British

Regional Heart Study, which included men only, an inverse association was also observed for systolic BP. In the 1986 Diet and Nutrition Survey of British adults, social class was not independently related to systolic or diastolic BP on adjustment for other risk factors. In the Brent study, systolic BP was not significantly associated with social class in African –Caribbeans or Europeans. An inverse association between BP and social class has also been found in English men in the Speedwell Study, but not Welsh men in the Caerphilly study.

In the Scottish Heart Health Study, diastolic and systolic BP were significantly higher in manual classes in women only, but showed an association with housing tenure in both sexes. Also, thirteen studies reporting the association between SES and BP in undeveloped and developing countries were found, half of which included adjustment for age or other variables. Overall a direct association between some measure of SES and BP was reported in either sex in six of these studies and an inverse association in four. In three of the six Indian studies a direct association was found between various SES measures and either BP or hypertension.

In the Kenyan Luo Migration study, there was a positive correlation between years of education and systolic and diastolic BP adjusted for age, and in a Nigerian occupational status was found to be directly association with hypertension prevalence. The direct association between SES and BP in many of these studies is consistent with the hypothesis that, as economic prosperity occurs, risk factors for hypertension like salt intake and obesity, become more prevalent in those with higher SES. As development becomes more widespread risk factor gradients invert.

The paper concluded that publication bias notwithstanding, lower SES is associated with higher BPs in most studies from developed countries. The differences between SES groups are small, the age-adjusted difference between the highest and lowest SES group being about 2–3 mmHg for systolic BP in most studies. However, this small difference in BP is important at the population level. In contrast, among adults in undeveloped and developing countries a direct association between SES and BP has often been observed.

In developed countries, a substantial part of the SES gradient in men and women is accounted for by the SES gradient in BMI. Alcohol consumption pattern across SES groups also appears to account for part of the association in men though few studies have reported its specific effect. SES differences in BP are not detectable in most studies of children. This may be because height, which is inversely related to SES, has an overwhelming influence on BP in childhood. There is little evidence to suggest that SES itself increases BP other than through conventional risk factors for hypertension. However, stronger relationships may exist between BP and more specific stressful aspects of low SES such as unemployment or job insecurity. They added that in order to reduce SES variations in BP the major challenge is to identify the causes of and strategies for prevention of the higher BMI and obesity rates associated with lower SES, particularly in women.

Chapter Summary

The objective of the study is to determine how socioeconomic conditions mediate the effect of exercise in blood pressure. This chapter captures already existing literature on blood pressure and exercise. First, the chapter presented literature on augments on staging of blood pressure. It then looked at the importance of physical exercise on general health and then narrowed the augment down to how it can help treat hypertension. Finally, evidence on how socioeconomic conditions affect blood pressure was presented. Health authorities have agreed that if systolic and diastolic blood pressure of an individual fall under different stages of blood pressure level, the higher stage should be used as the basis for diagnosis and treatment. It is largely agreed that physical exercise has a lot of health benefits and helps control and treat hypertension. Studies have also shown that the SES of an individual relates to his/her blood pressure status.

CHAPTER THREE

METHODOLOGY

Introduction

The study determined the mediating role of wealth on the effect of exercise on blood pressure. This chapter presents the methods that were used to test the various hypotheses of the study. The chapter presents the research design, the data source and nature, theoretical model on which the study analysis is built, the empirical model used for testing the study hypotheses, description of the variables used for the study and lastly how the post-estimation tests of the study were conducted.

Research Design

The study adopts the positivist research philosophy. This means results obtained from the study were not due to value judgement but based on a scientific method of enquire. This design was adopted for the study because data on already existing observable characteristics of the respondents were analysed. The study is also quantitative in nature. The study is, therefore, objective and free from manipulations.

Data Source and Description

This thesis is based on data from the 2014 Ghana Demographic and Health Survey (GDHS). The 2014 GDHS is a nationally representative survey of health, demographic and other related issues of importance to development, conducted among 9,396 women age 15-49 and 4,388 men age 15-59 from 11,835 interviewed households. Since 1988, six GDHS surveys have been conducted at five-year intervals. The 2014 GDHS, from which data for the study was obtained, is the sixth in the series of population and health surveys conducted in Ghana as part of the global Demographic and Health Surveys (DHS) Program.

The surveys have been conducted by the Ghana Statistical Service (GSS) and, occasionally, in collaboration with the Ghana Health Service (GHS) and/or National Public Health Reference Laboratory (NPHRL) of the GHS, with technical support from ICF International through the DHS Program, a USAID-funded project offering support and technical assistance in the implementation of population and health surveys in countries worldwide.

The male and female recode files (datasets) were used for the analysis. Each of these datasets has information on the blood pressure measurements of individuals, risk factors of high blood pressure and also information on wealth status of the household the individual resides in and other socioeconomic conditions of each and every individual. Data on blood pressure of individuals was for the first time, in the series of the DHS in Ghana, captured in the 2014 GDHS. To capture the data needed to determine the effect of physical exercise and socioeconomic factors on blood pressure in Ghana, the male and female datasets were merged. Cumulatively, the men and female data files have information for 13,784 individuals. However, this study used information from 13,723 respondents for its analysis due to missing observations for some of the variables used for the study. Table 2 shows how the researcher arrived at the sample size of 13,784.

Table 2: Number of Observations in 2014 GDHS Data Set and Number of Observations Used

Variable	Number of Observations in GDHS Data	Number of Missing Observations	Number of Observations used
Blood Pressure	13784	48	13723
2nd BP (males)	*4388*	*11*	*4377*
3rd BP (males)	*4388*	*1*	*4388*
2nd BP (females)	*9396*	*33*	*9363*
3rd BP (females)	*9396*	*3*	*9393*
Age	13784	0	13723
Fruit	13784	12	13723
Arm Circumference	13784	0	13723
Exercising habit	13784	0	13723
Smoking habit	13784	1	13723
Wealth	13784	0	13723
Education	13784	0	13723
TOTAL	**13784**	**61**	**13723**

Note: Number of missing observations for the variables fruit and smoking habit is a cumulative same of missing observations in the men and women data sets. Missing observations for blood pressure captures that of both systolic and diastolic *blood pressure values. The average of the 2^{nd} and 3^{rd} blood pressure readings is captured as the true blood pressure of the individual.*

For the purpose of validation of the 2014 GDHS data for the study, computed descriptive statistics for four different variables (age of household head, household size, type of place of residence, sex of head of household) are analysed from the 2014 GDHS household dataset and compared with computed descriptive statistics of the same variables from the household dataset of the Ghana Living Standard Survey round 6 (GLSS-6) conducted from 2012 to 2013. In spite of the fact that the timing of the two surveys vary and also given that the GLSS-6 sample is inclined towards gathering information on the living conditions and well-being of households in Ghana, finding broad patterns remains essential for proceeding with this exercise. Computed descriptive statistics from both datasets are presented on Table 3.

Table 3: The 2014 GDHS and GLSS 6 Data Sets

Variable	2014 GDHS	GLSS 6
Average age of household head	44.230	45.055
Average household size	3.713	3.991
Type of place of residence		
Rural	45.05	44.61
Urban	54.95	55.39
Sex of head of household		
Male	66.18	69.47
Female	33.82	30.53

Note: All statistics from each dataset are weighted by the household sample weight

It can be seen from Table 3 that, though statistics obtained for each of the four variables from each dataset are different, the difference is not wide. This implies the observed distribution of demographic characteristics and health data as captured by the 2014 GDHS mimics the actual distribution of the variables in Ghana. Thus, the data is representative of the actual demographic and health situation in Ghana. Hence, estimates made from the 2014 GDHS data sample is likely to be true for the whole nation.

Modeling and Model Specification

The models that are used for the study are presented under this section. First the theoretical model on which the study is founded is presented. The section, at the latter part presents the empirical models used to estimate the study parameters.

Theoretical Model

As mentioned in the first chapter, all factors that causes one's blood pressure to rise or fall are not known. However, scientists and the WHO posit that blood pressure can be controlled by a number of factors. These factors are called the risk factors of hypertension. These factors are either genetic or behavioural. On this premise, blood pressure changes can be modeled using these risk factors. The foundation of this study is however mainly based on the self-in-context model. The model's foundation is found in Bronfenbrenner's (1994) ecological perspective which was later developed by Feinstein et al. (2006). Before presenting in detail Feinstein et al.'s (2006) version of the model; the Ecological models of human development by Bronfenbrenner (1994), on which the self-in-context model is founded is discussed.

Ecological models encompass an evolving body of theory and research concerned with the processes and conditions that govern the lifelong course of human development in the actual environments in which human beings live. Although most of the systematic theory-building in this domain has been done by Bronfenbrenner (1994), his work is based on an analysis and integration of results from empirical investigations conducted over many decades by researchers from diverse disciplines. Bronfenbrenner's (1994) ecological paradigm, first introduced in the 1970s, represented a reaction to the restricted scope of most research then being conducted by developmental psychologists. Bronfenbrenner (1994) presented a conceptual and operational framework (supported by the comparatively small body of relevant research findings then available) that would usefully provide the basis and incentive for moving the field in the desired direction. Urie Bronfenbrenner argues that in order to understand human development, one must consider the entire ecological system in which growth occurs. This system is composed of five socially organized subsystems that help support and guide human growth. They range from the microsystem, which refers to the relationship between a developing person and the immediate environment, such a school and family, to the macrosystem, which refers to institutional patterns of culture, such as the economy, customs, and bodies of knowledge.

Bronfenbrenner's (1994) ecological model is defined by two propositions. Proposition 1 states that, especially in its early phases, and to a great extent throughout the life course, human development takes place through processes of progressively more complex reciprocal interaction between an active, evolving, biopsychological human organism and the persons, objects, and symbols in its immediate environment. To be effective, the interaction must occur on a fairly regular basis over extended periods of time. Such enduring forms of interaction in the immediate environment are referred to as proximal processes. Proposition 2 identifies the three-fold source of these dynamic forces. Proposition 2 states that the form, power, content and direction of the proximal processes effecting development vary systematically as a joint function of the characteristics of the developing person; of the environment- both immediate and more remote- in which the processes are taking place; and the nature of the developmental outcomes under consideration. Bronfenbrenner (1994) stated that propositions 1 and 2 are theoretically inter-dependent and subject to empirical test. He added that a research design that permits their simultaneous investigation is referred to as a process-person-context model. Another distinctive feature of the ecological model, its highly differentiated reconceptualization of the environment from the perspective of the developing person. The ecological environment is conceived as a set of nested structures, each inside the other like a set of Russian dolls. Moving from the innermost level to the outside, these structures are; microsystems, mesosystems, ecosystems, macrosystems and chronosystem.

The most recent extension of the ecological paradigm, which was done by Bronfenbrenner and Ceci in 1993 involves a reconceptualization of the role of genetics in human development. The new formulation calls into question and replaces some of the assumptions underlying the established percentage-of-variance model employed in behaviour genetics. Specifically, it talks about the genetics-environment interaction, the proposed bioecological models posit proximal processes as the empirically assessable mechanisms through which genotypes are transformed into phenotypes. It is further argued, both on theoretical and empirical grounds, that heritability is highly influenced by events and conditions in the environment. Specifically, it is proposed that heritability can be shown to vary substantially as a direct function of the magnitude of proximal processes and the quality of the environments in which they occur, potentially yielding values of heritability.

Feinstein et al. (2006), based on Bronfenbrenner (1994) ecological model on human development (especially, the most recent extension of the ecological paradigm by Bronfenbrenner and Ceci mentioned in the preceding paragraph) and, thus, developed the self-in-context model, which looks at determinants of health and how they inter-relate to affect one's health. The central notion of the self-in-context model is that individuals live in a multiple, multi-layered and interacting context, each of which is a domain of social relations and environmental health risk and protection. According to Feinstein et al. (2006), the social relations in each context include elements of structure such that in each context the individual experiences bounded agency that in different ways at each level may be important in the formation of health outcomes. Before discussing in detail, the conceptual relationships between the features of the model, first the conceptual definitions of the key features of the model (i.e. health, self, context) are given.

The self-in-context model integrates biological, psychological and social aspects of health into its framework. That is, it adopted the WHO biopsychosocial definition of health which states that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2006, pp. 1). Thus, it accepts the importance of biological determinants of health, it emphasises the reciprocal and dynamic interactions between different levels of human and social systems, from the biochemical to the sociocultural. The model was welcomed by psychologists and social scientists because it highlighted the importance of psychological and social factors in the study of health and disease. Beliefs about health, coping strategies, and risky behaviours were identified as important to the promotion of health.

The self, or the individual, in the model, is seen as having a degree of agency with cognitions, beliefs and psycho-social capabilities features as crucial elements of the self. The model concentrates on features of the self that are amenable to intervention through learning or other developmental impacts, rather than on bio-medical features of the self. The model does not deny the great importance of biomedical factors that are not within the control or choice of the individual. Health is a property of an individual organism and so any consideration of health must recognise the role of biology. Nonetheless, the individual does have a considerable degree of potential agency in the formation of health outcomes and so it is important to clarify the role of these features of the self. The model concentrates on the three characteristics of individuals that have been hypothesised to be important in the formation of health outcomes. These three aspects of the self are beliefs, valuation of the future, and resilience. There are very complex interactions between these components of the individual, even holding to one side for the moment the importance of structure and context. Behaviours are the result of heterogenous and diverse interactions between individuals' beliefs, skills, capabilities and values. The agency of the individual is always limited by structure and context, a point at the heart of the person-in-context model. That is, though humankind has some degree of agency to determine the individuals state of health, the degree to which the individual can control health depends on the context in which the individual lives.

The term context is used to refer to the domains of interaction for the individual with others. In a multi-level sense, if one defines the individual as a level one unit, then contexts are a very general term for spatial and non-spatial domains of interaction of individuals with higher level units. There are various levels of context: family, religion, neighbourhood, community, district, regional, national, etc. There are also important potential effects on health that result from social relationships at the macro level. These include the potentially very important impacts on health of national levels of disparity in social and economic status that may be defined in terms of wealth, education, type of place of residence or social class. It is worth highlighting that there may be very important interactions between effects at different levels. National level inequality of income or education has been hypothesised to impact on individual identity and well-being with implications for health and healthy behaviours. This suggests an impact of social level factors on individual health. However social cohesion as a social level outcome is the result in part of the multitude of individual behaviours, attitudes and decisions that comprise social action. These are influenced by individual level factors. Thus, individual and social factors are constantly in dynamic interaction with implications for health. Simply put, apart from biomedical or genetic determinants of health status, an individual's health depends on the person's lifestyle/behaviour (agency to determine health), SES (context) and interactions between the two.

Some of the socioeconomic factors affect health status only directly while others affect health status both directly and indirectly. That is, the effect of some socioeconomic conditions on health is not only direct but also mediate the effect of some behavioural/lifestyle factors on health. The self-in-context model is fairly static in that it holds constant many important dynamic and life-course processes. This is useful in focusing on the core issue of the effects of the self-in-context on health which will be manifested in part via health behaviours. This enables to foreground the core issue that individuals have a degree of agency in the determination of their mental and physical health. But that this agency is bounded by structures and contexts and by features of the self that constrain healthy choices that in other terms may seem rational.

Empirical Model

Generally, two econometric models were used for the study. The multinomial logit model was used to examine the relationship between exercise and blood pressure status while the multiple regression model was used to Investigate the effect of wealth status on the relationship between exercise and blood pressure.

Testing the First Hypothesis

To determine whether or not exercising reduces the likelihood of being prehypertensive or hypertensive, a multinomial discrete response model is used. That is the dependent variable, which captures responses on individual's blood pressure level is categorical in nature. Blood pressure levels are classified into four categories: Normal blood pressure, systolic prehypertensive or hypertensive, diastolic prehypertensive or hypertensive, and prehypertensive or hypertensive. These classifications were done based on WHO classification. Assuming that each individual faces the same set of responses, the random utility model is expressed as:

$$y^* = \beta' X + \mathcal{E} \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

Where $\beta' X$ is an index function;

$X =$

$\{\text{Age, Fruit, Armcircumference, Exercise, Smokenothing, type of place of residence,}$

$\text{wealth status, educational attainment}\}$; is a set of explanatory variables.

[Age, Fruit, Arm circumference, Exercise, and Smoke nothing] captures the behavioural or lifestyle and genetic risk factors of high blood pressure.

[Type of place of residence, wealth status and educational attainment] captures socioeconomic determinants of blood pressure status.

$\mathcal{E} \sim f(0,1)$, where f is the probability density function (pdf) and f is symmetric.

y^* is unobserved and hence are given values to represent their occurrences. Below are the categories of y^* and the values representing them.

$$y^* = \begin{cases} 0 & \text{Normal Blood Pressure} \\ 1 & \text{Systolic Prehypertensive/Hypertensive} \\ 2 & \text{Diastolic Prehypertensive/Hypertensive} \\ 3 & \text{Systolic and Diastolic Prehypertensive/Hypertensive} \end{cases}$$

Although y^* is unobservable, y can be observed; where,

$$y = \begin{cases} 0 & \text{if SBP} < 120\text{mmHg and DBP} < 80\text{mmHg} \\ 1 & \text{if SBP} \geq 120 \text{ mmHg and DBP} < 80\text{mmHg} \\ 2 & \text{if SBP} < 120\text{mmHg and DBP} \geq 80 \text{ mmHg} \\ 3 & \text{if SBP} \geq 120\text{mmHg and DBP} \geq 80\text{mmHg} \end{cases}$$

Given that the model in question is a multinomial response model, the interest is in how ceteris paribus, changes in the elements of X affect the response probabilities. Prehypertension means that the blood pressure reading is not high enough to be called high blood pressure (hypertension), but that it is higher than normal. Thus, Prehypertensive/Hypertensive, mentioned in this study consist of any blood pressure reading that is higher than normal.

$$P(y = j|X) \quad ; \quad j = 0 \ldots, 3 \qquad \ldots \ldots \ldots \ldots (2)$$

Since the probabilities must sum to unity, $P(y = 0|X)$ is known once the probabilities for $j = 1, \ldots, 3$ are determined. Given that X is a (1×13) vector with first element unity. The multinomial logit (MNL) model has response probabilities,

$$P(y = j|X) = \frac{\exp(X\beta_j)}{[1 + \sum_{h=1}^{3} \exp(X\beta_h)]} \ldots \ldots (3) \ ,$$

Where β_j is $(K \times 1)$ vector, $j = 1, \ldots, 3$ and $K = 13$ (i.e. number of explanatory variables).

Expanding $\exp(X\beta_j)$ gives;

$$\begin{aligned}\exp\big(\beta_{j0} &+ \text{Age}\beta_{j1} + \text{Fruit}\beta_{j2} + \text{Armcircumference}\beta_{j3} + \text{Exercise}\beta_{j4} \\ &+ \text{Smokenothing}\beta_{j5} + \text{Urban}\beta_{j6} + \text{Poorer}\beta_{j7} + \text{Middle}\beta_{j8} \\ &+ \text{Richer}\beta_{j9} + \text{Richest}\beta_{j10} + \text{PrimaryEducation}\beta_{j11} \\ &+ \text{SecondaryEducation}\beta_{j12} + \text{HigherEducation}\beta_{j13}\big)\end{aligned}$$

Likewise, expanding $\exp(X\beta_h)$ gives;

$$\begin{aligned}\exp(\text{Age}\beta_{h1} &+ \text{Fruit}\beta_{h2} + \text{Armcircumference}\beta_{h3} + \text{Exercise}\beta_{h4} \\ &+ \text{Smokenothing}\beta_{h5} + +\text{Urban}\beta_{h6} + \text{Poorer}\beta_{h7} + \text{Middle}\beta_{h8} \\ &+ \text{Richer}\beta_{h9} + \text{Richest}\beta_{h10} + \text{PrimaryEducation}\beta_{h11} \\ &+ \text{SecondaryEducation}\beta_{h12} + \text{HigherEducation}\beta_{h13})\end{aligned}$$

Because the response probabilities must sum to 1, the response probability of the base category (i.e. $j = 0$) was estimated as:

$$P(y = 0|X) = \frac{1}{[1 + \sum_{h=1}^{3} \exp(X\beta_h)]} \dots \dots (4)$$

The direction of the partial effect of the kth variable on the probability of an individual belonging to category j given that all other explanatory variables, X was estimated as:

$$\frac{\partial P(y = j|X)}{\partial X_k} = \frac{\exp(X\beta_j)}{[1 + \sum_{h=1}^{3} \exp(X\beta_h)]} \left\{\beta_{jk} - \frac{\sum_{h=1}^{3} \beta_{hk} \exp(X\beta_h)}{1 + \sum_{h=1}^{3} \exp(X\beta_h)}\right\} \dots (5)$$

Where β_{jk} is the coefficient of the Kth variable in explaining $P(y = j)$

Equation (5) shows that the direction of the effect is not determined entirely by β_{jk}. That is, the partial effect of X_k (the k^{th} explanatory variable) depends on β_{jk} and β_{hk} ; the k^{th} element of β_j and β_h respectively. Only the signs of the estimates of equation (5) were interpreted. If the sign is positive, it implies increase in X_k will increase the likelihood of belonging to the jth category than having a normal BP. Conversely, If the sign is negative, it implies increase in X_k will decrease the likelihood of belonging to the jth category than having a normal BP. Thus, the interpretation of β_j is not obvious unless a base category is used. A simpler interpretation of β_j was given by the odds-ratio which was estimated as:

$$\frac{P_j(X,\beta)}{P_0(X,\beta)} = \frac{\frac{\exp(X\beta_j)}{[1 + \sum_{h=1}^{3} \exp(X\beta_h)]}}{\frac{1}{[1 + \sum_{h=1}^{3} \exp(X\beta_h)]}} = \exp(X\beta_j) \dots \dots \dots \dots \dots (6a)$$

Taking the natural-log of equation (6a) gives equation (6b)

$$\ln\left(\frac{P_j(X,\beta)}{P_0(X,\beta)}\right) = \ln\left(\exp(X\beta_j)\right) = X\beta_j \dots\dots\dots (6b)$$

To determine the value of the constant, β_j, the log of odds-ratio is differentiated to get;

$$\frac{\partial}{\partial X_k}\left[\ln\left(\frac{P_j(X,\beta)}{P_0(X,\beta)}\right)\right] = \frac{\partial X\beta_j}{\partial X_k} = \beta_j \dots\dots\dots (6c)$$

Equation (6c) above gives by how many times the likelihood of belonging to the jth category is higher or lower than the likelihood of belonging to the base category (normal BP). If the value of the odds-ratio is greater than one, then given X, an individual is more likely to belong to category j than belonging to the base category. On the other hand, if the value of the odds-ratio is less than one, then given X, an individual is less likely to belong to category j than belonging to the base category. That is, in all, if the coefficient of exercise is significantly negative or if the odds-ratio of exercise relative to the base category (normal BP) is less than one for a given category, then the null hypothesis that exercising increases the likelihood of an individual being hypertensive will be rejected. Otherwise, we fail to reject the null hypothesis. Since we have fully specified the density of given X and y, estimation of the multinomial logit model was carried out using maximum likelihood method.

Testing the Second Hypothesis

To test the research hypothesis that 'there are socioeconomic factors that mediate the effect exercise has on blood pressure', equation (8) was estimated:

$$\mathrm{BP} = \beta_0 + \beta_1\mathrm{Age} + \beta_2\mathrm{Agesquared} + \beta_3\mathrm{Fruit} + \beta_4\mathrm{Armcircumference} + \beta_5\mathrm{Exercise} + \beta_6\mathrm{Smokenothing} + \beta_7\mathrm{Urban} + \beta_8\mathrm{Poorer} + \beta_9\mathrm{Middle} + \beta_{10}\mathrm{Richer} + \beta_{11}\mathrm{Richest} + \beta_{12}\mathrm{Primaryeducation} + \beta_{13}\mathrm{Secondaryeducation} + \beta_{14}\mathrm{Highereducation} + \beta_{15}\mathrm{ExerciseUrban} + \beta_{16}\mathrm{ExercisePoorer} + \beta_{17}\mathrm{ExerciseMiddle} + \beta_{18}\mathrm{ExerciseRicher} + \beta_{19}\mathrm{ExerciseRichest} + \beta_{20}\mathrm{ExercisePrimaryeducation} + \beta_{21}\mathrm{ExerciseSecondaryeducation} + \beta_{22}\mathrm{ExerciseHighereducation} + \varepsilon \quad \dots\dots\dots\dots\dots\dots\dots\dots. (8)$$

Equation (8) is a multiple regression model. The F-statistic for the joint test of significance for each of the following pairs of coefficients will be estimated: (β_4, β_{15}), (β_4, β_{17}), (β_4, β_{18}), (β_4, β_{19}), (β_4, β_{21}) and (β_4, β_{22}) will be estimated. The expression of the F-test is given as:

$$F = \frac{(SSR_r - SSR_{ur})/q}{SSR_{ur}/(n-(k+1))} \dots\dots\dots\dots\dots (9),$$

Where SSR_r stands for the sum of the squared residuals of the restricted model (i.e. the model with the variables whose coefficients are being jointly tested being excluded) and SSR_{ur} is the same for the unrestricted model (i.e. the model with the variables whose coefficients are being jointly tested included). We also have that n is the number of observations, k is the number of independent variables in the unrestricted model and q is the number of restrictions (or the number of coefficients being jointly tested) which is equal to 2 in each case.

The null hypothesis for the F-test for each of the joint coefficients being tested is that the said coefficients are jointly equal to zero. At 1 percent, 5 percent and 10 percent levels of significance, if the test statistic is significant, the null hypothesis that there are no socioeconomic factors that re-enforces the effect exercise has on blood pressure in Ghana will be rejected and hence the study will conclude that the state of these socioeconomic factors, on the average, mediate the effect exercise has on an individual's blood pressure. On the other hand, if the test statistic is not significant, the researcher will fail to reject the null hypothesis.

Variable Description

The variables used for the study are blood pressure (systolic and diastolic), age of respondent, fruit consumption, arm circumference of respondent, smoking habit, habit of exercising, type of place of residence, wealth and educational attainment. Below is the description of the variables that are used for the study:

Blood Pressure: This is a continuous variable made up of the systolic and diastolic blood pressure scores for each individual. In the 2014 GDHS, three blood pressure measurements were taken from consenting individuals in a subsample of households selected for the survey. Blood pressure was measured using the LIFE SOURCE® UA-767 Plus blood pressure monitor: a digital oscillometric blood pressure measuring device with automatic upper-arm inflation and automatic pressure release. The blood pressure of each respondent was measured thrice. Measurements were taken at intervals of 10 minutes or more. The unit of measurement for both the systolic and diastolic blood pressure is measured in millimetres of mercury (mmHg). The average of the second and third measurement scores of the systolic and diastolic blood pressures was calculated to determine the true blood pressure values for each individual. This is done in accordance with internationally recommended way of measuring blood pressure in surveys (GDHS report, 2014).

Age: This variable is a continuous variable capturing the age in years of the individuals used for the study. The age range of male and female respondents used for the study are fifteen-to-fifty-nine (15-59) years and fifteen-to-forty-nine (15-49) years respectfully. To make interpretation of this variable meaningful, fifteen (15), which is the lowest observation of the variable age among the study sample is subtracted from each of the observations such that age zero if mentioned is equivalent to age 15 years in the observed values. This is done to make the interpretation of the various intercept values (the average of the dependent variable when all the explanatory variables assume the value zero) in the various models meaningful since none of the study subjects has age zero in years. For instance, age 1, 10, and 15 in the model is equivalent to 16 years, 25 years and 30 years respectively in the observed values.

Fruit: This variable measure adequate nutrition, especially sufficient intake of fruits, which is essential for good health and general wellbeing. The 2014 GDHS respondents were asked a number of questions on the consumption of fruits and vegetables over the last seven days. The variable is, thus, continuous in nature.

Arm circumference: This variable is a proxy for the weight of the individual. The circumference of the respondent's arm midway between the elbow and the shoulder is measured. The unit of measurement is centimetres (GDHS report, 2014). It is assumed that the bigger the arm circumference an individual record, the heavier one is. That is, a person who records a higher value for arm circumference is presumed to be heavier than a person who records a lower value for arm circumference. The minimum and maximum measurement values in the sample are 7 and 53 respectively. To make interpretation of this variable meaningful, seven (7), which is the lowest observation of this variable among the study sample is subtracted from each of the observations such that if arm circumference is said to be zero; it is equivalent to saying the individual has an arm circumference of 7 centimetres in the observed values. This is done to make the interpretation of the various intercept values (the average of the dependent variable when all the explanatory variables assume the value zero) in the various models meaningful since none of the study subjects has an arm circumference of zero in centimetres.

Exercising Habit: This variable capture whether an individual exercise or not. Exercise, as captured in the 2014 GDHS, is a categorical variable and hence dummies have been provided such that the value one (1) means the individual exercises and the value zero (0) means the individual does not exercise. Exercising in this context means any physical activity that an individual engages in with the intention of gaining health benefit(s).

Place of Residence: This captures whether the respondents live in a rural area or an urban area. It is, thus, a categorical variable with those living in the rural areas set as the base category.

Smoking Habit: This variable is also categorical in nature. It tells whether respondent smokes or does not smoke. Those who smoke are the reference category.

Wealth Index: It is an indicator of wealth that is consistent with expenditure and income measurement among households. The index, as captured in the 2014 GDHS dataset, was constructed from household asset data using principal components analysis. These assets or consumer items consist of a television, bicycle, or car, as well as dwelling characteristics, such as a source of drinking water, sanitation facilities, and type of flooring material. The wealth index is created in three steps. In the first step, a subset of indicators common to urban and rural areas is used to create wealth scores for households in both areas. Categorical variables to be used are transformed into separate dichotomous (0-1) indicators. These indicators and those that are continuous are then examined using a principal components analysis to produce a common factor score for each household. In the second step, separate factor scores are produced for households in urban and rural areas using area-specific indicators. The third step combines the separate area-specific factor scores to produce a nationally applicable combined wealth index by adjusting area-specific scores through a regression on the common factor scores. This three-step procedure permits greater adaptability of the wealth index in both urban and rural areas. The resulting combined wealth index has a mean of zero and a standard deviation of one. Once the index is computed, national-level wealth quintiles (from lowest to highest) are obtained by assigning the household score to each de jure household member, ranking each person in the population by his or her score, and then dividing the ranking into five equal categories, each comprising 20 percent of the population. Thus, this variable is categorical in nature and has the following categories: poorest, poorer, middle, richer and richest (GDHS report, 2014). The category of people who are classified as poorest are used as the base category.

Educational Level: This variable is categorical in nature. It captures the highest education level an individual has attained. The categories of educational attainment are; no education, primary education, secondary education and higher education. Here, people with no education are used as the base category.

Table 4: Expected Directional Effects of Variables on Blood Pressure

Variable	Type	Base Category	Unit of Measurement	A' prior Sign
Systolic BP	Continuous		Millimetre of Mercury (mmHg)	
Diastolic BP	Continuous		Millimetre of Mercury (mmHg)	
Age	Continuous		Age in years	Positive
Fruit	Continuous		Number of days fruits are taken in a week	Negative
Arm Circumference	Continuous		Centimetres	Positive
Exercise	Dummy	Do not exercise	Whether one exercises or not	Negative
Smoke Nothing	Dummy	Smokes	Smokes tobacco, or weed or any substance	Negative
Urban	Dummy	Rural	Type of Place of Residence	Positive
Wealth Quintile	Categorical	Poorest	Wealth status	Positive
Education	Categorical	No education	Level of education attained	Positive

Systolic and diastolic blood pressure are dependent variables. All other variables are independent variables.

Post-Diagnostic Test

For the model estimates to be efficient and consistent ε must be normally distributed. To test for homoscedasticity and normality, the White's Test for Homoscedasticity and Skewness and Kurtosis Test for Normality of the error term respectively were conducted and presented. The null hypothesis of the normality test is that the residuals are normally distributed. Also, the null hypothesis of the homoscedasticity test is that the residuals have equal variance. The null hypotheses of each of these tests will be rejected if the probability value for the test of significance is greater than 0.5. Otherwise, the researcher fails to reject the null hypotheses.

Chapter Summary

In the quest to achieve the purpose of this study, was based on the WHO theory on the risk factors of hypertension. The self-in-context model was mainly used to test the second hypothesis. Two econometric models were used. The study first employed the multinomial logit model to examine the relationship between physical exercise and blood pressure status, while controlling for other variables. Later the multivariate regression models were used to test the theoretical relationship between exercise and blood pressure in Ghana. Lastly, the researcher sought to ascertain socioeconomic factors mediating the effect of exercise on blood pressure. This was done by employing a multivariate model. All multivariate model used in the study were estimated using the maximum likelihood method. A normality test of the various errors estimated from the regression models is conducted by constructing normal and inverse cumulative curves.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter discusses the results obtained from the study. The chapter starts by reporting descriptive statistics of the variables used for the study. Continuous variables are described using summary statistics. Distribution of blood pressure status among categories under the study variables are also presented. Finally, the chapter reports and discusses results generated from testing the hypotheses of the study.

Descriptive Statistics

Table 5: Descriptive Statistics of Continuous Variables

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Systolic BP	13723	112.908	16.192	69.5	236.5
Diastolic BP	13723	73.639	11.401	29.5	148
Age	13723	30.492	10.726	15	59
Fruit	13723	3.328	2.545	0	7
Arm Circumference	13723	28.975	4.114	7	53

Table 5 shows the summary statistics of all continuous variables of the sample used for the study. It captures the number of observations, the mean values, standard deviation, maximum and maximum values of each variable. The average systolic and diastolic blood pressure values in Table 5 indicate that the average individual in Ghana has a normal blood pressure since systolic and diastolic blood pressure are less than 120 mmHg and 80 mmHg respectively.

Table 6: Prevalence of Hypertension Among the Study Sample [Weighted]

	Hypertensive (%)	Non Hypertensive (%)	P-value	Normal (%)	Systolic prehypertensive/ hypertensive (%)	Diastolic prehypertensive/ hypertensive (%)	Systolic and Diastolic Prehypertensive/ hypertensive (%)	P-value	Total
Gender									
Male	15.01	84.99	0.020	54.48	16.04	5.38	24.11	0.000	4375
Female	12.88	87.12		68.32	4.05	11.01	16.62		9348
Age									
15 – 19	2.10	97.90	0.000	82.34	9.16	4.28	4.22	0.000	2,471
20 – 24	5.08	94.92		74.15	8.45	8.78	8.62		2,184
25 – 29	8.22	91.78		69.40	7.66	9.54	13.41		2,184
30 – 34	13.54	86.46		63.14	6.96	10.50	19.39		1,913
35 – 39	18.34	81.66		54.52	6.23	14.26	24.99		1,763
40 – 44	23.65	76.35		48.39	6.68	11.96	32.97		1,474
45 – 49	34.21	65.79		41.94	7.43	8.44	42.19		1,202
Fruit									
None	13.74	86.26	0.157	65.74	7.42	8.73	18.11	0.077	2,351
1 day	12.79	87.21		63.82	6.83	9.84	19.50		1,634
2 days	11.93	88.07		65.66	7.76	8.60	17.98		2,083
3 days	13.77	86.23		63.66	9.35	7.96	19.04		1,996
4 days	16.81	83.19		59.86	7.52	9.86	22.76		1,162
5 days	13.99	86.01		62.34	10.54	10.07	17.05		745
6 days	14.97	85.03		60.52	6.60	12.09	20.79		718
7 days	13.12	86.88		64.23	7.66	9.36	18.74		3,034
Exercising Habit									
Exercise	13.52	86.48	0.840	64.00	7.59	9.35	18.70	0.004	1722
Donnot exercise	13.83	86.17		63.26	9.79	8.25	19.05		12001

Table 6 continued

	Hypertensive	Non Hypertensive	P-value	Normal	Systolic prehypertensive/ hypertensive	Diastolic prehypertensive/ hypertensive	Systolic and Diastolic Prehypertensive/ hypertensive	P-value	Weighted Total
Smoking Habit									
Donnot Smoke	13.53	86.47	0.817	63.99	7.86	9.24	18.91	0.230	13468
Smoke	14.78	85.22		59.37	8.40	7.88	24.35		255
Residence									
Rural	10.08	89.92	0.000	68.35	8.27	7.56	15.82	0.000	6422
Urban	16.62	83.38		60.00	7.51	10.67	21.82		7301
Wealth Quintile									
Poorest	7.50	92.50	0.000	73.37	8.48	6.10	12.05	0.000	2257
Poorer	10.09	89.91		67.59	7.75	8.25	16.42		2413
Middle	12.68	87.32		64.40	8.27	8.55	18.78		2758
Richer	16.02	83.98		60.65	7.82	10.62	20.91		3053
Richest	18.79	81.21		57.23	7.24	11.35	24.18		3243
Educational Attainment									
No Education	12.28	87.72	0.000	67.50	5.91	8.34	18.24	0.000	2249
Primary Education	11.99	88.01		65.94	8.78	8.48	16.80		2254
Secondary Education	13.58	86.42		63.29	8.18	9.24	19.29		8113
Higher Education	19.20	80.80		57.00	7.73	12.29	22.98		1106
Total	**13.56**	**86.44**		**63.91**	**7.87**	**9.22**	**19.01**		**13723**

P-values are probabilities of significance obtained from the Pearson chi-square test of significance of unweighted distributions of the variables. The chi-square table on which p-values were read is presented on Appendix C.

Individuals were classified as hypertensive if their systolic blood pressure was 140 mmHg or higher or if their diastolic blood pressure was 90 mmHg or higher. Following internationally recommended guidelines, individuals were also considered hypertensive if they had a normal average blood pressure reading but were taking antihypertensive medication. According to the cutoff points recommended by the World Health Organization individuals were also classified as having a normal BP, systolic prehypertensive or hypertensive, diastolic prehypertensive or hypertensive, and systolic and diastolic prehypertensive or hypertensive.

Prehypertension means that the blood pressure reading is not high enough to be called high blood pressure (hypertension), but that it is higher than normal. Thus, prehypertensive/hypertensive, mentioned in this study consist of any blood pressure reading that is higher than normal. Systolic prehypertensive or hypertensive individuals have a normal diastolic blood pressure reading (DBP<80mmHg) but a systolic blood pressure reading more than normal (SBP≥120mmHg). Diastolic prehypertensive/hypertensive individuals have a normal systolic blood pressure reading (SBP<120mmHg) but a diastolic blood pressure reading more than normal (DBP≥80mmHg). An individual is said to be systolic and diastolic prehypertensive/hypertensive if systolic blood pressure reading is higher than normal (SBP≥120mmHg) and also a diastolic blood pressure reading more than normal (DBP≥80mmHg). This was done to make it possible to examine whether or not physical activity has differential effects on the blood pressure status of individuals given that they belong to any of the three categories.

The WHO, as mentioned earlier, however posits that when a patient's systolic and diastolic blood pressure levels falls within different categories, the higher diagnostic category and recommended actions should apply. That is, in order to determine the percentage of individuals who are truly prehypertensive or hypertensive in among the study sample given their background characteristic in Table 6, the percentages under the three categories should be added.

Table 6 shows the prevalence of hypertension and distribution of various blood pressure status among the study sample. It can be seen in Table 6 that 13.56 percent of individuals used for the study are hypertensive. This is slightly below the overall prevalence of hypertension in Sub-Saharan Africa which was estimated as 16.2 percent in 2013 with an estimated number of hypertensive individuals to be 74.7 million (Ogah & Rayner, 2013). Among the study sample, 12.88 percent and 15.03 percent of women and men respectively were classified as hypertensive; that is, they had a systolic blood pressure of at least 140 mmHg or a diastolic blood pressure of at least 90 mmHg or they were currently taking antihypertensive medication to control their blood pressure. This finding is in line with the assertion made by van de Vijver et al. (2013) that hypertension is usually more pronounced in males than in females in Africa. He however, stated that the reverse is true in some African countries. there were higher levels of prevalence in women than men in countries such as Algeria 31.6 percent vs. 25.7 percent in 2003, Botswana 37.0 percent vs. 28.8 percent in 2006 and Mali 25.8 percent vs. 16.6 percent in 2007, for women and men, respectively.

The prevalence of hypertension among individuals who engage in physical exercise and those who do not do physical exercise are 13.52 percent and 13.83 percent respectively. Therefore, the prevalence of hypertension among the physically active individuals is slightly lower than the prevalence of hypertension among individuals who do not exercise. The p-value of the chi-square test for this association is, however, not statistically significant. Similar, though individuals who do not smoke has a lower prevalence of hypertension than those who smoke; the association is not statistically significant. Table 6 also show that there is no clear relationship between the number of days one consumes fruits in a week and blood pressure status. As expected, the prevalence of hypertension is positively associated with increasing age. A positive association between age and prevalence of hypertension is also deduced from the comparison of studies on hypertension in different African countries among different age populations at different times. An elderly South African setting recorded the highest prevalence of hypertension in 2008 (77.3 percent mean age 65 years). Other settings reporting higher prevalence rates of hypertension were also in older adult population surveys in Tanzania in 2010 (69.9 percent, mean age 76 years), Tunisia in 2003 (69.3 percent, mean age 69 years), and Senegal in 2009 (65.4 percent, mean age 69.5 years) respectively. The lowest prevalence rates of hypertension were recorded in Sudan (7.5 percent, mean age 35 years) and Ethiopia (9.9 percent, mean age 36.1 years) in 1989 and 2008 (Adeloye & Basquill, 2014). These figures, thus, show that the prevalence of hypertension is relatively lower in relative younger populations than in older ones.

Apart from sex differences in the prevalence of hypertension, there are also approximately large differences based on residence. From Table 6, 17 percent of urban residents among the study sample are considered hypertensive, compared with 10 percent in rural areas. This is in line with the position taken by van de Vijver et al. (2013) in their Status report on hypertension in Africa; a Consultative review for the 6th Session of the African Union Conference of Ministers of Health on NCD's. they stated that urbans population have a higher prevalence of hypertension than the rural population. In South Africa and Democratic Republic Congo, the urban has almost 10 percentage points higher prevalence than the rural population. This is in comparison to countries like Ethiopia and Tanzania where the prevalence is only a bit more than 5 percent higher. They however added that since countries are at different stages of the epidemiological transitions, there are some rural populations in some countries whose prevalence is higher than some urban populations in other countries. For instance, rural populations in South Africa, and DRC have a higher prevalence than the urban populations in Ethiopia and Tanzania (van de Vijver et al., 2013).

The prevalence of hypertension increases with a higher wealth quintile. That is, individuals who are in a relatively higher wealth category has high prevalence of hypertension. The situation of prevalence of hypertension across various levels of educational attainment is similar to that of wealth. Prevalence of hypertension among the class of people whose level of education is high is relatively greater than the prevalence of hypertension among the class of less educated people.

Table 6 clearly shows that the association between the various variables and systolic and diastolic prehypertension/hypertension among individuals is similar to the association between the variables and the prevalence of hypertension. Associations between the variables and systolic prehypertension/hypertension and diastolic prehypertension or hypertension are however not consistent with that of the prevalence of hypertension for all the variables. For instance, the association between age and systolic prehypertension/hypertension is positive while the association between age and diastolic prehypertension/hypertension is negative. Also, while a higher percentage of individuals who do not exercise are systolic prehypertensive or hypertensive compared to those who exercise; the reverse rather holds in the case of the distribution of diastolic prehypertension/hypertension among individuals per their exercising habit. In the case of wealth status, the association between wealth and diastolic prehypertension/hypertension is positive while the association between wealth and systolic prehypertension/hypertension is not clearly obvious.

However, if the percentages of the three categories are added, as the staging process of the WHO says, it is obvious that the association between prehypertension or hypertension and the study variables are the same as their association with the prevalence of hypertension stated earlier. Thus, the percentage of the sample who are prehypertensive/hypertensive is 36.10. That is, even though the prevalence of hypertension in among the sample is as low as 13.56 percent, three are 22.54 percent of the sample whose blood pressure, though not high enough to be classified as hypertensive, is higher than normal and hence if not controlled will be hypertensive. Hence it is prudent for all individuals and stakeholders of health to take the necessary measures to help control the blood pressure of the Ghanaian citizenry to curb the possible of a greater number of them becoming hypertensive in the near future and hence visit unto themselves the related burden of the disease on their households and the country at large. This study will at least provide some guidelines in respect of that.

Relationship Between Exercise and Blood Pressure Status

To determine the relationship between physical exercise and blood pressure level, a multinomial logit model is estimated to determine whether physical exercise makes one more or less likely to have a given blood pressure status than have a normal blood pressure. The multinomial dependent variable has four categories or alternatives. These are normal BP, systolic prehypertensive or hypertensive, diastolic prehypertensive or hypertensive, and prehypertensive/ hypertensive.

Table 7: Distribution of Blood Pressure Status Among the Study Sample [Weighted]

Blood Pressure Status	**Codes for Alternatives**	**Percent Frequency**
Normal BP	0	63.91
Systolic Prehypertensive/ Hypertensive	1	7.87
Diastolic Prehypertensive/ Hypertensive	2	9.22
Systolic and Diastolic Prehypertensive/ Hypertensive	3	19.01
Total		**100**

This table is extracted from Table 6. These four categories, as shown in chapter three, are the categories under the dependent variable of the multinomial logit model (see below).

Table 7 shows that among the study sample, most of the respondents had a normal blood pressure (63.91%). Also, 7.87 percent of the respondents were systolic prehypertensive or hypertensive. That is, they have systolic blood pressure greater than or equal to 120 mmHg but diastolic blood pressure less than 80 mmHg. The percentage of the respondents who were diastolic prehypertensive or hypertensive is 9.22. This means they have diastolic blood pressure greater than or equal to 80 mmHg but systolic blood pressure less than 120 mmHg. Finally, 19.01 percent of the study sample had a systolic blood pressure greater than or equal to 120 mmHg and diastolic blood pressure greater than or equal to 80 mmHg. Results obtained from the multinomial logit model are presented in Table 8.

Table 8: Multinomial Logit Results Showing the Likelihood of Hypertension

Dependent Variable – Blood pressure status						
Base category is normal BP						
CATEGORY	**Systolic Prehypertensive or Hypertensive**		**Diastolic Prehypertensive or Hypertensive**		**Systolic and Diastolic Prehypertensive or Hypertensive**	
Variable	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Constant	-2.366 (0.000)	0.094	-2.372 (0.000)	0.093	-2.178 (0.000)	0.113
Age	0.025 (0.000)	1.025	0.027 (0.000)	1.027	0.081 (0.000)	1.084
Fruit	-0.028 (0.027)	0.972	-0.007 (0.569)	0.993	-0.015 (0.127)	0.985
Arm circumference	0.011 (0.234)	1.011	0.085 (0.000)	1.088	0.092 (0.000)	1.096
Habit of Exercising (Don't Exercise=0)						
Exercise	-0.274 (0.002)	0.761	-0.026 (0.782)	0.974	-0.041 (0.578)	0.960
Smoking Habit (Smoke=0)						
Smoke nothing	-0.024 (0.911)	0.976	0.056 (0.808)	1.057	0.108 (0.498)	1.114
Place of Residence (Rural=0)						
Urban	-0.124 (0.155)	0.883	0.254 (0.003)	1.289	0.094 (0.158)	1.099

Table 8 continued

CATEGORY	Systolic Prehypertensive or Hypertensive		Diastolic Prehypertensive or Hypertensive		Systolic and Diastolic Prehypertensive or Hypertensive	
Variable	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**	**Coefficient**	**Odds Ratio**
Wealth Quintile (Poorest=0)						
Poorer	-0.005 (0.962)	0.995	0.214 (0.043)	1.238	0.174 (0.038)	1.190
Middle	-0.031 (0.774)	0.970	0.203 (0.070)	1.225	0.335 (0.000)	1.398
Richer	0.056 (0.652)	1.057	0.325 (0.009)	1.385	0.427 (0.000)	1.532
Richest	-0.040 (0.782)	0.961	0.260 (0.061)	1.297	0.396 (0.000)	1.486
Level of Education (No Education=0)						
Primary education	0.404 (0.000)	1.498	0.021 (0.846)	1.021	0.299 (0.000)	1.349
Secondary education	0.541 (0.000)	1.718	0.065 (0.482)	1.068	0.403 (0.000)	1.497
Higher education	0.651 (0.000)	1.917	0.228 (0.111)	1.256	0.422 (0.000)	1.525
Number of Observations	13723					
Log-Likelihood	-12621.703					

Wald test of the joint significance of exercise: chi2(3) =14.05; P-value=0.0028

Table 8 shows that compared to people who do not exercise, those who exercise are 0.239 times less likely to belong to any of the three prehypertensive/hypertensive categories relative to having a normal blood pressure. This implies that, relatively, if an individual exercises the probability of him/her having a normal blood pressure is higher than him/her being prehypertensive/ hypertensive. This observation is in line with the findings of Sturtevant (2005) and Tuxworth et al. (1986), who observed that exercise causes blood pressure to drop. He also noted that relative fitness is associated with improved health status through lower blood pressures. That is, if an individual who exercises he is more likely to have improved health status in general through the reduction in blood pressure. Table 8 also show that while the decrease in the likelihood that an individual who exercises will be systolic prehypertensive or hypertensive is statistically significant; the decrease in the likelihood of an individual who exercises to become diastolic prehypertensive/hypertensive or systolic and diastolic prehypertensive or hypertensive relative to having a normal blood pressure is statistically not significant.

As expected, in comparison to having a normal blood pressure status, aging is associated with higher likelihood of an individual being systolic prehypertensive/hypertensive, diastolic prehypertensive/hypertensive, and systolic and diastolic prehypertensive/hypertensive. Increase in number of days one consumes fruits in a week decreases the probability of him/her being systolic prehypertensive/hypertensive. Also, positive coefficient for arm circumference for all the response categories means an individual getting fatter or gaining more weight is associated with a higher likelihood of being systolic prehypertensive or hypertensive, diastolic prehypertensive or hypertensive and prehypertensive or hypertensive. Compared to people who smoke, those who do not smoke are less likely to be prehypertensive or hypertensive than have normal blood pressure.

Table 8 also shows that compared to a rural resident, the probability of an urban resident to be diastolic prehypertensive or hypertensive is higher than have a normal blood pressure. Also, relative to the poorest, the poorer and richer in society are 0.238 times and 0.385 times more likely to be diastolic prehypertensive or hypertensive than have normal blood pressure. Similarly, the poorer and richer in society are 0.174 times and 0.427 times more likely to be systolic and diastolic prehypertensive/hypertensive than have normal blood pressure, compared to the poorest. In general, the wealthier in society is significantly more likely to be prehypertensive or hypertensive than have normal blood pressure. In the case of the effect of educational level on blood pressure status, Table 8 shows that the highly educated is more likely to be systolic prehypertensive/hypertensive and systolic and diastolic prehypertensive/hypertensive than the less educated compared to having a normal blood pressure. The above analysis show that with respect to the relationship between socioeconomic status and blood pressure status; urban residence, higher wealth status and high education level independently increases the probability of an individual to be prehypertensive/hypertensive than have normal blood pressure.

Effect of Wealth Status on the Relationship Between Exercise and Blood Pressure

This section looks at the marginal effects of the theorised risk factors of high blood pressure and various socioeconomic conditions of individuals among the study sample on their systolic and diastolic blood pressure. That is, it investigates how on the average, changes in each of these variables causes movements in the systolic and diastolic blood pressure of the individual. More importantly, the section concentrates on the mediating role of wealth status on the effect of physical exercise on blood pressure.

Table 9: Regression Results Showing the Role of Wealth Status on the Effect of Physical Exercise on Blood Pressure

Dependent Variable	SYSTOLIC BP	DIASTOLIC BP
Variable	**Coefficient**	**Coefficient**
Constant	89.502***	54.300***
	(0.000)	(0.000)
Age	-0.505***	0.317***
	(0.000)	(0.000)
Age squared	0.014***	0.000
	(0.000)	(0.732)
Fruit	-0.087*	-0.021
	(0.087)	(0.553)
Arm circumference	0.547***	0.478***
	(0.000)	(0.000)
Habit of Exercising (Don't Exercise=0)		
Exercise	-2.554***	-0.055
	(0.006)	(0.881)
Smoking Habit (Smoke=0)		
Smoke nothing	-0.041***	-1.209**
	(0.963)	(0.050)
Place of Residence (Rural=0)		
Urban	0.253	0.956***
	(0.495)	(0.000)
Wealth Quintile (Poorest=0)		
Poorer	1.287***	0.780***
	(0.003)	(0.009)
Middle	2.049***	1.543***
	(0.000)	(0.000)
Richer	2.598***	2.042***
	(0.000)	(0.000)
Richest	2.367***	1.985***
	(0.000)	(0.000)
Level of Education (No Education=0)		
Primary education	2.573***	1.006***
	(0.000)	(0.002)
Secondary education	3.748***	1.701***
	(0.000)	(0.000)
Higher education	3.664***	1.601***
	(0.000)	(0.001)

Table 9 continued

Dependent Variable	SYSTOLIC BP	DIASTOLIC BP
Variable	**Coefficient**	**Coefficient**
Exercise × Urban	0.856	0.436
	(0.407)	(0.539)
Exercise × Poorer	-1.623	-0.225
	(0.144)	(0.769)
Exercise × Middle	-2.449**	-1.558*
	(0.046)	(0.037)
Exercise × Richer	-2.786*	-2.249
	(0.057)	(0.161)
Exercise × Richest	-3.232*	-2.158*
	(0.055)	(0.002)
Exercise × Primary education	0.047	1.187
	(0.969)	(0.158)
Exercise × Secondary education	-0.233	0.620
	(0.831)	(0.408)
Exercise × Higher education	0.106	1.907
	(0.954)	(0.128)
Number of Observations	13723	13723
Log-likelihood	-56652.963	-51515.100

*P-Values in Parentheses: * P<0.10, ** P<0.05, *** P<0.01*

Table 9 shows the determinants of systolic and diastolic blood pressure levels. It indicates that an individual who exercises or is physically active, on the average, has a systolic blood pressure of 2.554 mmHg lower than the systolic blood pressure of a person who does not exercise. This is to say that exercising reduces the risk of being systolic hypertensive. This outcome is in line with the findings made by Minter-Jordan et al. (2013), who identified exercising to have a lot of benefits including reduction in blood pressure. However, there is no significant difference between the diastolic blood pressure of people who exercise and those who do not. This outcome is close to that of Assarzadeh et al. (2012) who investigated and compared the effect of four types of sub-maximal aerobic exercises and found a significant difference between systolic blood pressure during and after front crawl swimming, running, bicycle riding and rhythmic movements. They also found a significant difference between diastolic pressure during and after swimming, running, bicycle riding and rhythmic exercises. However, no significant difference existed between diastolic blood pressure before and after swimming and running exercises while a significant difference existed between their diastolic pressure before and after bicycle riding and rhythmic movements. Thus, the observation that exercising does not significantly decrease the likelihood of the individual becoming diastolic hypertensive might be due to the type of physical exercise most of the respondents engage in. That is, if they are engaged in less rigorous exercises, it is less likely to affect their diastolic blood pressure.

It can also be seen from Table 9 that on the average, an individual who is 30 years old, does not consume fruits or vegetables in a week, does not exercise, has an arm circumference of 30 centimetres and smokes has a blood pressure of 112.807/72.148mmHg, which falls within the range of normal blood pressure. Also, the total effect of an increase in age (in years) on systolic blood pressure is -0.619 (i.e. $-0.635 + 2 \times [0.016 \times 0.492385]$); where 0.492385 is the mean of age centered around 30 years. Thus, if a person gets a year older his systolic blood pressure decreases by 0.619 mmHg. This finding is contradicting that of Arbor (2014) and Tin et al. (2002). According to them, systolic blood pressure continues to rise with advancing age. This contradictory relationship between age and systolic BP found in this current study might be due to the age range of the study sample, which is 15-49 years. According to Arbor (2014), aging causes an individual's blood pressure to gradually lose some of its elastic quality, which increases the blood pressure. Given that the respondents of the 2014 GDHS survey are relatively young, an increase in age within the sample age range is likely not to increase the likelihood of being systolic hypertensive. The age-blood-pressure paradox is disentangled by looking carefully at the partial effects of age and age-squared on blood pressure. While the aging partially has a negative effect on blood pressure, the coefficient of age-squared which measures the partial effect of getting relatively very old on systolic BP is positive. This means even though an increase in age reduces blood pressure at the younger stage; as a person becomes aged, the risk of becoming systolic hypertensive increases. In the case of diastolic blood pressure, Table 9 shows that its relationship with age confirms Arbor's (2014) observation. Tin et al. (2002) also confirm this. According to their study, just like systolic blood pressure, diastolic blood pressure continues to rise as one advances in age. That is, as an individual gets older the risk of becoming diastolic hypertensive increases. Thus, as one lives an additional year, his diastolic blood pressure increases by 0.317 mmHg. However, diastolic blood pressure of an individual stops responding to increases in age as the person becomes aged. Tin et al. (2002) believe this should be the case. They note that systolic hypertension, due to hardening and loss of elasticity of the major arteries is an unavoidable consequence of aging and augmented by hypertension, in contrast to diastolic BP which is thought to be a function of peripheral resistance. Therefore, while systolic BP continues to rise with advancing age, diastolic BP stabilizes or declines giving rise to isolated systolic hypertension. That is, the near-zero effect of aging (age-squared) on diastolic hypertension in Table 9 might be because peripheral resistance which causes the diastolic hypertension to fluctuate is not a function of age.

If a person consumes fruits for many days of the week the risk of being systolic hypertensive reduces. Specifically, if an individual increases the number of days of consuming fruits by one, systolic blood pressure will reduce by 0.087 mmHg. Similar to the difference between the effect of physical activity on systolic blood pressure of respondents who exercise and those who do not, it is observed that individuals who do not smoke at all has lower diastolic blood pressure of 1.209 mmHg than individuals who smoke. On the other hand, the statistical difference between the systolic BP of smokers and non-smokers is zero. Thus, generally smoking increases the risk of being hypertensive. Lam (2011) agrees with this assertion. He posits that smoking is independently associated with higher systolic blood pressure. That is smoking increase the risk of becoming systolic hypertensive. Arm circumference, on the average, has a direct relationship between both systolic and diastolic blood pressure. That is to say, if an individual's arm circumference increases (or decreases) by 1-centimetre, his/her systolic blood pressure will rise (or fall) by 0.522 mmHg while his diastolic blood pressure will increase (or decrease) by 0.507 mmHg. This means the heavier or fatter a person gets, the risk of becoming hypertensive increases. Again Lam (2011) using a multivariate model, also observed that body mass index and greater waist circumference, which behave similarly to arm circumference used in this study were associated with higher systolic blood pressure.

Table 9 shows that the average blood pressure of an individual who is 30 years old, does not consume fruits or vegetables in a week, does not exercise, has an arm circumference of 30 centimetres, smokes, lives in the rural area, has no education and is classified as poorest is 89.502 / 54.300 mmHg. It can also be seen from Table 9 that the effect of physical exercise on systolic blood pressure among the study sample is both direct and indirect. The direct effect of exercise on the systolic blood pressure of Ghanaians is favourable (as mentioned earlier). That is to say, people who exercise have relatively low systolic blood pressure than those who do not exercise. Again, the effect of physical exercise on systolic blood pressure is mediated by the wealth status of an individual (detailed explanation is provided at the latter part of this section). Just like exercising, socioeconomic factors (i.e. urbanisation, wealth and educational attainment) independently affects the blood pressure of individuals. For instance, it can be seen from Table 9 that, on the average, persons who live in urban centres have a diastolic blood pressure of 0.956 mmHg higher than persons who live in rural areas. This confirms Ng et al.'s (2014) report that the prevalence of hypertension is increasing in Africa due to growing urbanization and related lifestyle changes. The Ministry of Health in Ghana reported earlier that the prevalence of hypertension has been increasing and that in some urban centres, about half of all adults have hypertension (MoH, 2012). This statement confirms the position of this study.

Compared to the poorest, the poorer have a systolic and diastolic blood pressure of 1.287 mmHg and 0.780 mmHg higher. Also, those under the middle wealth quintile's blood pressure is relatively higher than those under the poorest and poorer wealth quintile; the richer has a higher systolic BP than the poorest, poorer and middle wealth class members. Lastly, the systolic and diastolic blood pressure of individuals classified under the richest wealth quintile is higher than individuals who are under the poorer, poorest and middle wealth quintile. This implies that the wealth status of an individual is associated with his/her blood pressure level. Lam (2011) and Colhoun et al. (1998) have similar findings. Lam (2011) states in his study that on the average, wealthier individuals have higher systolic and diastolic blood pressure than those who are poor. Lam (2011) also cited a similar finding by Brummett et al. (2011) in his study. He cited that using path models, they found that, in 14,299 Americans aged 24 to 35 years, higher household income, which is a component of wealth, was associated with lower systolic blood pressure. Again, Brummett et al. (2011) found higher household income to be associated with lower systolic blood pressure by way of lower resting heart rate and remained inversely associated with systolic blood pressure even after adjusting for all measured covariates. Colhoun et al. (1998) more importantly, showed that each $50 000 increase of household income was related to a decrease in systolic blood pressure of 0.61 mmHg in Australia. These studies support the relationship between blood pressure and wealth found in the present study.

It is also clear in Table 9 that an individual who has a higher educational attainment has a higher diastolic and systolic blood pressure than those whose educational attainment is relatively low. Brummett et al. (2011) made similar findings (Lam, 2011). They found that higher education level is associated with lower systolic blood pressure by way of lower BMI, smaller waist circumference, and lower resting heart rate. However, they observed that education was no longer significantly related to systolic blood pressure after accounting for these indirect effects. Also, in the Medical Research Council (MRC) National Survey of Health and Development, (a cohort born in 1946), education was associated with systolic BP in men (Colhoun et al., 1998). Brummett et al. (2011) and MRC failed to state what kind of relationship exist between these variables. In this study, however, education is found to relate inversely with both systolic and diastolic blood pressure even after controlling for most of the risk factors of high blood pressure. Colhoun et al. (1998) also found an inverse association between hypertension and education in white South African men and women. Contrary to the outcome of the present study however, is the results obtained in a Kenyan Luo Migration study which found a positive correlation between years of education and systolic and diastolic BP after adjusting for age (Colhoun et al., 1998). This contradiction might be because in the Kenyan Luo Migration study, other risk factors of high blood pressure except age were not controlled for and hence the sign of this relationship might be biased. The relative differences in the blood pressure of people per their SES might be due to the kind of activities and jobs the educated and the wealthy in Ghana are mostly engaged in relative to the kind of jobs the poor in society do. It is observed in Ghana that the poor in society are mostly engaged in physically active practices. For instance, they walk more often than the rich and also the kind of work they do for livelihood mostly physically active in nature.

All in all, while the wealth status, type of place of residence and educational level of an individual partially affects blood pressure independently, the wealth status of an individual also determines the degree to which their systolic BP will fall if they exercise. The total effect exercising has on the systolic blood pressure of an individual is given by the expression (with p-values of coefficients in parentheses):

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Systolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = \underset{(0.000)}{-2.554} \underset{(0.407)}{+0.856\mathrm{Urban}} \underset{(0.144)}{-1.623\mathrm{Poorer}} \underset{(0.046)}{-2.449\mathrm{Middle}} \underset{(0.057)}{-2.786\mathrm{Richer}} \underset{(0.055)}{-3.232\mathrm{Richest}}$$
$$\underset{(0.969)}{+0.047\mathrm{Primaryeducation}} \underset{(0.831)}{-0.233\mathrm{Secondaryeducation}} \underset{(0.954)}{+0.106\mathrm{Highereducation}}$$

NOTE: Given that the coefficients of Urban, Poorer, Primary education, Secondary education and Higher education are not significant at 10 percent level of significance and hence are statistically zero, the expression above is reduced to:

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Systolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = -2.554 - 2.449\mathrm{Middle} - 2.786\mathrm{Richer} - 3.232\mathrm{Richest}$$

The dynamics of the real effect of exercise on systolic blood pressure of a person, given his SES, are given below with p-values of joint test of significance of the total effect of exercise. The particular social or economic condition of an individual is given in parentheses:

All other things being equal, if individual i falls under the poorest wealth quintile

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Systolic}}}}{\partial Exercise_{ij}} = -2.554 - 2.449(0) - 2.786(0) - 3.232(0) = -2.554$$

All other things being equal, if individual i falls under the middle wealth quintile

$$\frac{\partial BP_{ij_{Systolic}}}{\partial Exercise_{ij}} = -2.554 - 2.449(1) - 2.786(0) - 3.232(0) = -5.003 \;\; (0.000)$$

All other things being equal, if individual i falls under the richer wealth quintile

$$\frac{\partial BP_{ij_{Systolic}}}{\partial Exercise_{ij}} = -2.554 - 2.449(0) - 2.786(1) - 3.232(0) = -5.340 \;\; (0.000)$$

All other things being equal, if individual i falls under the richest wealth quintile

$$\frac{\partial BP_{ij_{Systolic}}}{\partial Exercise_{ij}} = -2.554 - 2.449(0) - 2.786(0) - 3.232(1) = -5.786 \;\; (0.000)$$

From the above calculations, it is clear that exercising affects an individual's systolic BP no matter his/her SES negatively. However, the magnitude of the effect of exercising on the systolic BP of an individual differs depending on his/her wealth status. It shows that all things being equal, given that an individual falls under the middle wealth quintile and exercises, his systolic BP will be 2.449 mmHg ($-5.003 - -2.554$) less than the systolic BP of the poorer and poorest citizens who exercises respectively. A richer individual who exercises has a systolic BP of 2.786 mmHg ($-5.340 - -2.554$) and 0.337 mmHg ($-5.340 - -5.003$) less than an individual who is under the poorest/poorer and middle wealth quintiles and exercises respectively. Finally, given that a person is classified as richest and exercises, his/her systolic BP will be 3.232 mmHg ($-5.786 - -2.554$)), 0.783 mmHg ($-5.786 - -5.003$) and 0.446 mmHg ($-5.786 - -5.340$) less than a person who falls under the poorest/poorer, middle and richer wealth categories and exercises respectively. That is, all things being equal, though the wealthy has a high risk of being systolic hypertensive, if such persons exercise, the risk of being systolic hypertensive reduces.

In the case of diastolic blood pressure, the total effect of exercise on the diastolic blood pressure of an individual in Ghana is given by the expression (with p-values of coefficients in parentheses):

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Diastolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = \underset{(0.717)}{0.055} \underset{(0.539)}{+0.436\mathrm{Urban}} \underset{(0.769)}{-0.225\mathrm{Poorer}} \underset{(0.064)}{-1.558\mathrm{Middle}} \underset{(0.161)}{-2.249\mathrm{Richer}} \underset{(0.063)}{-2.158\mathrm{Richest}}$$

$$\underset{(0.158)}{+1.187\mathrm{Primaryeducation}} \underset{(0.408)}{+0.620\mathrm{Secondaryeducation}} \underset{(0.128)}{+1.907\mathrm{Highereducation}}$$

NOTE: Given that the constant term as well as the coefficients of Urban, Poorer, Richer, Primary education, Secondary education and Higher education are not significant at 10 percent level of significance in the $\frac{\partial BP_{ij_{Diastolic}}}{\partial Exercise_{ij}}$ *expression and hence are statistically zero; the expression is reduced to:*

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Diastolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = -1.558\mathrm{Middle} - 2.158\mathrm{Richest}$$

The dynamics of the real effect of exercise on systolic blood pressure of a person given his SES, are given below with p-values of joint test of significance of the ual, if individual i falls under the poorest wealth quintile

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Diastolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = -1.558(0) - 2.158(0) = 0$$

All other things being equal, if individual i falls under the middle wealth quintile

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Diastolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = -1.558(1) - 2.158(0) = -1.558 \ \ (0.061)$$

All other things being equal, if individual i falls under the richest wealth quintile

$$\frac{\partial \mathrm{BP}_{\mathrm{ij}_{\mathrm{Diastolic}}}}{\partial \mathrm{Exercise}_{\mathrm{ij}}} = -1.558(0) - 2.158(1) = -2.158 \ (0.004)$$

Given the above dynamics of the effect of exercising on diastolic blood pressure, it is clear that, as in the case of systolic blood pressure, if a person falls under the middle wealth quintile and exercises, his/her diastolic BP will be 1.558 mmHg $(-1.558 \ - 0\,)$ less than the diastolic BP of the poorer and poorest citizens who exercises. Also, given that an individual is classified richest and exercises his/her diastolic BP on the average will be 2.158 mmHg $(2.158 - 0)$ and 0.6 mmHg $(-2.158 - -1.558)$ less than an individual who is under the poorest/poorer and middle wealth quintile and exercises respectively. All things being equal, as in the case of systolic blood pressure, though the wealthy has a high risk of being diastolic hypertensive, if such persons exercises the risk of them becoming diastolic hypertensive reduces.

The above analysis shows that the self-in-context model is true in the case of blood pressure status in Ghana. Feinstein et al. (2006), the propounders of the model stated that individuals live in multiple, multi-layered and interacting contexts, each of which is a domain of social relations and environmental health risk and protection. That is, the effect of some socioeconomic conditions on health are firstly direct and secondly are mediated by the effect of some human behaviours on health. In the Ghanaian context, it is found that education and urbanisation only affect blood pressure (health) directly while the wealth status of the individual affects his blood pressure both directly and also mediate the effect physical exercise has on blood pressure. It is observed that the wealthy who exercises has a greater decrease in systolic blood pressure than the poor. Decrease in diastolic blood pressure due to physical exercise is however evident only in the rich in society. This brings a new dimension to the way hypertension and health should be looked at. Causes of ill-health in Ghana should, thus, be looked at holistically incorporating in them the role society and the social and economic standing of the individuals concerned are in. This suggest that future studies on determinants of health should take into consideration the social and economic conditions of the subjects used.

Post Estimation Test Results

Normality and Homoscedasticity tests of the estimated residuals for each of the regression models whose results are presented in Table 9 were conducted. The White's Test for Homoscedasticity show that the regression residuals for each of the models are normally distributed. That is, the null hypothesis of the test is that the variance of the residuals is constant. The probability value of this test is 0.144 and 0.230, which are greater than all traditional levels of significance. Hence the null hypotheses are not rejected and the study, thus, conclude that there exists homoscedasticity among residuals. The Skewness and Kurtosis Test for Normality also show that the estimated residuals for each of the models are homoscedastic. That is, the probability values of the test are above all traditional levels of significance. Hence estimates obtained in this study are, thus, efficient, unbiased and consistent. Tables showing normality and homoscedasticity tests of the residuals for each model are presented in Appendix B.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The study sought to determine whether or not the effect of physical exercise on blood pressure is only direct as most studies posit or is mediated by some socioeconomic factors or determinants of blood pressure. Specifically, the study was guided by three hypotheses. This chapter captures the summary of findings that were made from the study. It goes on to provide conclusions made from the study and thereafter give recommendations to various stakeholders in society based on the findings. The limitation of the study as stated in chapter one is reiterated. The chapter ends by giving suggestions for further research.

Summary of Findings

The study is built on the self-in-context model. The model was initially developed by Bronfenbrenner's ecological perspective which was later developed by Feinstein et al. (2006). The study generally sought to determine the effect of physical exercise on blood pressure. The study then looked at whether the effect of physical exercise on blood pressure is only direct or it is partially mediated by the socioeconomic condition of the individual.

A multinomial logit model was used to determine the likelihood of an individual who exercises to have a particular blood pressure status. The dependent variable of the model was blood pressure level which comprises four (4) categories-normal blood pressure, isolated systolic prehypertensive or hypertensive, isolated diastolic prehypertensive or hypertensive, and systolic-diastolic prehypertensive or hypertensive. The category normal blood pressure was set as the base category. Relative to the base category, the likelihood of an individual who exercises to belong to any other category was tested. It was found that individuals who exercise have a significantly higher probability of having a normal blood pressure than being systolic prehypertensive or hypertensive. Also, relative to having a normal blood pressure, physical exercise reduces the probability of being within the other two (2) groups (i.e. isolated diastolic prehypertensive or hypertensive, and systolic-diastolic prehypertensive or hypertensive). However, the decrease in the likelihoods of being isolated diastolic prehypertensive or hypertensive, and systolic-diastolic prehypertensive or hypertensive were statistically not significant. This means if an individual develops the habit of being physically active, the chance of becoming hypertensive reduces.

The study also determined the effect of wealth status on the relationship between exercise and blood pressure. It was found that, relative to those who do not exercise, an individual who exercises has a significantly lower systolic blood pressure. That is, physical exercise reduces the systolic blood pressure of the individual. In the case of diastolic blood pressure, it was also found that there is a negative relationship between diastolic blood pressure and physical exercise. The statistical relationship between diastolic blood pressure and physical exercise was however not significant. The researcher observed that the degree to which exercise will reduce blood pressure is positively associated with the wealth status of the individual. That is to say, the reduction in the blood pressure of the wealthy in society who engage in physical exercise is far greater than the reduction in the blood pressure of the poor if they exercise. This means though all individuals might benefit from exercising, the rich and the richest in society benefit the most. This is because in Ghana, the poor, by virtue of the kind of activities they do, already benefit from active daily work. It is also worth mentioning that physical exercise only causes a reduction in the systolic blood pressure of the near-rich and rich in society. It was also found that urbanisation, education status and wealth independently affects the blood pressure of people. The urban resident is found to have a significantly higher diastolic blood pressure than the poor. The highly educated also has a relatively higher blood pressure than the less educated. Lastly, the wealthy in society has a higher blood pressure than the poor. This might be so because on the average, the kind of activities and jobs the educated and the wealthy do in Ghana are relatively sedentary than the kind of jobs the poor in society do. Thus, the less physical activity among most educated and the wealthy individuals in Ghana might have led to this.

Conclusions

The study sought to mainly determine socioeconomic variables that mediate the effect of exercise on blood pressure in Ghana. It was found that physical exercise in general independently helps reduce systolic blood pressure in all individuals. This is not so in the case of the diastolic blood pressure of all subjects in the sample. It is however evident that physical exercise causes the diastolic blood of the wealthy to fall. This finding is, thus, important in controlling the blood pressure of the rich because, it is observed that, all things being equal, the blood pressure of the rich who do not exercise is higher than that of the poor. This deficiency by the virtue of being rich can however be solved by engaging in physical exercise. All individuals especially the highly educated, urban residents and wealthy in Ghana should take up positive behaviours in order to control their blood pressure and prevent the risk of being hypertensive. This is because it is evident from the study that such people are more susceptible to risk of high blood pressure. They should therefore desist from smoking, eat more fruits and be physically active. In summary therefore, it is evident from the study that while physical exercise, urbanisation, educational attainment and wealth affects the blood pressure of individuals independently, the effect of exercise on blood pressure is also mediated by the wealth status of the individual.

Recommendations

The following recommendations are made based on the findings of the study:

First, the Ministry of Health and, for that matter the Government of Ghana, should enact a health education policy that will by and large educate all citizens on the risk factors of hypertension and hence promote positive lifestyle practices. In other words, Government should encourage citizens to take physical exercise seriously. The Ministry of Health in collaboration with the Ministry of Sports and Recreation, with support from the Ministry of Finance should promote investment in provision of facilities like gyms, recreational parks, and so on in each and every community to entice people to be physically active. The Government of Ghana can also make a national policy to provide runways by all roads that run through communities in Ghana. These kinds of initiative will at least encourage people to be more physically active than they are.

Again, hospitals and clinics in Ghana should incorporate in their yearly activities regular education and health programmes aimed at encouraging people to develop the habit of exercising. Hospitals and clinics should also give special attention to the highly educated, urban residents and wealthy citizens in Ghana when it comes to monitoring their blood pressure levels. This is because these people are more susceptible to high blood pressure and hence regular blood test can help them know the thread of their blood pressure and hence take the appropriate action based on their results. This can help facilities detect any risk of hypertension and hence take measures to prevent it. More importantly, hospitals and clinics should recommend exercising to all their clients and especially to wealthy clients since it will considerably prevent high blood pressure or control their blood pressure when they are already hypertensive.

Also, Non-Governmental Organisations (NGOs) who aim at helping countries and societies fight against hypertension should focus their attention not only on antihypertensive drugs and other curative interventions, but also reinforce efforts to provide primary health education on the consequence of some lifestyle behaviours and health in general and on blood pressure in particular. NGOs should channel more of their resources to promoting physical activity which is a preventive measure of hypertension than channeling resources to provide curative assistance.

Limitation of the Study

According to WHO, the risk factors of high blood pressure or, in other words, the determinants of blood pressure that can be controlled are physical activity (exercise), sodium(salt), overweight and obesity, alcohol intake, smoking and tobacco use, stress and sleep apnea. The 2014 Ghana Demographic Health Survey (GDHS), where data for the present study is extracted, does not have data on alcohol intake, sodium (salt) intake, stress and sleep apnea. Hence these variables, which are also determinants of blood pressure, were not used during this study. Omission of these variables might bias the magnitudes of effects on blood pressure obtained from this study. Though the methodologies employed cannot correct for these biases, the signs of estimate coefficients rightly predict the directional effect of the independent variables used on blood pressure. Also exercise, which is the main variable of concern, was captured as dummy (i.e. whether one exercises or not). That is, the type of exercise one engages in and the number of days or times an individual exercise per week and the duration of exercise per session were not captured. This incapacitates the study to delve deep to explain the effect of exercise on blood pressure. Exercise as captured in the 2014 GDHS and used in this study comprises any physical activity a person does. Also, since the 2014 GDHS does not involve the aged in their study, results are only limited to the middle age group of Ghanaians. Since blood pressure among the aged is said to be relatively high, it is believed that if they were included in the study, the results obtained could be different. Also, the health history and medical conditions of subjects which are important determinants of blood pressure, were not considered in this study. Finally, the bi-causal relationship between physical activity and level of blood pressure can lead to endogeneity in the models' estimation. However, the researcher found no appropriate method to solve this problem. This could also have consequences on the parameter estimates.

Suggestions for Further Research

Future studies on the determinants of blood pressure should consider and control for the SES of their subjects. Also, Given the above limitations of the study, future studies should try as much as possible to include risk factors like alcohol stress and sleep apnea if they become available to restudy this same topic to determine if there will be significant changes in the results. Future studies should also look at how these socioeconomic factors mediate the effect of other behavioural risk factors of hypertension on blood pressure. Studies can also look at the influence of the Ghanaian physical environment on their exercising habit.

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APPENDIX A

Description of Ghanaians Behaviour Towards Risk Factors of Hypertension that can be Controlled

Risk Factor	Mean	Frequency	Percentage
Fruit	3.331	-	-
Arm Circumference	29.219	-	-
Exercising Habit			
Exercise	-	1,722	12.55
Do not exercise	-	12,001	87.45
Smoking Habit			
Smoke	-	13,468	1.86
Do not smoke	-	255	98.14

APPENDIX B

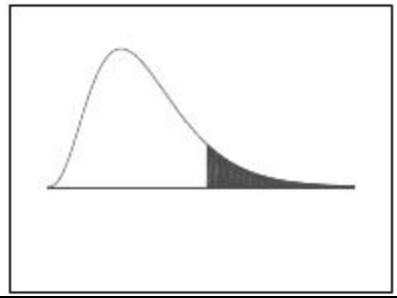
Post Estimation Test

	Observations	Chi-square	Pr(Skewness)	Pr(Kurtosis)	P-value
Homoskedasticity	3723	2.14			0.144
Normality	3723		0.9115	0.0445	0.123

APPENDIX C

Chi-Square Distributiin Table

The shaded area is equal α to for $\chi^2.995 = \chi^2_\alpha$



df	$\chi^2.995$	$\chi^2.990$	$\chi^2.975$	$\chi^2.950$	$\chi^2.900$	$\chi^2.100$	$\chi^2.050$	$\chi^2.025$	$\chi^2.010$	$\chi^2.005$
1	0.000	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.300
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.041	30.813	33.924	36.781	40.289	42.796
23	9.260	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.195	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278	50.993
29	13.121	14.256	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.953	16.791	18.493	20.599	40.256	43.773	46.979	50.892	53.672
40	20.707	22.164	24.433	26.509	29.051	51.805	55.758	59.342	63.691	66.766
50	27.991	29.707	32.357	34.764	37.689	63.167	67.505	71.420	76.154	79.490
60	35.534	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.379	91.952
70	43.275	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.425	104.215