Meta-Analysis of a Systematic Review on Adult Obesity in Kuwait

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Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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Abstract

Background: There has been a continuous rise in obesity rates in global human populations and this has become a national health crisis in many nations in the Middle East, including Kuwait, which has an extremely high population of obese people. Several researchers have undertaken systematic reviews of factors leading to the prevalence of weight-related health issues in a number of developed countries, but such research on Kuwait is scarce.

Objective: The key objective of this project is to conduct a meta-analysis on a systematic review of research on obesity in Kuwait with the use of retrospective research studies conducted on the incidence of obesity in Kuwait with emphasis on demographic factors.

Methods: Using some keywords, the electronic databases of PubMed and Health Technology Assessment were searched, while Hindawi Publishing Corporation Journal of Obesity (publication dates 1990-2014), the Oxford Journal of Occupational Medicine (publication dates 1990-2014), Psychiatric Services Journal, Elsevier Diabetic Research and Clinical Practice (publication dates 1990-2014) were manually searched. As a result, eighteen studies were identified. Fixed and Random Effects Models were applied to the 18 studies. Tests of homogeneity were also performed. The presence of publication bias was assessed. The overall prevalence of obesity in Kuwait and the odds of developing obesity based on certain demographic factors was obtained. Additionally, year of publication, average age of samples, and minimum age were considered to account for extra variation between studies.

Results: Eighteen studies were selected based on the selection criteria and analyses performed. The overall prevalence of obesity was estimated as 33.19% with very high heterogeneity among studies. Based on gender, the odds of obesity for the 'old' category estimated by the random and fixed effects models are 0.63 ($p = 0.0769$, 95% CI = 0.38 to 1.05) and 0.58 ($p < 0.0001$, 95% CI = 0.55 to 0.61) respectively. The odds of obesity in females is 1.25 when compared to the odds in males while the risk of obesity in females is 1.1 when compared to obesity risk in male. Year of publication, average age, and minimum age of studies were not able to account for this significant variation.

Conclusions: The incidence of obesity across the adult population is relatively high at about 33,19% and is increasing. Females are at a higher risk of obesity than males. Older people are associated with higher risk of obesity than younger people, contrary to what one would

expect due to a marked reduction in youth participation in physical activities as a result of increased availability of technology. The government of Kuwait and its health stakeholders should implement policies to reduce obesity. Future work should focus on meta-analysis of studies on obesity in the Middle East where obesity has become a pressing issue in nations such as the UAE, Bahrain, Saudi Arabia, Qatar, Oman, and Kuwait.

Keywords:

BMI, obesity, overweight, Kuwait, prevalence, trend, risk factor

Definitions:

BMI: Body mass index (BMI) is an index calculated by dividing the weight of an individual by the square of height. It is commonly used as a measure of overweight and obesity in adults.

Obesity: Abnormal or excessive fat accumulation in an individual that may impair health (BMI ≥ 30).

Overweight: Abnormal or excessive fat accumulation in an individual that may impair health (BMI ≥ 25).

Kuwait: An Arab country in the Arabian Gulf.

Prevalence: The percentage of all individuals in a particular population affected by a disease at a particular time.

Risk Factor: Any attribute, characteristic, or exposure of an individual that increases the likelihood of developing a disease or injury.

Chapter 1: Introduction

Obesity is a physical condition whereby the ratio of mass of muscle to that of fat is such that it can negatively affect health (WHO, 2016). A person is said to be obese when the body mass index (BMI), an estimate obtained by dividing the weight of an individual by the square of height, is greater than 30 kg/m^2. When BMI falls within the range of 25-30kg/m^2, the person is said to be overweight (WHO, 2016).

In recent decades, obesity has become a global issue as it is a leading factor for morbidity and mortality and its prevalence is increasing worldwide. It is estimated that approximately a third of the entire human population suffers from obesity, and projections predict continued increases in obesity rates in various nations (Wang et al., 2008). The WHO published a fact sheet in 2015 which indicated that the prevalence across countries ranged from 10 to 14% in 2008. The WHO fact sheet also reported that since the early 1980s, the global obesity rate has doubled, with more than 1.9 billion adults overweight at the end of 2014.

Furthermore, obesity is now a public health issue and data recorded presents a grim picture with a bleak future. Obesity rates have increased by 100% in children and adults and by 200% in adolescents over 20 years (Ahmad et al, 2010; Nguyen and El-Serag, 2010). Sixty six percent of Americans are either obese or overweight. Every year in America, about 400 000 deaths linked to obesity are recorded and $117 billion is spent in the healthcare sector on costs linked to obesity (Basset and Perl, 2004). Obesity is considered a serious public health problem since it is linked to multiple health conditions and illnesses. According to Wang et al (2008), the concern does not just relate to health-associated outcomes of mortality and morbidity, but due to obesity being related to much higher costs of health. The ceaselessly rising obesity rate has increased total prevention and treatment costs associated with obesity, which tend to account for a large proportion of government healthcare budgets running into billions of dollars.

Another concern is related to reports on obesity resulting in a higher number of deaths in nations compared to being underweight. This has also been identified as a primary reason for health conditions such as heart disease, hypertension, diabetes, some types of cancer, and some reproductive conditions, as indicated by Wang et al., (2008). Other related outcomes are economic, social, and psychological issues.

The obesity rate was particularly high in some developed countries such as the United States and Italy (Anon, 1997; Pagano, 1997). Furthermore, the adult obesity rate in the United States of America dramatically increased between the mid-1970s and the 1990s, with the highest rates occurring in the 1980s, as indicated by Flegal et al., (2002). Obesity rose more than three-fold among adolescents and children over the same period of time, according to Ogden et al., (2002). Consequently, 66 % of adults in the United States (aged 20 and above) are presently either obese or overweight (with a BMI of 25kg/m^2 or more). Moreover, one in every five American adults (about 22 %) as of 2002 were categorised as obese on the basis of self-reported height and weight, and one in every three persons, (about 32 %) as of 2002 were obese on the basis of clinical measurement of data, as indicated by Ogden et al., (2006).

On a larger scale, Popkin and Doak (1997) revealed that Finland, Germany, Italy, and USA have the highest obesity rates, using data obtained from various sources as well as publications of surveys conducted in Russia and China. Additionally, it was revealed that the obesity rate, as well as its rate of increase per year, was highest in Western countries including England and America.

A large number of European nations are encountering a marked increase in obesity rates, as indicated by Seidell, (1995). However, in Russia and most parts of Eastern Europe, obesity is not as prevalent (Popkin and Doak, 1997). Kautiainen et al., (2002) reported that there was an abrupt increase in the overweight and obesity rates in adolescents in Finland between 1977 and 1999. Similarly, in Hungary, the obesity rate in children rose from about 12 %, to 16 % between 1980 and 1990. In developed nations, the obesity epidemic might now be gradually reducing after a steep increase between 1967 and 2005 (Olds et al., 2011). Any reduction in childhood obesity rates may be as a result of substantial attention of the media paid to this issue in recent times (The Department of Health, 2007), and to strategic targets and policies on obesity nationally (Reilly & Wilson, 2006; Reilly et al., 2010).

High obesity rates are no longer limited to the developed nations. Increased childhood obesity rates have been discovered in developing nations (Gupta et al., 2012). For example, the obesity rate in adolescents and children between the ages of 5 and 19 years was 42% in Mexico, 19 % in Argentina, 22 % in India, and 22 % in Brazil. Rising rates have been recorded in many nations. It increased from 4 to 14% in Brazil between 1974 and 1977, from 12 to nearly16% in Thailand between 1991 and 1993, and from 10% to nearly12% in India between 2006 and 2009, as Gupta et al., (2012) indicates. Popkin and Doak (1997) stated that in Latin America, the obesity rate in adult females was over 10 % in Colombia and Brazil combined, the overweight rate was over 50 % in Mexico, and the obesity rate was over 30 % in Peru. Although the rates were lower in South American countries than in Mexico, since these data were obtained from urban samples, it is possible that rates are higher in rural settings.

Similarly, countries of the Caribbean have experienced a high obesity rates (Forrester et al., 1996), including St Lucia and Jamaica having rates of between 12 and 15 % and Barbados and Cuba over 20 %. Popkin and Doak (1997) suggested that obesity is generally exceptional and not exceptional in Asian and African nations, but remains more predominant in cities than in rural areas. Nevertheless, in these developing regions it is continually increasing, particularly in people with higher incomes and whole areas experiencing more wealth. The majority of nations in Asia had obesity rates in the 5-15 % range, aside from Malaysia, urban China, Central Asian nations, and urban Thailand prior to 1992.

Continuing the global trend, an investigation conducted by Popkin and Doak (1997) revealed that close to half of the entire population of nations of the Western Pacific territories were obese. The results of a Lebanese national population-based review revealed high obesity and overweight rates similar to those seen in developed nations, both in children and adults (Sibai et al., 2003). More recently, an investigation conducted on trends in obesity and overweight rates in Lebanon over twelve years discovered an unprecedented rise in obesity rates (Nasreddine et al., 2012c). More than 33 % of people in the oil-producing nations in the Middle East, such as Saudi Arabia and Kuwait, were either obese or overweight (Popkin et al., 1997). In Africa, the situation was similar, as indicated by El Mugamer, (1995). In the majority of African nations, food security and under-nutrition have been two important related problems. Nevertheless, nations such as South Africa and Mauritius have experienced trends of rising obesity similar to those seen in Western nations.

In fact, the rates of obesity and overweight in adolescents and children have risen quickly in the most parts of the world, and not just in the developed nations. A few developing nations now have childhood obesity rates even higher than that in the United States (Sinha & Kling 2009). Concerns now are extended to these countries, which are expected to experience continuing increases in the near future (Wise, 2011).

Correspondingly, in the Middle-East obesity has become a critical public health issue in Kuwait, Qatar, Oman, Saudi Arabia, and Bahrain among other oil-rich high-income countries (Ng et al. 2011; Al Nohair 2014). Al Nohair (2014) notes that in the Gulf Nations, the obesity rate in adolescents and children is between 5 % and 14 % in males and between 3 % and 18 % in females, while in adult females in recent years, the rate has increased from 2% to 55%. In adult males, the rate ranges from 1% to 30% across countries in the Gulf region (Al Nohair 2014). These increased obesity rates in the Middle-East motivated the author of the present review to study this important public health issue, as data on obesity rates in the Middle-East is limited.

More specifically, Kuwait is a nation with one of the highest rates of obesity in the Middle East, and this continues to rise significantly over time (Karageorgi et al., 2013). Obesity in Kuwait has become one of the major problems facing plans for development. Kuwait is ranked as the fourth most obese country on the planet according to a published annual list based on official data collected by governments of the countries listed and the world health organization (WHO, 2016). This is why the author chooses to focus his research on Kuwait.

Karageorgi et al (2013) reviewed adult obesity rates in Kuwait, along with risk factors, trends, and epidemiological techniques. The study methodology adopted by Karageorgi et al., (2013) was to search the PubMed database, making use of the keywords ‘adults’ and ‘obesity prevalence in Kuwait’. This produced an aggregate of about 111 specific cross-sectional research studies, which left just 39 after abstract review and review of depth of research. Only 18 of these studies were retained for this study after text reviews were completed.

Among these 18 studies, sample sizes ranged widely from 177 to 3861 adult individuals, with only 30% based on randomly selected samples. Obesity rates (BMI $\geq$ 30) recorded in their findings also varied widely, from 24 % to 48 %, while in adults above 50 years of age, the rate was over 52%. Interestingly, it was discovered that women were more obese than men. This study discovered a rise in obesity trends from 1980 to 2009 and that there were multiple risk factors. This systematic review has confirmed that metabolic syndrome, as well as obesity, is regarded as a cardiovascular risk factor present in Kuwait. This study has concluded that the obesity rate (BMI $\geq$ 30) in the human population of Kuwait was about 47.5%, while the overweight rate (BMI $\geq$ 25) was about 80.4%.

Karageorgi et al (2013) carried out a systematic review of eighteen papers representing the existing research on obesity rates in Kuwait nationally including identified risk factors and some relevant trends. Variation in the results of the studies reviewed by Karageorgi et al (2013) cannot be explored properly through only a systematic review. This motivated the use of meta-analysis by the author of this study, to further synthesize data across studies and to attempt to identify a common effect.

The aim of this project is to conduct a meta-analysis on a systematic review of research on obesity rates in Kuwait and their implications for the country as a whole to further the work of Karageorgi et al. (2013). This study targets adults with BMI in the overweight range. The present study aims to examine the results obtained in the systematic review conducted by Karageorgi et al., (2013) and to assess methodologies used in the retrospective studies, which report obesity rates, risk factors, and trends in these factors. The objectives of this study are therefore to:

1) extend the previous systematic review to include more recent studies until the end of 2016;
2) achieve this by conducting an exhaustive search of obesity research in Kuwait;
3) filter obesity research in the literature related to important factors such as lifestyle and socio-cultural related factors;
4) conduct a meta-analysis on all studies identified in (3).

This review will include a search and extraction of earlier published cross-sectional research articles via the PubMed database. Additionally, the search technique used will be very straightforward, using keyword combinations of 'obesity', 'adults', and 'Kuwait' to make each enquiry. Additionally, the study also targets other researchers from Kuwait to include the factors and articles missed in this paper.

Accordingly, this thesis will contribute to the current literature on trends in obesity rates in Kuwait and related factors. Specifically, a systematic detailed review of research on obesity rates in Kuwait will be presented. Important factors that are associated with obesity will be identified. Finally, results from the reviewed studies will be re-analysed and summarized using meta-analysis methods. Though a considerable amount of research including reviews has been done on obesity and related factors and reasons for the development of obesity in many developed nations, few studies on Kuwait is have been conducted. Accordingly, this exploration fills a gap in the literature relating to obesity rates, particularly in Kuwait, by reviewing and summarizing several studies at once, producing a single generalized estimate of effects. Also, it is expected that the findings from this study will provide insight and other useful information on obesity rates and associated factors, which may be useful for policy makers and health practitioners in Kuwait.

To achieve the stated aims, the outline of this thesis is as follows: Chapter 2 consists of a review of health and obesity related problems in Kuwait and then reviews on meta-analysis. In Chapter 3 the two methods used here, systematic review and meta-analysis, are discussed relative to their use on research on obesity rates in Kuwait. Chapter 4 contains the analyses and results from the meta-analysis, which is the original contribution of this thesis. Chapter 5 completes the thesis with a summary and conclusions drawn from the results.

Chapter 2: Literature Review

2.1 Background on Kuwait

Kuwait, which was formerly known as the State of Kuwait, is a nation on the northern edge of Eastern Arabia at the tip of the Arabian Gulf between Iraq and Saudi Arabia (Central Intelligence Agency, 2016). Kuwait is listed as one of smallest nations on the planet with respect to its land mass of 17,818 sq km between longitudes 46°E and 49° E and latitudes 28°N and 31° N. In 2014, the population of Kuwait was 4.2 million, with 1.3 million Kuwaitis and 2.9 million expatriates (Central Intelligence Agency, 2016). As a result of oil reserves being found in 1938, from 1946 to 1982 substantial modernisation occurred.

In the 1980s, Kuwait encountered a period of geopolitical precariousness and economic turmoil after a stock market crash. In 1990 Kuwait was attacked by Iraq, leading to intervention by the United States armed forces (Trofimov, 2009). Toward the end of the war in 1991 after the military intervention, there were broad attempts to resuscitate the economy and remake national infrastructure to standard (Trofimov, 2009). The Kuwaiti government is a constitutional monarchy, the constitution being formally declared in 1962, causing Kuwait to become the most democratic nation in the area (Reporters without Borders, 2010; Elbadawi and Kubursi, 2014).

The economy of Kuwait is based on petroleum, which represents almost 50% of gross domestic product (GDP) and 94% of government income and export revenue (Central Intelligence Agency, 2016). In addition, the main revenue not based on petroleum comes from water desalination, financial services, and shipping. Kuwait's fresh water resources are limited, so desalination facilities produce the majority of water for human utilization. Agriculture is constrained by the absence of arable land and water. However, aquatic resources such as crustaceans, and fish are abundant in the Gulf. As indicated by the World Bank, Kuwait is the fourth wealthiest nation in the world per capita (World Bank, 2015) and the Kuwaiti dinar is the currency of the highest value in the world (Siliconindia Finance, 2016).

Between 2001 and 2009, Kuwait had the highest position on the Human Development Index among all Arab nations (Wikipedia, 2016). Also, Kuwait ranks exceptionally highly in local measurements of gender equality, as it has the area's most elevated Global Gender Gap positioning (KUNA, 2015). The proportion of men to women among the aggregate populace was 1.5: 1 due to very large numbers of single men among foreigner workers (PACI, 2008). The Kuwaiti populace is youthful, with roughly 40% below 20 years of age and its birth rate is high. Of relevance to the obesity issue, 90% of the population of Kuwaitis live in urban zones (MOP, 2007).

The climate is extremely hot during the summer, which extends from April to September, with temperatures often exceeding 50°C during the day. In the months of August and September moderate humidity is experienced. The highest temperature in January, the coldest month in the year, is typically about 13.5°C. Rainfall is normally less than 160mm per year, which mostly falls during the winter (FAO, 2008).

2.2 Health Issues in Kuwait

Kuwait is a rich nation in which the government provides numerous services and social amenities for its human population including good education and health services. Thus, all citizens of Kuwait experience a high standard of wellbeing, with the burden of disease and health indicators similar to those of highly advanced nations. Moreover, life expectancy, particularly at birth as of 2015, was about 74 years for men and about 76 years for women (WHO, 2016). More than 76 % of the reasons for the high mortality rate in Kuwait is because of non-transmittable diseases, mainly heart disease and cancer. Moreover, diabetes, dyslipidemia, physical inactivity, and obesity are increasing and becoming significant risk factors nationally (WHO, 2016). Health indictors in Kuwait are summarised in Table 2.1.

Table 2. 1: Health indicators in Kuwait (Data Source: The April 2014 Global Health Observatory http://apps.who.int/gho/data/node.cco)

Key Indicators: Kuwait	
WHO Region	Eastern Mediterranean
Health of Children	
Immunization of Diphtheria tetanus toxoid and pertussisa among children of 1 year of age (%) (2014)	95%
The Statistics of the Demography and Socioeconomy	

Key Indicators: Kuwait	
gender inequality index rank (2014)	79th (rank)
Human development index rank (2014)	48th (rank)
Health Financing	
Aggregate expenditure on health as a percentage of gross domestic product (2014)	3.04%
Private expenditure on health as a percentage of total expenditure on health (2014)	14.07%
General government expenditure on health as a percentage of total government expenditure (2014)	5.77%
Health Systems	
Density of physicians (per 1000 population) (2009)	1.793 (per 1000 population)
Midwifery and nursing personnel density (per 1000 population) (2009)	4.55 (per 1000 population)
Estimates of Global Health and Mortality	
Rate of neonatal mortality (per 1000 live births) (2015)	3.2 [2.6-3.8]
Mortality rate of under-fives (te probability of death by the age of 5 per 1000 live births) (2015)	8.6 [7.8-9.4]
Ratio of maternal mortality (per 100 000 births) (2015)	4 [3 - 6]
Environment and Public Health	
Sources of population with the use of enhanced drinking-water (%) (2015)	99.0 % (total) 99.0% (rural) 99.0% (urban)

Key Indicators: Kuwait	
Population with the use of enhanced sanitation facilities (%) (2015)	100.0% (rural) 100.0% (urban) 100.0% (total)
Sustainable Development Goals	
Life expectancy at birth (years) (2015)	73.7 (male) 76.0 (female) 74.7 (both sexes)
Births attended by skilled health personnel (%) (2013)	99.9%
World Health Statistics	
Population (in thousands) total (2015)	3892.1
Literacy rate among adults aged >= 15 years (%) (2007-2012)	94

Data Sources: The April 2014 Global Health Observatory, http://apps.who.int/gho/data/node.cco

This is reflected in a nation's position with respect to normative ideals in the major dimension of the health of women. Generally speaking, the gender inequality index (GII) highlights the difference between men and women in the dimensions of financial status and empowerment. Kuwait's ranking of 79th demonstrates high imbalances in these areas and in more generally, high failure to develop human potential (Gender Inequality Index, 2016).

The human development index (HDI) rank of 48th shows that human development in areas such as life expectancy, education, and per capital income in Kuwait is below average. A country scores a higher HDI when life expectancy, education level, and GDP per capita are higher. (Economics Concept, n.d.)

The aggregate expenditure of health as a percentage of GDP is 3.04 %, which indicates that the amount spent on health is low. Life expectancy at birth (in years) for males is 73.7, for females is 76.0, and for both sexes combined is 74.7, which indicates that females live longer than males.

2.3 Obesity in Kuwait

Obesity is a morbid condition that has transformed into a global issue in recent years. Like the rest of the world, Arab countries including Kuwait have experienced a significant increase in obesity rates. While there are differences between obesity rates in men, women, and children, if current increase in obesity persists, future outcomes will be alarming.

In Kuwait, obesity has been recognised as the causative agent for multiple health problems, heart and lung diseases being the primary ones. Olusi et al. (2003) reported an overall obesity rate of 23.5% in Kuwaiti adults (15 years and older). The results were even more staggering when segmented on the basis of gender. The obesity rate in adult females was greater than that of adult males in Kuwait. Where a total of 30.0% adult women were obese, only 17.5% men were obese. The combined adult obesity and overweight rate was 58%. Moreover, diabetes mellitus and hypercholesterolemia are major diseases occurring in the obese population.

In response to the increasing levels of obesity and overweight in Arab countries and especially in Kuwait, much research has focussed on the problem. In light of this, a systematic review of this research is justified. Such a systematic review will eventually enable a deeper understanding of the severity of the problem, the major risk factors that may trigger obesity and overweight, and the possible ways out of this dilemma.

A systematic review of the literature was conducted by Karageorgi, et al. (2003), which examined methodologies, results, and discoveries of relevant studies on the trends, risk, and rates of Kuwaiti obesity. Their search found 111 published on the PubMed Database from the years 1997-2002, out of which 18 were used. Sample sizes from the 18 chosen studies ranged between 177 and 3861, although only 30% of these studies selected their samples randomly. The national obesity rates (BMI $\geq 30 kg/m^2$) found in these studies ranged from 24 % to 48 %. Additionally, the obesity rate of Kuwaitis over the age of 50 was higher than younger adults at 52% (Karageorgi, et al. 2013).

Figure 2. 1: Map of the six governorates in Kuwait. Source: (Karageorgi et al. 2013).

Obesity was more common among women than men and a rise in obesity rates occurred between the years 1980 and 2009 with various risk factors involved, as shown in Figure 2.1. The current study aims to extend the Karageorgi, et al. (2013) study by incorporating more recent studies and by selecting two factors that could be major obesity risk factors.

This systematic review identifies chronic diseases and conditions associated with obesity and overweight. The common unit for measuring obesity, as used by researchers, is the Body Mass Index (BMI). An individual with a BMI ≥ 30 is considered to be obese. Therefore, BMI was considered as a key component in this systematic review.

Demographic, socio-cultural, and lifestyle factors exert a strong influence on the distribution of type II diabetes globally. According to Kanter and Caballero (2012), gender disparities in overweight and obesity are exacerbated amongst women in developing countries, particularly in the Middle East and North Africa. This thesis will be focusing on demographic factors such as age and gender with the goal of determining patterns of distribution of diabetes based on them in Kuwait.

Prevalence of obesity in Kuwait - demographic, sociocultural, and life-style related variables

In a systematic review published by Rashdan and Nesef (2009), extremely large community-based surveys were done across the country to study overweight, metabolic disorder, and obesity in the Kuwaiti populace. Their results revealed a high obesity rate in Kuwait. They found that the overweight and obesity rates in adult females were higher than in adult males: about 82 % and 53 % respectively in females, and 78 % and 39 % in men. Furthermore, a few other reviews likewise report high rates of overweight and obesity in Kuwaiti children. For example, the a conducted by Shady and Lofty (2009) emphasised the high obesity and overweight rates in intermediate school students in Kuwait between the ages of 10 and 14. There were rates of 31% and 15% for obesity and overweight respectively.

In a different systematic review performed by Al-Kandari (2006), the obesity rate in Kuwait and its relationship with socio-cultural factors was examined. The study included equal sample sizes of female and male adults, 212 individuals each. Most of the participants were either overweight or obese, while only a small number were underweight (BMI < 20). Their results incorporated three grades of obesity and showed that about 31 % of the aggregate sample size was classified as grade 1 obese ($30 < BMI < 35$). About 37 % of the sample were classified as grade 2 obese ($35 < BMI < 40$). Also, a relationship was found between Kuwaiti obesity rates and socio-cultural factors. It was additionally reported that obesity rates increase with age, and that obesity levels in women of different ages are higher than those of men in each age group.

In another review by Ghazali et al. (2010) assessing the association between obesity and lifestyle, of 320 Kuwaiti students from Kuwait University, the majority of overweight and obese students were consistent buyers of fast food, with sedentary ways of life. Furthermore, the mean BMI discovered in the review was 30.94 ± 4.06 kg/m^2. About 93 % of the aggregate sample was either overweight or obese. About 7 % of the sample was of healthy BMI and these individuals consumed more vegetables and food of an adequate hygiene level.

Furthermore, obesity in Kuwait has been increasing since 1980 and is forecast to keep increasing in the near future. For this reason, obesity rates have become a national healthcare crisis in Kuwait, which if left unchecked could result in high costs to society relating to health and general wellbeing (Al-Isa, 1999).

Many studies record that the obesity rate in adult Kuwaiti females is greater than in males. Additionally, although these rates increase with age, childhood obesity is nevertheless of significant concern. Obesity is considered a risk factor in major conditions which increase death rates in Kuwait, namely cancer, diabetes, and heart disease. Moreover, personal expenses related to obesity combine with other consequences of low quality of life. While it is by and large contended that a key explanation for increasing obesity rates in the Kuwaiti populace can be explained by more sedentary ways of life and higher consumption of fast foods and added sugars than in previous decades, robust research needs to be conducted to discover and assess effects of important factors that cause obesity (Ahmad, 2010).

2.4 Systematic review

2.4.1 Methodology adopted in systematic review

The current study is an extension of the study by Karageorgi et al. (2013) in terms of years of coverage and selection of certain significant risk factors for human obesity in Kuwait.

A total of 24 research articles were searched from the PubMed database mainly because of the fact that the articles in this database are peer-reviewed and credible. These 24 articles were selected after a comprehensive search over the popular PubMed database by using the main keywords combinations relating to *Obesity in Kuwait, Obesity and Overweight in Kuwait, Obesity in Adults in Kuwait, and Obesity AND Risk Factors.* Incorporating these keywords into the search strategy made it easier for the paper to filter the most relevant studies to conduct the systematic review. In order for the research to remain focused and clear, the search range was limited to from 1990 to 2016, while all the researched articles were in the English language. The purpose behind putting a limitation to the date was to ensure that the data gathered was more recent and was not out-dated. The search strategy involved an initial selection of the research articles on the basis of their abstracts and titles, whereas papers that did not directly relate to the topic were excluded right away.

During the search, a total of 53 articles were selected from their abstracts and topics; however, 30 articles were rejected on the basis of the following; date of publication was unclear, research conducted did not include sufficient information on the central issue, and the research did not provide substantial evidence. Other reasons for the exclusion of the 30 articles included self-reported weights and BMIs instead of clinically measured indices. Some presented findings that were overlapping the already found results. Karageorgi*et al* (2013) coordinated the full-text reviews of these 53 articles. Only the studies that presented results and findings in a sufficient detail were included into the research while others that did not provide comprehensive elicitation were excluded. Only 23 articles were considered for the systematic review and 18 articles were selected for meta-analysis.

In order to keep the findings, clear and concise, a thorough comparison of the results and findings from the 23 articles was made and has been presented in the table See Appendix 1.

2.4.2 Findings from the systematic review

From all of the 23 articles included in the systematic review, a considerable degree of information was gathered. Many studies such as Al-Isa (1997) and Zaghloul et al. (2012) investigated the demographic profiles of people with obesity in Kuwait. Al-Isa (1997) compared two cross-sectional samples and uncovered that there exists an increasein BMI of men and women adults in Kuwait which was reported at 10.0 and 6.02% respectively, while Al-isa, et al. (2011) revealed that the rate of obesity in Kuwaiti adult men and women remained at 48.5% and 19.8% respectively. While, the prevalence rate of obesity was observed to increase at the rates of 15.5% and 20.6% for both men and women respectively. Similar results were indicated by the study conducted by Zaghloul et al (2012) who reported that Kuwaiti women are more overweight and obese than the Kuwaiti men.

Socio-cultural variables such as marital status, educational level socioeconomic statuswere discovered to be somewhat of a greater degree of association with increasing rates of obesity in the Kuwaiti population (Al-Kandari 2006). Ghazali, et al. (2010) found that of the total sample selected for study, 93.4% was found to be either obese or overweight with a mean BMI of 30.94. Only 6.6% of the total sample size was found to be overweight, whereas, unlike the other studies, this study indicated that 69.9% males were obese and overweight while a lesser percentage of females were obese. A study by Ahmed, et al. (2012) also revealed quite similar results. Their study indicates that the prevalence of a greater Body Mass Index increased from 61.8% and 59.3% in males and females respectively. This indicates that the BMI prevalence was greater in Kuwait's females than males. The study also indicated that for all age groups, the prevalence ~~rate~~ of female obesity in Kuwait was higher compared to males.

Studies suggest that obesity is more common in older males and females, especially those that are married. Al-Kandari (2006) indicated that the condition of obesity tends to increase with age. This increase with age is more likely to occur in women compared to men. A similar study conducted by Badr, Shah, and Shah (2012) indicated that the condition of being overweight was found in a total of 81% of respondents from their sample of 2,443 Kuwaiti adults of 50 years. Among these 81% overweight respondents, almost half (41%) were obese. A mean BMI of 30 kg/m^2 was found. The study also indicated that relatively younger Kuwaiti adults were more likely to become obese compared to the average Kuwaiti. At the same time, married individuals were found to be almost 2.3 times likely to be obese or overweight when contrasted with the single adults.

Furthermore, the review also enabled this study to gain insights about the prevalence of childhood obesity in Kuwait. Obesity and overweight are also found to prevail in intermediate school students of Kuwait between the ages of 10 and 14 (El-Bayoumy, Shady &Lotfy, 2009). The study indicated that an overall prevalence of 30.7% and 14.6% - for obesity and overweight respectively was found in the intermediate school student's sample. A study by Musaiger (2011) discovered the overall rate of obesity in adults of Kuwait, was between 25% and 81.9% whereas the reasons for the prevalence of obesity were mainly identified as transitions in nutrition, inactivity or low activity levels, shorter duration of breastfeeding, marital status, and urbanization. Badran and Laher (2011) argue the prevalence measure of obesity among the adolescent and children in the country varies from 5 to 14% in males and 3 to 18% in females. Key reasons identified by them for increasing obesity are increased food consumption, demographic and socioeconomic factors, multiple pregnancies and physical activity. Zaghloul et al. (2012) also found that Kuwaiti boys were found to be more obese than Kuwaiti girls. The boys between the age ranges of 9 to 13 years had the highest obesity prevalence rates of 37% while the percentage of females of the same age was found to be lower i.e. 24% (Zaghloul et al. 2012).

Several studies studied the obesity and its associations with ethnicity, especially with regards to metabolic risk factors in the Arab and South Asian population in Kuwait. For example, Babusik and Duris (2010) identified the obesity prevalence rate between the two sample groups and found that the Arab population in Kuwait acquired the condition of obesity in younger years of age compared to the South Asian population in Kuwait. It also reported that the Arab sample in Kuwait was found to be more obese than the South Asians in Kuwait. This was recognized by a greater hip and waist measurements.

A good number relating to studies provided insights about risk factors that made the population prone to obesity and overweight context of Kuwait. In an explorative study conducted by Al-isa (1999), the condition of obesity was classified into two BMIs and the associated risk factors including gender, age education, parental obesity and other factors were also studied. The study indicated a greater prevalence of grade 1 obesity compared to Grade-2 obesity, which was more severe. On the other hand, marital status, age, parental obesity, low level of school CGPAs and more frequent meals eaten were recognized as the major risk factors of obesity. The association between obesity and education was also explored by Ahmed, et al. (2012) who revealed that where gender and age were considered to be direct risk factors for increasing obesity, education was considered as negatively associated with an increase in obesity.

Importantly, Al-Kandari et al. (2008) utilized the instrument "Walker's Health Promoting Way of Life Profile II" to measure the level of health benefits and BMI due to lifestyle of Kuwaiti students at the college of nursing. The study discovered that in this population, males of normal BMI were more likely to become obese or overweight in the near future when following a 'positive-low health-promoting' lifestyle. Their lifestyle profiles had a considerable association with their marital status, socio-demographic factors, age, and nationality. Their study concluded with the finding that there was an increasing need for promoting a healthy lifestyle in order to help participants avoid obesity and the overweight and to avoid associated diseases.

The above suggestions are also reflected in Al-isa et al. (2011) who identified certain risk factors, such as having an obese parent or sibling, increased age, and low level of physical activity. Among each of these factors, the lower level of physical activity was recognized as a major contributor towards obesity. In a cross-sectional survey conducted on rates of obesity and overweight among employees of Kuwaiti oil companies, Al-Asi (2003) found that there was an overall prevalence of obesity and overweight at 75% in the total 3282 employees sampled.

In line with the results of other studies examined in this literature review, Al-Asi (2003) indicated that obesity rate among males was higher than that of the females. The study also indicated that field workers had a lower level of physical activity and higher levels of obesity and overweight.

Al Shayji and Akanji (2004) conducted a study in which they explored the association of obesity (through BMI) over certain metabolic syndromes. The study found that the sample with a greater level of any of the three indices BMI, WHR, or WC had higher levels of blood glucose, urate, mean BP, TG, insulin, and IGR. However, none of these three indices had a severe impact on the metabolic syndromes than any other. They concluded that the three indices could be considered equally good indicators of the various metabolic syndromes, especially in women. Al-isa (1999) found that obesity was directly associated with several chronic diseases including heart and lung disorders.

Assomi et al. (2005) conducted a study to evaluate and understand the levels of major risk factors for cardiovascular disease in the population of Surra, Kuwait. While the study found significantly higher level cardiovascular risks, including increased cholesterol and triglyceride levels, it also found that a major reason behind high cholesterol levels was greater BMI and family history of obesity. Additionally, obesity was a major risk factor in inducing non-insulin dependent diabetes among the sample groups. This obesity was basically acquired from family members (Abdella et al. 1998).

Metabolic syndrome, obesity, and overweight have been examined concurrently by some researchers. Al Rashdan and Nesef (2010) report that the adult Kuwaiti population has a high rates of metabolic syndrome, overweight, and obesity. In line with other literature discussed in this review, this study also reported higher rates of overweight and obesity in women at 82% compared to that in men at 78%. However, rates of metabolic syndrome were equally distributed among both male and female Kuwaiti adults at 36% in both.

Overweight and obesity have also been associated with glucose regulation impairment in young Kuwaiti adults. This is highlighted in the study Alattar et al. (2011) which indicates that out of a total 484 Kuwaiti adults with impaired glucose regulation, 50% of the population was overweight or obese. This indicates that glucose regulation impairment can be caused by overweight or obesity in individuals. An elevated waist circumference was also common in 42% of the total sample studied. Thus, the study concluded that increased waist circumference lead to impaired glucose regulation in a majority of the population.

Obesity and overweight are known to be associated with problems in pulmonary ventilatory function. Al-Bader et al.(2008) indicate that although BMI and waist-to-hip measurement ratio were not strong predictors of these problems, restrictive respiratory impairment occurred in cases where there was central adiposity as measured by high waist to hip ratio. The study also highlighted that an increase in obesity levels was a strong signal for increasing severity of restrictive respiratory impairment in the sample population.

To sum, the articles reviewed indicated that although the rates of obesity and overweight differ from one study to another, they have been increasing. Scholars suggest that a mean BMI of around $30kg/m^2$ prevails in the Kuwaiti population, making the majority of the population on the cusp of overweight or obesity. However, much bias exists in these calculations. For example, where some studies suggest that females have a higher obesity rate, others suggest this is true for males. A potential reason behind this bias may be the difference in size and characteristics of the sample. Obesity and overweight have also been found to prevail in the intermediate school students of Kuwait between the ages of 10 to 14. Risk factors such as low level of physical activity, low GPA, and family obesity are thought to be key causes of obesity.

There were major differences in age and marital status among samples used in different studies. This brings to light another key finding which relates to potential risk factors that may induce obesity or overweight: almost every study that considered risk factors indicated that marital status, age, education, family history of obesity, having an obese sibling or parent, low GPA, and lack of inactivity are key risk factors that may cause obesity and overweight. It has also been recognized that lack of physical activity and changes in food consumption lead to increases in obesity and overweight.

From the context of chronic diseases, evidence has been found for an association between cardiovascular problems and obesity occurring with high cholesterol levels. Impaired glucose regulation has also been highlighted as a major outcome of obesity and overweight. Additionally, restrictive respiratory impairment and metabolic syndrome have also been recognized to prevail in obese and overweight Kuwaiti adults. In this systematic review, the Kuwaiti population has been recognized to be at high risk of obesity and overweight in the near future. The overall prevalence of obesity in Kuwait has increased over time. This is a key concern for and calls for greater efforts to spread awareness about this condition to control it.

In this review, we have used meta-analysis to synthesize data across different obesity studies to determine if there are variations in results of various obesity studies in Kuwait and to identify a common effect.

2.5 Meta-Analysis: an Overview

2.5.1 Meta-analysis in Public Health

Meta-analysis involves statistical analysis of compiled results of different studies with the aim of combining the results (DerSimonian & Laird 1996). In recent years, meta-analysis has become very popular in medical/health research. It enables researchers to reach a conclusion (and thereby generate new knowledge) by aggregating and synthesizing findings from a range of clinical studies that have similar protocols.

Several authors have applied meta-analysis in the area of public health and obesity. Jin et al. (2014) applied meta-analysis to study the association between breastfeeding and childhood obesity. Another paper applying meta-analysis to study of obesity by Du et al.(2015) investigated the influence of fish oil on some parameters of body composition in overweight/obese adults. They and MacGregor (2009) conducted a meta-analysis of data from 28 studies to determine effects of modest salt reduction on blood pressure.

Patrick et al. (1994) also identified conditions in which biochemical evaluations of smoking increased or decreased assessments of smoking relative to self-reporting, utilizing 26 distributed reports. In Taylor et al. (2004), the adequacy of activity-based cardiovascular restoration in patients with coronary illness was investigated in light of 48 distributed clinical trials. DiCenso et al. (2002) re-examined 26 trials depicted in 22 distributed and unpublished reports on the adequacy of avoidance methodologies for deferring sexual activity, enhancing utilization of contraception, and lessening frequency of unintended pregnancy in young people. Thurnham et al. (2003) dissected information for groupings of plasma retinol and at least one intense stage protein from 15 investigations of evidently solid people to gauge effects of vitamin A deficiencies more precisely than previous studies.

Similar orderly search and meta-analysis were performed by Simmonds et al. (2015) to determine the capacity of straightforward measures of youth weight, for example BMI, to foresee future overweight in pre-adulthood and adulthood. Substantial related reviews, which measured overweight both in childhood, adolescence, and in adulthood, utilizing any perceived measure of overweight were searched for. Concentrate quality was evaluated. Studies were pooled utilizing analytic meta-investigation techniques. Fifteen related studies were incorporated into the meta-investigation. BMI was the main measure of weight d in all reviews, with follow-up of 200 777 individuals. Overweight children and adolescents were around five times more likely to be overweight in adulthood than those who were not overweight. Around 55% of overweight children are overweight in adolescence, around 80% of overweight adolescents will be overweight in adulthood and around 70% will be overweight once over age 30. Therefore, action is required to reduce overweight in these young people. In addition to these alarming results, 70% of overweight adults were not large in childhood or adolescence, so focusing on reducing excessive weight only in overweight children and adolescents is not the only action required to significantly decrease weight in all adults (Simmonds et al (2015)).

After systematic search, data from individual studies can be pooled and analysed afresh, using standardized methodology (Muir, 2001). This is called meta-analysis. The reason for a meta-analysis is that by aggregating the samples from the individual studies, the overall sample size is increased, improving the accuracy of results.

Meta-analysis is a two phase process (Deeks 2001). The principal stage involves calculation of impact of factors within a 95% confidence interval (CI) for each individual study. Parameters normally used to measure impact of factors incorporate chances proportions (OR), relative dangers (RR), and hazard contrasts. The second stage of meta-analysis ascertains the impact of factors as a weighted norm of the individual results. It is important to note that in meta-analysis, information from the individual studies is not just combined as if for a single study. Larger weights are given to results of studies with larger sample sizes, since these studies are more likely to find the true effects" of factors. These weights are frequently the opposite of the error term (the square of the standard error) of the effects of factors, which is closely associated with the estimate of the effect size. The results of a meta-analysis are usually displayed as a "forest plot" (Lewis, 2001).

2.5.2 Summary of Basic Statistics

Table 2. 2: Basic summary of the 18 papers used in this meta-analysis

	Study	Year of Publication	Event	Sample Size (Indivi-duals)	Effect Size	Mean Age	Minimum Age in Sample
1	Al-Isa	1997	306	3435	0.089	36.24330357	18
2	Abdella et al.	1998	1274	3003	0.424	43.14343891	20
3	Al-Isa	1999	479	842	0.568	20.79572447	15
4	Olusi et al.	2003	1789	7609	0.235	34.18461538	15
5	Al-Asi	2003	900	3282	0.274	40.63893967	25
6	Al-Shayji &Akanji	2004	36	177	0.2	29.7	18
7	Assomi et al.	2005	264	600	0.44	48.02631579	30
8	Al-Kandari	2006	158	424	0.372	38.83529412	20
9	Al-Kandari et al.	2008	25	202	0.119	21.7	17
10	Al-Bader et al.	2008	114	380	0.3	40.51	20
11	Babusik & Duris	2010	144	280	0.5142	44	18
12	Al-Rashdan & Nesef	2010	1088	2290	0.475	41.91312384	20
13	Zaghloul et al.	2012	453	1049	0.431	31.77670188	3
14	Badr et al.	2012	1124	2443	0.46	64.3	50
15	Alattar et al.	2012	96	484	0.198	20.3	17
16	Ahmed et al.	2012	12279	38611	0.318	36.20521354	20
17	Al-Isa et al.	2013	92	464	0.198	41.9612069	20
18	Musaiger et al.	2014	184	530	0.347	21.05	19

2.5.3 Meta-analysis

Meta-analysis approaches necessitate the finding of a common measure to be combined across studies. The standard deviation must be estimated as well as the samples sizes if not reported. A meta-analysis is performed by identifying a common measure of effect size, which is modelled by means of meta-regressions. The results found from aggregated studies, controlled for study features, are stronger approximations of the actual effect size than results based on one study (Chen and Peace, 2011). The comparative function could be the difference between means or the difference between percentages if data is binary or dichotomous. For binary data, the log-relative risk and the odds ratio are also comparative measures of effect size. If the treatment effect size is denoted by θ, a basic goal of a meta-analysis is to find whether $\theta$is significant. This is done by testing the set of hypotheses given as:

H_0: $\theta = 0$ (effect size is not significant) vs

H_1: $\theta \neq 0$ (effect size is significant)

The two main approaches to meta-analysis are 1) fixed-effect model; and 2) random-effects model (Schwarzer et al 2014). The aim of fixed-effect models is to make a conditional inference strictly regarding the k studies that are part of the meta-analysis (Hedges and Vevea 1998). Random/mixed-effects models, unlike fixed-effect models, provide unconditional inference about a set of studies. These methods assume that the k studies are a random sample (Hedges and Vevea 1998). The larger set of studies is not typically assumed to only include studies that have been conducted; instead, this larger set envisions a hypothetical population of studies made up of previous studies, future studies, or studies that may have been done.

The question that the random-effects model attempts to answer is what is the size of the average true effect in this larger population of studies (i.e. how large is μ)? Most meta-analyses are performed using studies that have not adopted precisely identical methods, and/or the included samples are also different. This type of heterogeneity is dealt with using the random effects model, given by data sets that do not use exactly the same methods and/or have exactly the same characteristics in the included samples.

The two models described above form the basis for most meta-analyses. Following Viechtbauer (2010), assume that there are $i = 1, \ldots, k$ independent effect size estimates, which each estimate a corresponding (true) effect size. Then, the fixed effects model is:

$$y_i = \theta_i + e_i, \qquad (1).$$

where y_i denotes the observed effect in the i-th study, θ_i the corresponding (unknown) true effect, e_i is the sampling error, and $e_i \sim N(0, v_i)$. The y_i are unbiased and normally distributed estimates of their corresponding true effects. The sampling variances (i.e. v_i values) are assumed to be known. Depending on the outcome measure used, a bias correction, normalizing, and/or variance stabilizing transformation may be necessary to ensure that these assumptions are (approximately) true. Following Normand (1999), given values of v_i, the expression for estimating the true effect size is:

$$\hat{\theta}_i = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i}$$

with $W_i = \frac{1}{v_i}$.

The fixed-effect model (equation (1)) assumes that the k study-specific summary statistics share a common mean θ. A statistical test for the homogeneity of study means is equivalent to testing:

$$\text{H}_0\text{: } \theta = \theta_1 = \theta_2 = \cdots = \theta_k \text{ against}$$

$$\text{H}_1\text{: At least one } \theta_i \text{ is different.}$$

Under H_0, for large sample sizes, $Q_W = \sum_i^k W_i(Y_i - \hat{\theta})^2 \sim \chi^2_{k-1}$. If Q_W is greater than the $100(1-\alpha)$ percentile of the χ^2_{k-1} distribution, then the hypothesis of equal means, H_0, would be rejected at the 100 % level. If H_0 is rejected, the meta-analyst may conclude the study means originated from a couple of individuals that are distinct and continue by either trying to identify covariates of studies of individuals that are homogeneous or estimating a random-effects model. If H_0 cannot be rejected, the investigator would conclude that the k studies share a common mean, θ, and estimate θ using $\hat{\theta}$.

In the random effects model, the formulation is similar to that of the fixed effects model, except the true effect size (Viechtbauer (2010)) is expressed as:

$$\theta = \mu + u_i \ ,$$

where $u_i \sim N(0, \tau^2)$. Thus, the true effects are considered normally distributed with mean 0 and variance τ^2. The aim is to estimate μ and the average true effect as well as τ^2, which is the aggregated heterogeneity within the true effects. When $\tau^2 = 0$, it indicates homogeneity among true effects (such as $\theta_i = \cdots . = \theta_k \equiv \theta$), thus $\mu = \theta$ indicates the true effect. If τ^2 is known, then the MLE of θ is given by:

$$\hat{\theta}(\tau) = \frac{\sum_{i=1}^k W_i(\tau) Y_i}{\sum_{i=1}^k W_i(\tau)}, \quad \text{Normand S.L (1999)}$$

$$\text{with } W_i(\tau) = \frac{1}{v_i + \tau^2}.$$

However, in the more realistic case of an unknown τ, a popular method of estimation that is usually employed is the restricted maximum likelihood (REML). The REML estimate of τ^2 is the solution to:

$$\hat{\tau}^2 = \frac{\sum_i W_i^2(\hat{\tau})\left(\frac{k}{k-1}\left(Y_i - \hat{\theta}_R\right)^2 - s_i^2\right)}{\sum_i W_i^2(\hat{\tau})}$$ Normand S.L. (1999)

The estimator for the population mean effect size is then calculated as:

$$\hat{\theta}_R(\hat{\tau}) = \frac{\sum_{i=1}^{k} W_i(\hat{\tau}) Y_i}{\sum_{i=1}^{k} W_i(\hat{\tau})}$$ Normand S.L. (1999)

In this study, since the included studies have not adopted exactly identical methods, and the included samples are also different, to address the heterogeneity, the meta-analysis uses the random effects model.

Chapter 3: Methods

3.1 Updated Systematic Review

The present study carried out a systematic review and analysis of obesity research in Kuwait to summarize and synthesize the research to date and to be able to draw conclusions from the body of research as a whole. Roberts and Petticrew (2006) stated that a systematic review extensively identifies, assesses, and synthesizes the important studies on a topic. A systematic review is applicable to research where the effects of the factors in question are not certain.

Robert and Petticrew (2006) compiled seven important steps for systematic reviews:

1. Define which studies will be included to make the study complete;
2. clearly define the research question or hypothesis;
3. carry out a comprehensive literature review to locate studies to include;
4. assess and screen the identified studies by assessing whether they meet the inclusion criteria or if they need additional analysis;
5. critically appraise studies to be included in the systematic review;
6. synthesize the studies and assess for homogeneity; and
7. Interpret the results of the review.

This review was written in compliance with the recommended format stated by the Campbell Collaboration (2001), which is the most commonly used and most recognized in the field of social sciences (Copper & Hedges 2009). This protocol includes a cover page, objectives, methods, background, criteria for including or excluding studies, criteria for determining independent findings, explicit description of methods implemented in the component studies, strategy used when identifying relevant studies, detailed study coding categories, statistical conventions and procedures, time frame, plans for updating the review, treatment of qualitative research, tables, acknowledgment, statement announcing any conflict of interest, and references.

3.1.1 Formulation of Problem

The primary objective of this study is to conduct a comprehensive and inclusive review of research on obesity in Kuwait by combining data from various studies using meta-analysis.

In addition, this study investigates important obesity risk factors related to lifestyle and socio-cultural factors. To achieve this objective, the following research question will be investigated: Are there variations in the results of various obesity studies in Kuwait?

3.1.2 Description of Primary Research Methods

Assessment of each individual study is necessary for such a study on obesity rates (BMI ≥ 30). For instance, a study was carried out by Zaghloul et al. (2012) and Al-Isa (1997) investigating demographic profiles of people with obesity and overweight in Kuwait. A similar study conducted by Zaghloul et al. (2012) reported higher rates of obesity and overweight in Kuwaiti women than men. Moreover, some studies investigated risk factors of obesity in the Kuwaiti population (Al-Kandari 2006; Ghazali et al. 2010 and Ahmed, et al. 2012).

3.1.3 Strategy for Identifying Relevant Studies.

It is paramount that in meta-analysis and systematic reviews, a systematic approach is used when carrying out the literature search, in an effort to make use of both studies that are published and those that are not. Wilson and Lipsey (2001) stated that inappropriate exclusion will probably result in increased bias in effect size.

The criteria for inclusion in the meta-analysis of the 18 papers in table 3.1 below were: clear publication date, adequate information on the central topic needed to compute effect sizes, adequate substantiated evidence, use of only clinically measured indices and no self-reported weights, heights, or BMIs, and absence of presentation of results overlapping with those of other included studies. Only articles with publication dates from 1990 to 2014 were included in this review.

The procedure below was used to identify studies for this review and meta-analysis:

Literature Search Key Words:

A comprehensive search for studies was done on the key word combinations “Obesity in Kuwait”, “Obesity AND Overweight in Kuwait”, “Obesity in Adults in Kuwait”, and “Obesity AND Risk Factors”.

Electronic Databases

The electronic databases searched were PubMed and Health technology assessment database.

Manual Searching

Hindawi Publishing Corporation Journal of Obesity, Oxford Journal of Occupational Medicine, Elsevier Diabetic Research and Clinical Practice, and Psychiatric Services Journal were manually searched for relevant studies.

Internet Searching

When searches were conducted using yahoo.com, google.com, and googlescholar.com, the same key word combinations were used as for searching the electronic databases above.

Reference Lists

Reference lists of studies identified for this review, were checked for other meta-analyses, and related studies were checked for sources for additional important data.

A detailed record of study inclusion procedures was kept on all searches together with:

- Period of time searched;
- Databases searched;
- Search engines used;
- Number of hits obtained for each search;
- Total time used for searching;
- Key word combinations used;
- Professionals that were contacted; and
- Professional organizations that were contacted.

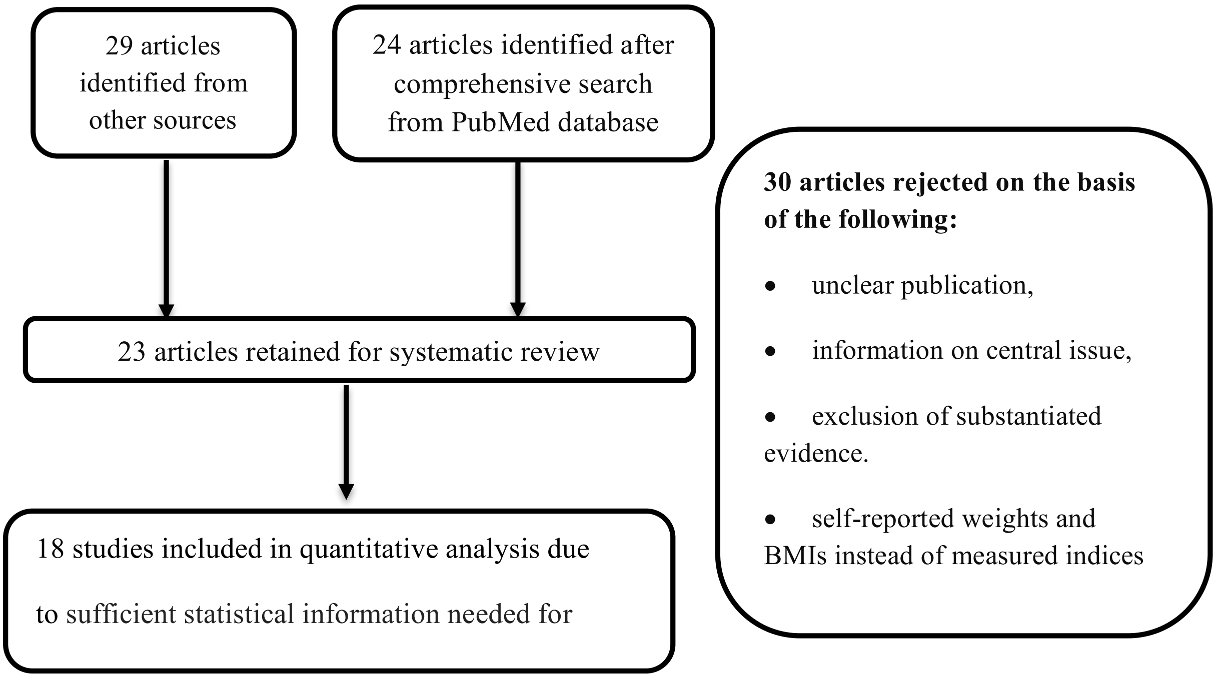

Figure 3. 1: Flow chart of articles identification and selection.

Table 3. 1: Details of studies on adult obesity epidemiology.

S/N	Authors	Population	Sample Size	Effect Size
1.	Musaiger et al. (2014)	Students aged 19 - 26	530	34.7%
2.	Ahmed et al. (2012).	Adults aged 20 - 69 (approximately 600,000)	38611	25.6% - 38.6%
3.	Alattar et al. (2012)	College students aged 17 - 24	484	19.8%
4.	Badr et al. (2012)	Kuwaitis aged 50 or older	2443	46%
5.	Zaghloul et al (2012)	Kuwaiti adults	1049	43.1%
6.	Al-Isa et al (2011)	Kuwaiti adult men age 20 or older	464	19.8%

7.	Al-Rashdan & Nesef (2010)	Kuwaiti adults	2290	47.5%
8.	Babusik & Duris (2010)	Arab and South Asian Adults in Kuwait	280	51.42%
9.	Al-Bader et al. (2008)	Kuwaiti adults	380	30%
10.	Al-Kandari et al. (2008)	Kuwaiti high school graduates aged 17 - 25	202	11.9%
11.	Al-Kandari (2006)	Kuwaiti adults aged 21—77	424	37.2%
12.	Assomi et al. (2005)	Kuwaiti adults aged30 or older	600	44%
13.	Al-Shayji &Akanji (2004)	Kuwaitis aged 18 - 50	177	20%
14.	Al-Asi (2003)	Kuwait Oil company employees	3282	27.4%
15.	Olusi et al. (2003)	Kuwaitis aged 15 or older	7609	23.5%
16.	Al-Isa (1999)	Kuwaiti university students	842	8.9%
17.	Al-Kandari et al. (2008)	Kuwaiti adults aged 20 or older	3003	42.4%
18.	Al-Isa (1997)	Kuwaiti adults	3435	56.8%

It is important to note that of the 18 papers included in the review by Karageorgi et al. (2013), one paper by Al Orifan et al. (2007) was removed due to insufficient information required to calculate effect size. Another paper by Musaiger et al. (2014) was added in the present study, making 18 papers in total in the meta-analysis.

3.1.4 Criteria for Determining the Independence of Findings

When evaluating a single study presenting data on multiple research questions for this review, the description of the methodology used is important to know if the results are produced from related or independent data. Non-independence can happen when data is collected at several points in time from the same samples or when categories evaluated within the sample overlap. In situations like this, their results are evaluated for this review based only on identical samples where there are non-independent estimates of the effects of factors or treatment (Campbell Collaboration 2001).

3.2 Review of Studies Included in the Meta-Analysis

In this section, we present a brief review for each of the 18 papers included in this study.

Al-Isa (1997) carried out a study on changes in obesity rates among adult Kuwaitis, the objective of which was to compare changes in BMI, in particular overweight (BMI > 25kg/m^2) and obesity (BMI > 30kg/m^2), between two periods of time. Rates of obesity and overweight, as measured by BMI, drastically increased between the two periods 1980-1981 and 1993-1994, probably as a result of the effects of affluence, including increased food intake, lifestyles changes, and modernization. The rate at which these changes occurred appeared to be greater in Kuwait than in other countries to which it was compared.

Olusi et al. (2003) published a study on rates of cardio-vascular disease among Kuwaitis over fifteen years of age, employing a baseline population survey. It was found that both adult females and males have high risk factors for cardio-vascular disease, so they should attract equal attention in future programs to forestall related deaths in Kuwaitis.

Babusik et al. (2009) examined overweight and its relationship to some metabolic risk factors of arterial sclerosis in expatriate Arab and South Asian adults living in Kuwait. It was discovered that levels of body fat in the two populations were different. Additionally, abdominal fat carries a different risk for cardio-vascular disease in these two ethnically distinct populations in Kuwait.

Zaghloul et al. (2012) published a study on evidence of an association between changes in nutrition in Kuwait, specifically excessive consumption of macronutrients, and obesity. It matched nutrient intake and rates of overweight and obesity across a stratified sample of Kuwaitis with reference values. It found that adult obesity rates were higher in females than males (i.e. 50% for 19–50 year old females and 70% for those over 51, and 29% and 42% for the corresponding male groups). In children, male obesity exceeded that of females, with the highest rate of obesity among 9–13 year olds (37% for males and 24% for females). Kilojoule consumption exceeded calculable energy needs for about half of Kuwaiti children and about a third of adults. These calculable energy needs were exceeded by 78–100% through intake of macromolecules. The majority of males aged 4 years and above exceeded the tolerable intake of heavy metals.

Al-Isa et al. (2013) conducted a study on factors related to overweight and obesity in adult Kuwaiti males. Logistical multivariate analysis of strongly related factors revealed that factors which contributed to higher risk of overweight and obesity included higher age, having an overweight sibling or parent, lower GPA, low physical activity levels, and bad health. Higher income and related fatigue were factors in obesity. Also, genetic history predicts overweight and obesity in adult male Kuwaitis.

Al-Kandari et al. (2008) published a study of improvements to lifestyle and effects on BMI in Kuwaiti nursing students. Results showed a relationship between socio-demographic variables, especially nationality, marital status, and age, with lifestyle. A strong association was established between the nutrition subcategory and therefore the overall walker's health promoting style Profile and BMI.

Abdella et al. (1998) additionally conducted a study on rates of non-insulin dependent polygenic disease and related risk factors in Kuwaiti adults. The rate of ketoacidosis-resistant diabetes mellitus was 14.8% (in both males and females, separately and combined). Obesity was found to be a major risk factor for this disease. Only 5.7 % (95% confidence interval 4.4–7.0) of adults had this disease at a relatively young age, from 20–39 years of age, whereas 18% (95% confidence intervals 16.1–20.6) of older adults, from 40–59 had it.

A study by Naser Al-Isa (1999) on the obesity rate in students of Kuwait University, found that important factors related to obesity included legal status, gender, age, diet, obesity in siblings, year of study, last scrutiny, regularity of meals, high school grades, and variety of siblings. Logistical multivariate analysis revealed that factors contributed considerably to obesity levels. The obesity rate in Kuwait University students is high. This might be a risk factor for many chronic diseases.

Badr et al. (2012) carried out a study on obesity rates along with its correlates and co-morbidities in Kuwaitis of 50 years of age or over. thein this study, 46% of participants were obese and 81% were overweight. The mean BMI of males was 28.1 and of females was 31.2. Kuwaitis of 50-59 years of age were less likely to be overweight than those of 70 years of age or over. Females were 3.6 more likely to be obese than men. Married people were 2.3 times more likely to be overweight or obese than the unmarried. Obesity and overweight were strongly positively correlated with high blood pressure (OR = 1.3 and 1.9 respectively), degenerative joint disease (OR = 1.8 and 1.6 respectively) and polygenic disease (OR = 1.4). They concluded that rates of overweight and obesity are very high in older Kuwaitis.

Al-Shayji et al. (2004) published a paper on obesity indices and its association with metabolic syndrome in young adult Arabs. In females, the BMI, Waist-to-Hip Ratio (WHR), and Waist Circumference (WC) were equally useful for identifying people at high risk of endocrine resistance (IR) and Atherogenic Dyslipidaemia (AD). However, in males, these indices indicated the risk of IR to a satisfactory degree but not AD.

Al-Asi (2003) conducted a study on overweight and obesity in Kuwaiti company staff. Rates of overweight and obesity for males were higher (79%) than for females (56%). The sphere employees had the next highest levels of overweight and obesity (78%) and worse inactivity (65%) than workplace employees (72% and 56, severally).

Al Kandari (2005) found a relationship between obesity in adult Kuwaitis and a number of cognitive content variables. Compared with some previous studies, there had been a rise in obesity rates in Kuwait.

Al-Rashidan et al (2010) found that overweight, obesity, and metabolic syndrome rates in Kuwaiti adults were 80.4%, 47.5%, and 36.2%, respectively. The rates of obesity and overweight of females at 81.9% and 53% respectively exceeded those of males at 78% and 39.2% respectively.

Alattar et al. (2010) did a study on rates of diminished glucose regulation in Kuwaiti adults with no related symptoms. They found that Kuwaiti youths have a high rates of overweight/obesity and of diminished glucose regulation and that an appropriate indicator of diminished glucose regulation in Kuwait youth is waist circumference but not BMI. They reasoned that in adult Kuwaiti females and males, increases in body fat were associated with a prohibitive effect on pulmonary breathing.

Bader et al. (2007) studied obesity and pulmonary ventilator functions in Kuwaiti adults, with 180 females and 200 males of 20–65 years of age observed in six medical centers between April 2004 and March 2006. They concluded that in both females and males, elevated body fat was related with a restriction of pulmonary ventilation.

Musaiger et al. (2014) examined rates of overweight and obesity in youths of seven Arab Kuwaiti states. They found that overweight and obesity rates were higher in males than in females at 34.8% and 20.6% respectively.

3.3 Statistical Conventions and Procedures

Statistical conventions and procedures consist of allowances for missing data, subgroup analysis, moderating analysis, calculating effect size, evaluating heterogeneity, sensitivity analysis, assessing publication bias, and discussion of software used to gather data in the analysis and review. First, the standard statistical terminology used is explained below, introducing the statistical procedures used in this technique.

3.3.1 Basics of Meta-Analysis

Effect size

The first step of a meta-analysis is to measure the effect size of the variables of interest (Cooper & Amp; Hedges 2009) which is a measure of the accuracy of the results of the study. Its computation depends on three key factors:

1. Measures of effects of variables found by the study;
2. Types of studies being reviewed; and
3. Applied statistical analyses that are reportable (Lipsey & Amp , Wilson 2001).

The metric used for the computation of effect sizes for this review is *Hedges' g*, because it includes an inherent correction for bias in tiny sample sizes (Borenstein et al. 2009; Cooper & Amp ; Hedges 2009). The standardized mean distinction, or d-index, is a control size that expresses the distinction between the means of two groups, notably between a divided cluster and an external cluster variable (Card, in press; Cooper & Amp ; Hedges 2009).

Assessing Heterogeneity

An important step in meta-analysis is assessment of the degree to which effect sizes disagree with each other (Petticrew & Roberts 2006). Statistical tests on effect sizes are used to evaluate whether inconsistencies in estimated effect sizes are larger than expected due to sampling variation. Homogeneity is accounted for when variability in estimated effect size is not larger than expected due to sampling error. This statistical assessment uses a chi-square test of hypothesis for homogeneity of effect sizes, Cochrane's letter of the alphabet datum, to determine if the results are consistent (Kulinskaya et al. 2008). If the null hypothesis is not rejected, then the associated test statistic approximately follows a chi-square distribution with degree of freedom equivalent to quantity of studies minus one, k-1. If the test statistic of the alphabet datum is critical, then heterogeneity is assumed. If the letter of the alphabet datum is found to be statistically insignificant, the effect sizes are considered homogeneous.

The random effect meta-analysis model is a technique for combining how effect sizes might be different from one another owing to both each sampling error and real variability in population variables (Cooper & Amp; Hedges 2009). The author of the current study foresaw that knowledge synthesis in this study would be based mostly upon a random results model, which can permit inferences of effect sizes to be made from the studied population.

Publication Bias

Evaluation of publication bias was based on a funnel plot to assess whether publication bias had any effect on the determined result. Consistent with Borenstein et al. (2009), the effect of bias should be insignificant if, once all the included studies are enclosed, the result size remains the same. Effects of bias are small if the result size changes, however, the main results stay basically identical. Effects of bias are significant if all included studies remain and therefore the result size or main results might be altered.

Sensitivity Analysis

Due to different manners in which decisions about selection, aggregation, and inclusion of data are made, there may be an effect on the main results, changing the manner of aggregation. Sensitivity analysis will explore this effect by excluding several categories of studies, which includes not publishing those of poor quality. In addition, the consistency of the results across subgroups may be examined. Without sensitivity analysis in meta-analysis, the reader must guess the likely effects of the main factors on the results.

Moderator Analysis

One can embody one or more additional study-level variables, normally known as moderators, in a meta-analysis model. The ensuing model may be a mixed effects model that will explain a minimum of a part of the heterogeneity within the true effects. This model is given by:

$$\theta_i = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_p x_{ip} + u_i,$$

where x_{ij} is employed to represents the value of the j-th moderator variable for the i-th study, assuming again that $u_i \sim N(0, \tau^2)$. Here, τ^2 represents the level of residual heterogeneity within the true effects. In other words, it represents the variability in the true effects which is not explained by the moderators enclosed within the model. The target of the moderator analysis is to see how much the model's moderators influence the dimensions of the typical true result.

Missing information

Sometimes, one might come across omitted information during a meta-analysis. That typically encountered may be missing studies, missing outcomes, missing outline information, and missing data points. Also, missing information may be missed randomly or not. Information square measure aforementioned to be 'missing at random' if the reason for being missing is not related to actual values of the missing information. Information square measure aforementioned to be 'not missing at random' if the reason for being missing is related to values of the particular missing information. Consistent with Higgins (2011), the approach used here for handling the missing information square measure was:

- Ignoring the missing information and analysing the accessible information only.
- Imputing the missing information with replacement values, and treating these as if they were determined. The replacement values may be the last observation carried forward, assumed outcomes, the mean, expected values from a multivariate analysis, etc.
- The missing information was imputed and for the actual fact that these that were imputed with uncertainty was accounted for;
- Mistreatment applied mathematics models to permit for missing information, creating assumptions concerning their relationships with the accessible information.

Two typically employed manners for the case of losing participants square measure is to assume that each missing individual expertise the result, or that not one of the missing individual expertise the result (Gould, 1980). The cut and fill advice augmentation technique described by Duval and Tweedie (2000a; 2000b) is frequently used to estimate the number of studies lost from a meta-analysis. This is because of the culling of any extreme results that are leading in a single section of the funnel plot. The cut and fill methodology will only be used in a fixed- or random-effects model (i.e. in models without moderators).

Software

A variety of software programs are helpful for running a meta-analysis. The first is the Statistical Analysis System (SAS), which provides approximations of mistreatment limited most likelihood estimate. MetaWin (Rosenberg et al. 2000) and Comprehensive Meta-Evaluation (Borenstein et al. 2005) square measure common company programs for meta-analysis. RevMan (Review Manager) is freely accessible from The Cochrane Collaboration (2008) and includes a whole toolset for making preparing and maintaining Cochrane reviews with functions for running meta-anlayses. Meta-present code programs may also do out evaluation. Join (Bax et al., 2006) and MetaEasy (Kontopantelis and Reeves, 2009) are square measure add-ins for meta-analysis and standout functions/macros are created reachable for Stata (StataCorp., 2007; for details, see Sterne 2009) and SPSS (SPSS opposition., 2006). Also, many meta-analysis programs also are accessible to augmentation using R (R Development Core Team, 2010), e.g., meta (Schwarzer, 2010), rmeta (Lumley, 2009) and trope (Viechtbauer, 2010). Metafor and the R Package Meta were used in this dissertation for all analyses.

3.3.2 Fixed versus Random Effects Models

Most meta-analyses rely upon random or fixed effects models. In the fixed effects model, we often assume that there is one accurate consequence size (hence the term fixed effect) that is the basis of each of the studies within the investigation, which all differentiations in driven effects square measure owing to sampling error. Whereas we often take when the action of occupation this a result that is set model, an added descriptive term would have been a typical consequence model. Either way, we often use the one (effect) after there is stand out the actual outcome.

By differentiation, below the random results model, we tend to allow that truth effect might fluctuate from study to contemplate. As an example, the result size could also be higher (or lower) in studies wherever the member's square measure undergone, or additional schooled, or additional advantageous than in others, or once an additional serious variation of mediation is used, etc. Since studies can distinction within the blends of members and within the executions of mediations, among completely different reasons, there may be various result sizes hidden distinctive studies. On the possibility that it had been conceivable to perform Associate in Nursing long range of studies into consideration the consideration criteria for our investigation), truth size of the result for these studies would be calculable. Within the studies performed, the result sizes were assumed to represent random samples that is where the term random effects emerged.

It is assumed in the fixed-effect model that all studies in the meta-analysis share a typical result size. Factors that could affect the magnitude of the effect size are identical in all studies. Hence, the sizes of the true effects are all the same (hence the label fixed). Theta (θ) is used to denote the true effect size (unknown).

Since all studies carried out share an equivalent true effect, it follows that the discovered effect size is different from one study to another solely owing to the random error inevitable in every study. If every study had an associate degree, infinitely large sample size, the sampling error would be zero, and therefore the determined result for every study would be identical because of the true result. If observed effects were plotted instead of true effects, the observed effects would specifically match the true effects.

Rather than starting with the population effect in an actual meta-analysis, and also projecting the observed effects, this work is done backwards by estimating the population effect and starting with the observed effects. To arrive at a more accurate estimate of the effect of the population (to minimize the variance), we add up the weighted means, and the study's variance is the inverse of the weight assigned to each study. The weight assigned to each of the studies in a fixed effects meta-analysis is:

$$W_i = \frac{1}{V_{Y_i}}$$, Normand S.L (1999)

where V_{Y_i} is the within-study variance for study (i). The weighted mean (M) is then calculated as

$$M = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i}$$, Normand S.L (1999)

the reciprocal of the sum of the weights estimates the variance of the summary effects, or

$$V_M = \frac{1}{\sum_{i=1}^{k} W_i},$$ Normand S.L (1999)

and the estimated standard error of all the total effect then equals the square root of the variance,

$$SE_M = \sqrt{V_M}$$

Then, 95% lower and upper limits for the summed effect are estimated as

$$LL_M = M - 1.96 \times SE_M$$

and

$$UL_M = M + 1.96 \times SE_M$$

Finally, a Z-value is calculated to test the null hypothesis that the common true effect θ is zero, which uses:

$$Z = \frac{M}{SE_M}$$

for a two-tailed test the *p-value* is:

$$p = 2\left[1 - \left(\Phi(|Z|)\right)\right]$$

where $\Phi(|Z|)$ is the standard normal cumulative distribution and p is probability obtained from the standard normal table.

Meanwhile, assuming we have a tendency to area unit performing on studies that assess the result of an instructional intervention. The magnitude of the result would possibly take issue that depends on the opposite resources that area unit on the market to the category size, the age, the kids and different factors that are probably to vary.

These covariates will not be accessed in every study. However, we would not have best known the covariates that are literally associated with the result size. Still, it is settled by the logic that such factors do exist and can result in variation in the magnitude of the result.

This variation will be self-addressed across studies is to hold out a random-effect meta-analysis in which it is assumed that true effects area unit distributed usually.

More typically, the obtained result $Y_i$for any study is given by the grand mean, the deviation of the study's true result from the grand mean, and the deviation of the study's obtained result from the study's true result. That is,

$$Y_i = \mu + \eta_i + \varepsilon_i \ .$$

Hence, to predict the way the obtained result Y_i is probably going to fall from μ in any given study, we need to think about the variance of each η_i and the variance of ε_i .

In a meta-analysis, instead of beginning with the population result and projecting towards the obtained effects, we have a tendency to start with the ascertained results and check out to estimate the population effect. In other words, our aim is to use the gathering of Y_i to estimate the entire mean, μ. So as to get the foremost correct estimation of the entire mean (to minimize the variance), we have a tendency to add up a weighted mean, wherever the burden appointed to every study is reciprocally proportional thereto of the study's variance.

To calculate a study's variance in the random-effects model, we need to understand each within-study variance and τ^2, since the study's total variance is the sum of those two values.

τ^2 is the between-study variance (the variance of the result size parameters across the study populations). That merely suggests that, if we have a tendency to somehow knew truth result size for every study, Associate in Nursing calculated the variance of those result sizes (across an infinite variety of studies), this variance would be τ^2. One technique for scheming τ^2 is the technique of moments (or the DerSimonian and Laird) method, as follows. We compute

$$T^2 = \frac{Q - df}{C}$$

Where

$$Q = \sum_{i=1}^{k} W_i Y_i^2 - \frac{\left(\sum_{i=1}^{k} W_i Y_i\right)^2}{\sum_{i=1}^{k} W_i} ,$$

$$df = k - 1 ,$$

$$C = \sum_{i=1}^{k} W_i - \frac{\sum_{i=1}^{k} W_i^2}{\sum_{i=1}^{k} W_i} .$$ Normand S.L (1999)

In the fixed-effect analysis, every study was weighted by the inverse of its variance. Within the random-effects analysis too, every study is weighted by the inverse of its variance. The distinction is that the variance currently includes the initial (within-study) variance and the estimate of the between-study variance, T^2. In the random-effects model, the weight applied to each study is:

$$W_i^* = \frac{1}{V_{Y_i}^*} ,$$

where $V^*_{Y_i}$ is the within-study variance for study i plus the between-study variance T^2. That is,

$$V^*_{Y_i} = V_{Y_i} + T^2.$$

The weighted mean, M^*, is then computed as

$$M^* = \frac{\sum_{i=1}^{k} W_i^*{}_i Y_i}{\sum_{i=1}^{k} W_i^*}$$. Normand S.L (1999)

The variance of the summary effect is calculated as the reciprocal of the sum of the weights, or

$$V_{M^*} = \frac{1}{\sum_{i=1}^{k} W_i^*},$$

and the estimated standard error of the summary effect is then the square root of the variance,

$$SE_{M^*} = \sqrt{V_{M^*}}$$. Normand S.L (1999)

Other estimates follow as in the case of fixed-effect models.

Chapter 4: Results

4.1 Introduction

This chapter presents the findings of this systematic review and meta-analysis of the available literature on obesity rates in Kuwait and their association with life style and socio-cultural factors. First, table 4.3 provides a summary of the 18 studies whose data is included in the meta-analysis. Criteria eligibility and inclusion of studies is summarized in section 4.2. Section 4.3 discusses the results of this meta-analysis. Finally, section 4.4 discusses publication bias as relevant to this review.

Table 4. 1: Information about each reviewed study by study domain.

Study Publication	Study design	Study Analysis	Study results
First author	Year of survey	Statistical methods	Sample size (percentage of males)
Publication year	Recruitment period	Statistical software	Age range and/or mean age
Author affiliation	Study design type		Ethnicity or nationality
Journal name	Eligibility criteria		Obesity prevalence and/or mean BMI
	Sampling source/frame		Obesity correlates and/or trend
	Sampling method		
	Response rate		
	Data collection method		
	Type of collected data		
	Obesity category		

4.2 Meta-Analysis Studies

4.2.1 Research Designs

Fifty-three studies met the primary inclusionary criteria of topic on obesity prevalence and its association with lifestyle and socio-cultural factors. Of these studies, thirty (57%) were adequate for the other requirements of the meta-analysis described in sections 3.1.3 and 3.1.4. Five (9%) of the studies were excluded from the meta-analysis due to insufficient information about statistical analyses required for calculating effect sizes. The remaining 18 (34%) studies were first used in the meta-analysis before subdivision into those that considered lifestyle and those that considered socio-cultural effects.

Table 4. 2: Study design of studies of Kuwaiti adult obesity epidemiology

Authors (Publication Year)	Year of Survey (Recruitment Period)	Study Design	Eligibility Criteria	Sample Size (% males) Age Range (Years)	Sampling Source/ Frame	Sampling Method (Response Rate)
Ahmed et al. (2012)	2002-2009 (96 months)	Cross-sectional	Kuwaitis of 20-69 years	6356 (43%) (20-69yrs)	National Nutrition Surveillance System.	Non-random: Volunteers attending registration for employment or pensions and Hajj Pilgrimage check-ups or accompanying children for immunizations
Al-Assomi et al. (2005)	2002-2003 (13 months)	Cross-sectional study	Kuwaitis over 30 years.	597 (41%) 30–70+ yrs Kuwaiti: 77% Non-Kuwaiti: 23%	Surra Family Practice Health Centre.	Non-random: volunteer Surra district residents that learned about study through posters, brochures, and two open days for raising awareness were given appointment for

						interview at the clinic (not stated).
Musaiger et al. (2014)	Not stated	Cross-sectional study	Kuwaitis of 19-26 years	530(43%) (19-26yrs)	Kuwaiti adults	Random Sampling of Kuwaiti adults
Alattar et al. (2012)	2009-2010 (not stated)	Cross-sectional study	Kuwaiti, young adults, no current acute infection, not pregnant or diabetic, no diabetes inducing drugs.	484 (36%) 17–24 yrs Kuwaiti	Students attending the Public College for Basic Education between March 2009 and January 2010.	Non-random: volunteer students that learned about study through flyer advertisement and/or informational lectures about study (not stated).
Al-Bader et al. (2008)	2004–2006 (2 years)	Cross-sectional study	Kuwaiti, adults, FEV1 > 80%, absence of smoking, pulmonary, cardiac, neurological, spine diseases.	380 (53%) 20–65 yrs Kuwaiti	Six medical centres covering all six governorate s in Kuwait.	Non-random: patient volunteers (not stated)
Al-Kandari et al. (2008)	2005 (one day	Cross-sectional study	Kuwait College of Nursing students.	202 (28%) 17–35 yrs Kuwaiti: 43% GCC: 29% Other Arab: 20% Non-Arab: 8.3%	All associate degree students enrolled in 2nd semester of 2004-5 (total of 350 students) at Kuwait College of Nursing.	Non-random: students in class on a specific day who agreed to participate (88%).

Al-Isa et al. (2013) 3	2 weeks 92	cross-sectional study 0	Kuwaiti, adults.2 .198 1 20	464 men		Non-random
Olusi et al. (2003)	2001 (9 months)	National cross-sectional survey (rheumatic disorders' prevalence survey)	Kuwaiti, adults > 15 yrs.	7,609 (52%) 15–84 yrs Kuwaiti	Kuwaiti households.	Randomly chosen households from all six governorates in Kuwait according to population size of each governorate. households visited by interviewer (not stated).
Al-Isa (1997)	1980-1981 (not stated) 1993-1994 (12 months)	1980: National cross-sectional survey (Nutrition Status Assessment of Adults Survey) 1993: Cross-sectional study	Kuwaiti, adults.	1980: 2,067 (43%) 18–≥60 yrs Kuwaiti 1993: 3,435 (50%) 18–≥60 yrs Kuwaiti	Primary health care clinics.	1980 sample: stratified random sampling of 17 primary health care clinics in 5 governorates. Sample stratified by gender according to population gender ratio (not stated). 1993 sample: volunteer patients and those accompanying the patients attending 6 randomly selected primary health care clinics in 5 governorates of Kuwait (85%)
Zaghloul et al. (2012)	2008-2009 (16 months)	National cross-sectional survey (National Nutrition Survey (NNS))	Kuwaiti.	1,049 (45%) 19–86 yrs	Kuwaiti households from all six governorates.	Multistage cluster sampling (53% households) stratified by age and gender based on 2005 national census data. Subjects asked to attend

						interview at one of seven primary health clinics at various districts (24% of individuals).
Babusik and Duris (2010)	2004–2007 (44 months)	Cross-sectional study	Arab or South Asian ethnicity, absence of medical condition or drugs affecting outcome/exposures	280 (64%) 18–69 yrs Arab: 51% South Asian: 49%	Al Rashid Private General Hospital.	Non-random: patient volunteers (not stated).
Al-Kandari et al. (2006)	Not stated (not stated)	Cross-sectional study	Kuwaiti, adults.	424 (50%) 21–77 yrs Kuwaiti	Primary health care clinics or home interviews.	Non-random opportunistic sample: volunteers from six governorates of Kuwait (not stated).
Abdella et al. (1998)	1995-1996 (9 months)	Cross-sectional study	Kuwaiti, >20 yrs.	3,003 (37%) 20–≥60 yrs Kuwaiti	Hawalli and Capital governorate.	Non-random: volunteer subjects that learned about study through a publicity campaign (newspaper, radio, TV, brochures, posters at homes, supermarkets and post offices) were asked to attend the primary health care center in their area of residence (response lower in men).

Al-Isa (1999)	1997 (5 days)	Cross-sectional study	Kuwait University students.	842 (46%) <18–≥23 yrs Not stated	All male and female students coming in the first 5 days of registration for the 1997 fall semester at Kuwait University.	Non-random: students coming in to register who volunteered to participate in study (85%).
Badr et al. (2012)	2005-2006 (20 months)	Cross-sectional study	Kuwaitis ≥50 yrs	2,443 (39%) 50–70+ Kuwaiti	Kuwaiti households in Ahmadi and Capital governorates	Multistage cluster sampling (78% of households). Households visited by interviewer (96% individuals).
Al-Shayji and Akanji (2004)	Not stated (not stated)	Cross-sectional study	Kuwaiti, <50 yrs, no prior chronic illness, not pregnant.	177 (41%) 18–50 yrs Kuwaiti	A wide section of Kuwaiti population.	Non-random: volunteers who found out study through advertisement (not stated).
Al-Asi (2003)	1999-2000 (18 months)	Cross-sectional study	Kuwait Oil Company employees.	3,282 (85%) Median age: 40 yrs Kuwaiti: 62% Non-Kuwaiti: 38%	All full-time employees due for their periodic medical examination between June 1999 and December 2000.	Non-random: full-time company employees due for their medical examination who agreed to participate (95%).
Al-Rashdan and Al-Nesef (2010)	2006 (not stated)	National cross-sectional survey (WHO STEPS survey)	Kuwaiti, 20–65 yrs.	2,280 (40%) 20–65 yrs Kuwaiti	Public Authority of Civil Information (PACI) database used to randomly select sample of participants	Stratified random sampling: individuals asked to attend participating primary health care clinic for interview (78%).

					across 5 governorates in Kuwait.	

Table 4. 3: More characteristics of studies included in the meta-analysis

S/N	Reference	Study design	Age	Sample Size	Obesity definition	Confounders
1.	Musaiger, et al. (2014)	CS	(19 - 26) years	530	BMI > 30	Eating habits, physical activity, gender, age
2.	Ahmed, et al. (2012).	CS	(20 - 69) years	38611	BMI ≥ 30	Age, gender, education.
3.	Alattar, et al. (2012)	CS	(17 - 24) years	484	BMI > 30	Glucose level, waist—hip circumference
4.	Badr, et al. (2012)	CS	≥ 50 years	2443	BMI ≥ 30	Age, years of education, marital status, income
5.	Zaghloul et al (2012)	CS	≥ 20 years	1049	BMI ≥ 30	Age, gender, nutrition.
6.	Al-Isa, et al (2011)	CS	≥ 20 years	464	BMI > 30	Hereditary, physical activity
7.	Al Rashdan&Nesef (2010)	CS	≥ 20 years	2290	BMI ≥ 30	Metabolic syndrome
8.	Babusik&Duris (2010)	CS	(18—69) years	280	BMI ≥ 30	Age, waist hip size
9.	Al-Bader, et al. (2008)	CS	≥ 20 years	380	BMI > 30	Respiratory impairment
10.	Al-Kandari et al. (2008)	CS	≥ 20 years	202	BMI ≥ 30	Health promoting life style
11.	Al-Kandari (2006)	CS	(21—77) years	424	BMI 31- 40	Age, education, socio-economic status, physical activity

12.	Al-Assomi et al. (2005)	CS	≥ 30 years	600	BMI > 30	Cholesterol level
13.	Al Shayji &Akanji (2004)	CS	(18—50) years	177	BMI > 30	Metabolic syndrome
14.	Al-Asi (2003)	CS	≥ 40 years	3282	BMI > 30	physical activity, diabetes, hypertension
15.	Olusi et al (2003)	CS	≥ 15 years	7609	BMI ≥ 30	Gender, coronary artery disease
16.	Al-Isa (1999)	ES	(18—30) years	842	BMI > 30	Age, marital status, more, Parental obesity, frequent meals taken
17.	Abdellah et al. (1998)	CS	(17 - 25) years	3003	BMI ≥ 30	Non-insulin dependent diabetes
18.	Al-Isa (1997)	CS	≥ 18 years	3435	BMI > 30	Education, Region, marital status, occupation.

****CS indicates Cross sectional study, ES indicates Exploratory study.*

The table 4.3 above summarizes relevant characteristics of papers used in this study for meta-analysis.

4.3 Meta-Analysis Results.

The eighteen studies eligible for the meta-analysis yielded a total sample size of 66105, ranging from 177 to 38611. Individual odds of obesity were extracted for each study. Table 4.4 presents the effect sizes found for each study as well as other information used for the meta-analysis.

4.3.1 Random and Fixed-Effect Models Based on the 18 studies

Two meta-analysis models (fixed and random) were fitted to ascertain the best model for the data obtained. Firstly, the fixed effects model was fitted. The effect size (odds) was estimated to be 0.4768 ($p < 0.0001$, 95% CI = 0.4689 to 0.4849). Also, the model produced AIC and BIC values of 1986.40 and 1987.29 respectively. However, the test for study heterogeneity showed significance ($Q = 2048.02$, d.f. = 17, $p < 0.0001$). This is an indication of substantial heterogeneity among the studies. A random effects model was therefore fitted to allow for between-study heterogeneity as well as within-study variability which produced AIC and BIC values of 40.56 and 42.23 respectively. The effect size estimated by the random effects model was 0.4601 ($p < 0.0001$, $\tau = 0.70$, 95% CI = 0.3319 to 0.6378). This is summarized in Table 4.6.

Table 4. 4: Chronological arrangement of odds of obesity studies in Kuwait and their effect sizes

Study	Year	Event	Sample Size	Effect Size	Age
Al-Isa	1997	306	3435	0.098	36.243
Abdella et al.	1998	1274	3003	0.737	43.143
Al-Isa	1999	479	842	1.320	20.796
Olusi et al.	2003	1789	7609	0.307	34.185
Al-Asi	2003	900	3282	0.378	40.639
Al-Shayji &Akanji	2004	36	177	0.255	29.700
Assomi et al.	2005	264	600	0.786	48.026
Al-Kandari	2006	158	424	0.594	38.835
Al-Kandari et al.	2008	25	202	0.141	21.700
Al-Bader et al.	2008	114	380	0.429	40.51
Babusik & Duris	2010	144	280	1.059	44.000
Al-Rashdan & Nesef	2010	1088	2290	0.905	41.913
Zaghloul et al.	2012	453	1049	0.760	64.300
Badr et al.	2012	1124	2443	0.852	20.300
Alattar et al.	2012	96	484	0.247	36.205
Ahmed et al.	2012	12279	38611	0.466	41.961
Al-Isa et al.	2013	92	464	0.247	31.777
Musaiger et al.	2014	184	530	0.532	21.050

Table 4. 5: Percentage contribution of each study to total heterogeneity among studies

Study	Year	Contribution (%)
Al-Isa	1997	2.02
Abdella et al.	1998	5.33
Al-Isa	1999	1.50
Olusi et al.	2003	9.94
Al-Asi	2003	4.74
Al-Shayji & Akanji	2004	0.21
Assomi et al.	2005	1.07
Al-Kandari	2006	0.72
Al-Kandari et al.	2008	0.16
Al-Bader et al.	2008	0.58
Babusik & Duris	2010	0.51
Al-Rashdan & Nesef	2010	4.15
Zaghloul et al.	2012	1.87
Badr et al.	2012	4.41
Alattar et al.	2012	0.56
Ahmed et al.	2012	60.82
Al-Isa et al.	2013	0.54
Musaiger et al.	2014	0.87

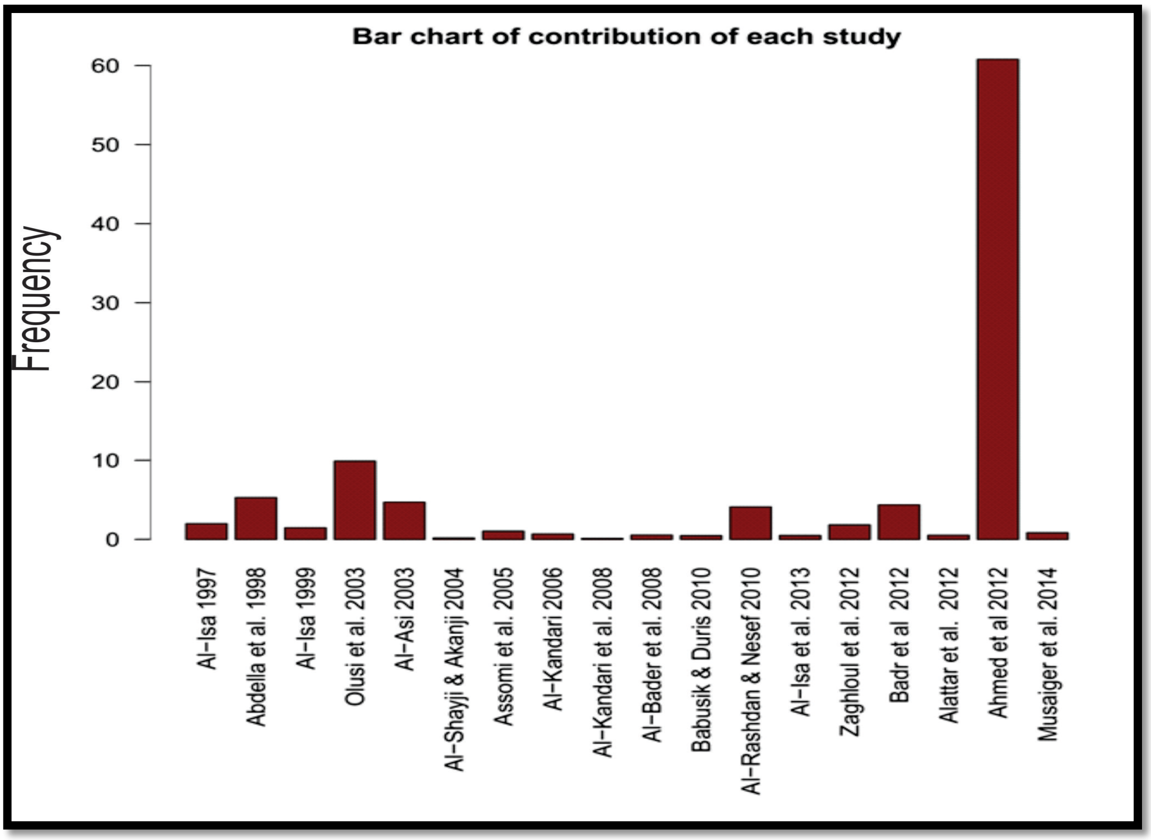

Figure 4. 1**:** Bar chart showing magnitude of heterogeneity contribution of each study

Table 4. 6: The summary of fixed and random effects model estimates based on the 18 papers

	Random Effect	Fixed Effect
Odds	0.4601	0.4768
95% Confidence Interval for odds	0.3319 - 0.6378	0.4689 - 0.4849
AIC	40.5626	1986.4046
BIC	42.2290	1987.2950

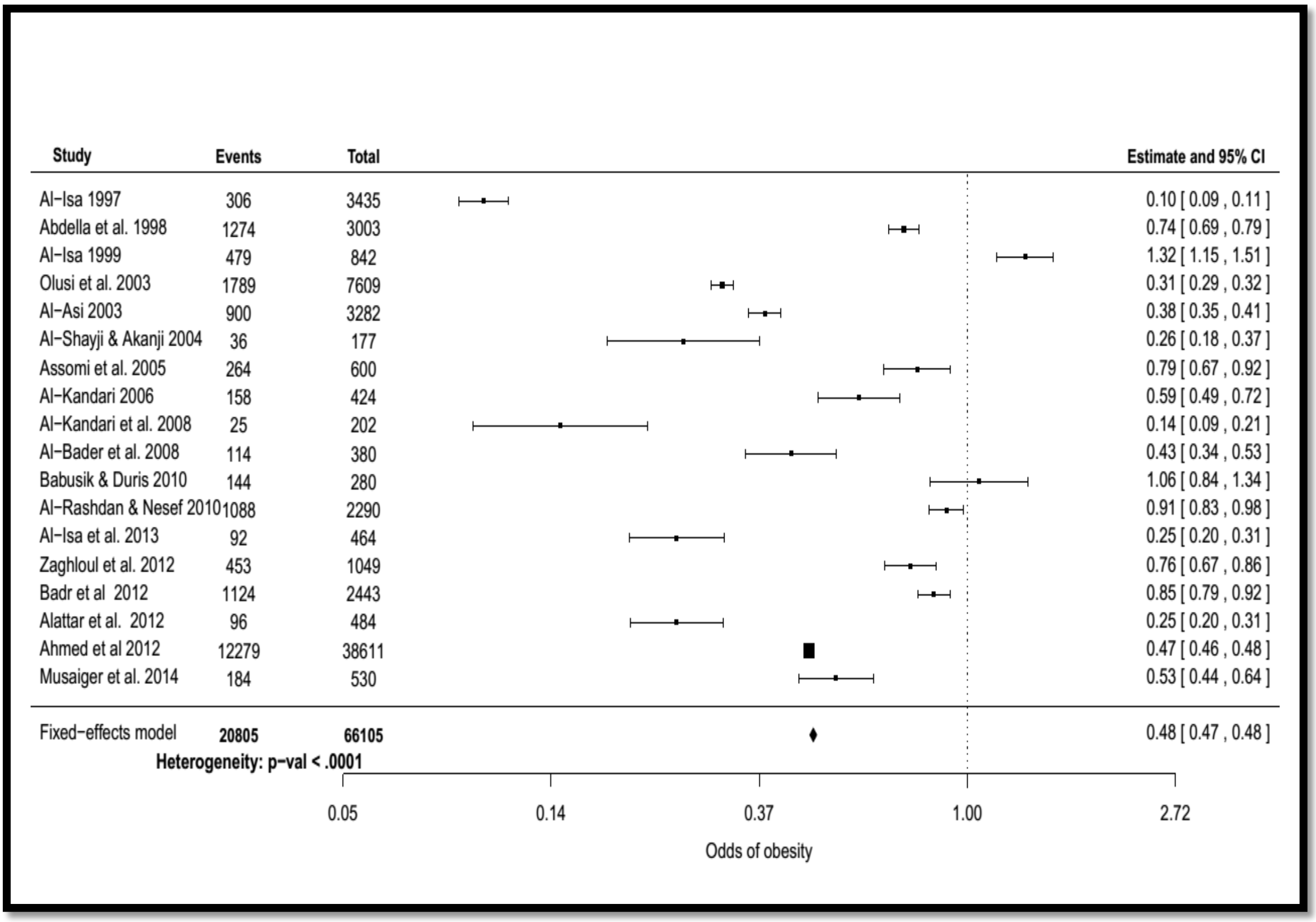

Figure 4. 2: Fixed effects model forest plot of odds of obesity in Kuwait. The rectangular symbols and superimposed horizontal lines represent the odds and corresponding 95% CI respectively for each study included in the meta-analysis. The size of the symbol is in proportion to the weight of the study. The diamond symbol represents overall odds of obesity, which is the pooled estimate of the odds of obesity.

From the forest plot displaying the odds of obesity obtained from the studies and the overall pooled odds given by the fixed effects model in figure 4.2, one can observe that the odds did not overlap but varied substantially. The pooled odds of being obese were 0.48, which was significantly different from 1, with the 95% confidence interval ranging from 0.47 to 0.48, which indicated that the odds of obesity were significantly different from zero. One study (Babusik and Duris 2010) produced odds not significantly different from 1. Two studies (Babusik and Duris 2010; Al-Isa 1999) produced odds significantly different from 1. However, only the odds reported by Al-Isa (1999) were significantly greater than 1. The target group in Al-Isa (1999) was different from those of the other studies in that the group consisted of University students. In the study, grade point average (G.P.A.) was found to be a significant factor associated with obesity. The study showed that lower G.P.A. was associated with a higher risk of obesity.

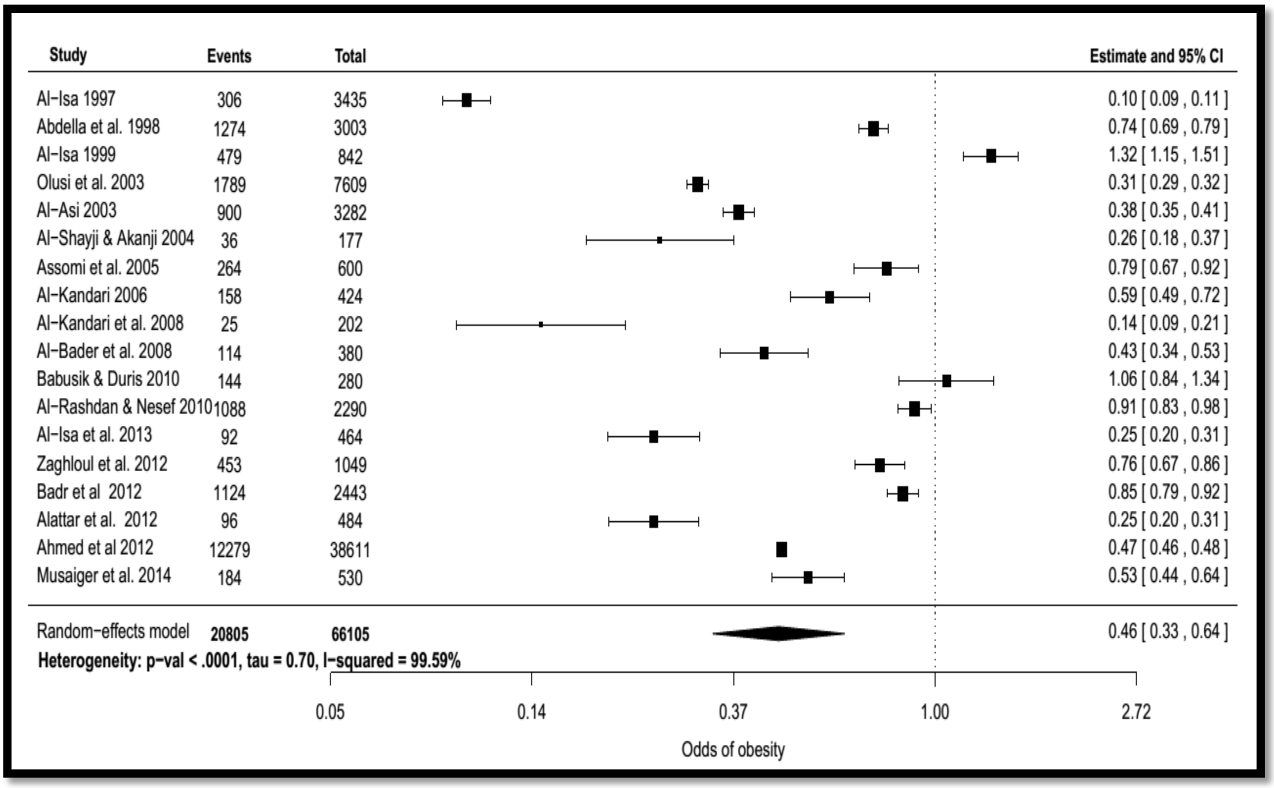

Figure 4.3: Random effects model forest plot of odds of obesity in Kuwait.

The forest plot in figure 4.3 displaying the odds of obesity as obtained from the studies and the overall pooled odds given by the random effects model depicts results that are very similar to those of the fixed effects model shown in figure 4.2. However, the confidence intervals here were wider. The pooled odds of being obese were 0.46, still significantly different from 1. Only one study (Babusik and Duris 2010) produced odds that were not significantly different from 1. In this model, the odds in Al-Isa (1999) were still significantly more than 1.

4.3.2 Fixed and Random Effects Models Based on Random Sampling

Here were considered studies conducted using random sampling. Two meta-analysis models (fixed and random) were fitted to ascertain the best model for the data obtained. Firstly, the fixed effects model was fitted. The effect size (odds) was estimated to be 0.44 ($p < 0.0001$, 95% CI = 0.43 to 0.46). The model produced AIC and BIC values of 1449.9055 and 1449.8514 respectively. However, the test for study heterogeneity showed significance (Q = 1475.330, d.f. = 6, $p < 0.0001$) indicating substantial heterogeneity among studies. Due to this large heterogeneity, a random effects model was fitted to allow for between-study heterogeneity as well as within-study variability. The random effects model produced AIC and BIC values of 18.6016 and 18.1852 respectively. The effect size estimated by the random effects model was 0.42 ($p < 0.0001$, $\tau = 0.7003$, 95% CI = 0.23 to 0.77).

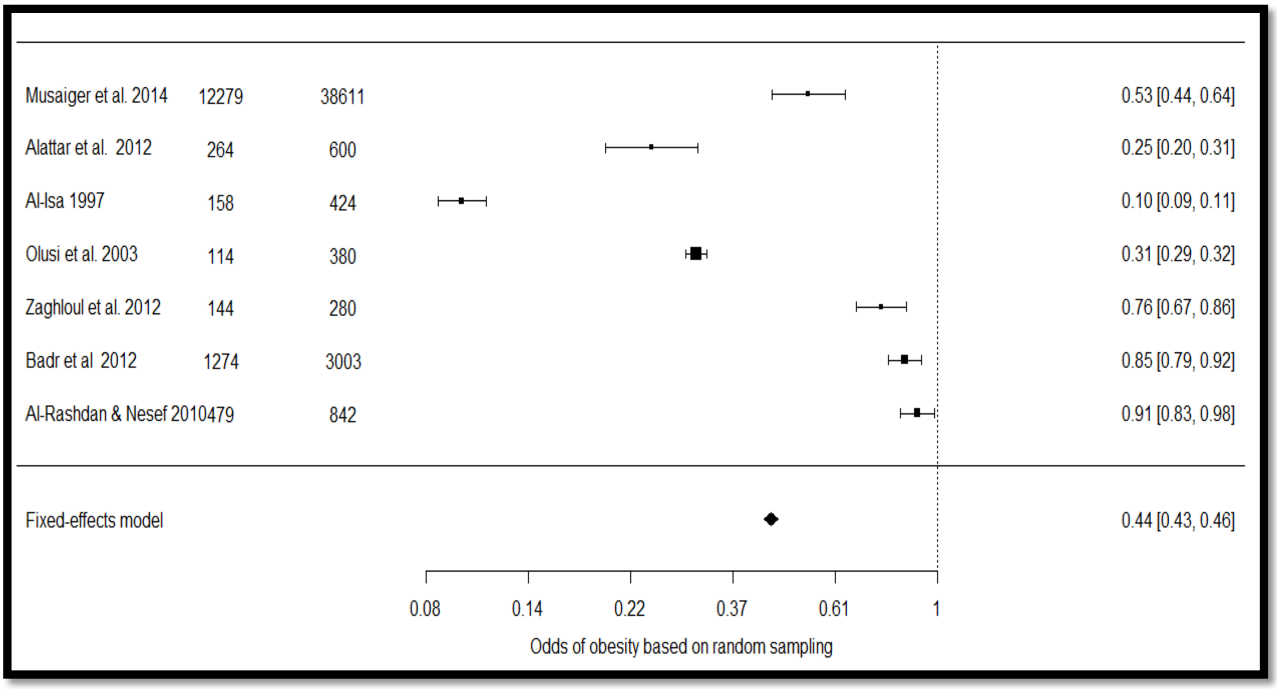

Figure 4. 4: Fixed effects model forest plot of odds of obesity in Kuwait based on random sampling. The rectangular symbols and the superimposed horizontal lines represent the odds and corresponding 95% CI respectively in all studies included in the meta-analysis. The size of the symbol is in proportion to the weight of the study. The diamond symbol represents the overall odds of obesity, which is the pooled estimate of the odds of obesity.

The forest plot displays the odds of obesity obtained from the studies where random sampling was used, with the overall pooled odds given by the fixed effects model shown in figure 4.4. As shown in the plot, the odds did not overlap but varied substantially. The pooled odds of obesity were 0.44, which was significantly different from 1 with the 95% confidence interval ranging from 0.43 to 0.46. This indicated that the odds ratio of obesity was significantly different from zero.

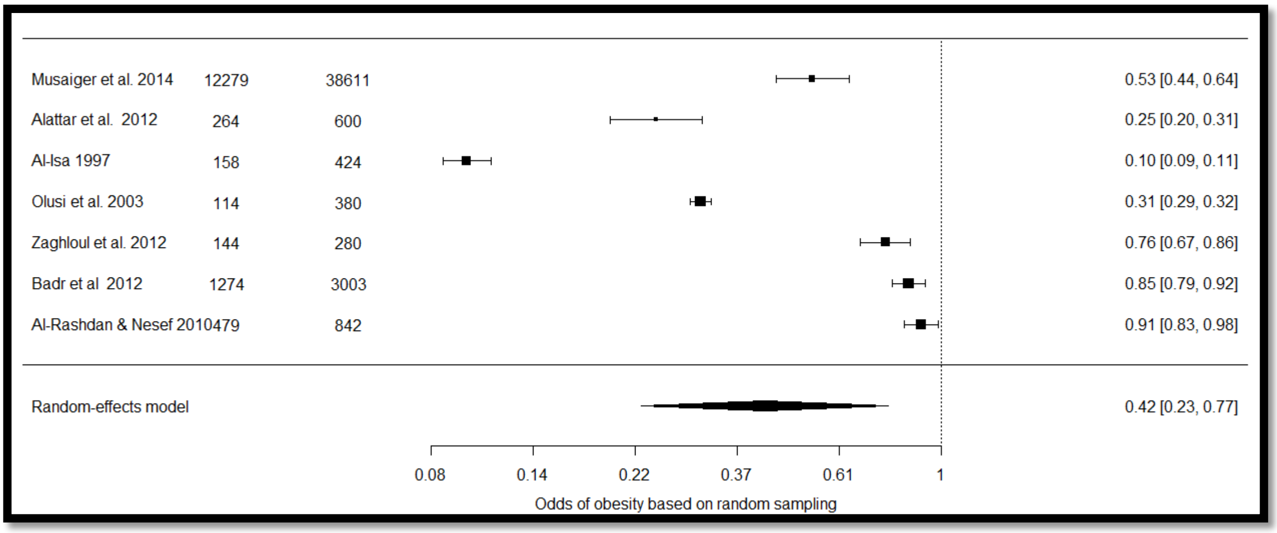

Figure 4. 5: Random effects model forest plot of odds of obesity in Kuwait based on Random Sampling.

Figure 4.5 is a forest plot displaying the odds of obesity as obtained from the studies that used random sampling and the overall pooled odds given by the random effects model. The plot depicts results that were very similar to those of the fixed effects model shown in figure 4.4. However, the confidence intervals here were wider.

The overall estimates of odds of obesity from the fixed and random effects models were 0.44 and 0.42 respectively. This indicates that the odds of obesity were approximately 0.4. That is, the chance of a Kuwaiti being obese was a bit lower than the chance of not being obese.

Table 4. 7: The summary of fixed and random effect model estimates based on random sampling

	Random Effect	Fixed Effect
Odd	0.42	0.44
95% Confidence Interval	0.23- 0.77	0.43 - 0.46
AIC	18.6016	1449.9055
BIC	18.1852	1449.8514

4.3.3 Fixed and Random Effect Model Based on Age

Data from the studies were further sub-divided based on age category, with young ≤30 years of age and old >30. Four studies belonged to the young category, whereas the old category consisted of only three studies. Both fixed and random effects models were used to estimate odds of obesity for each category (old and young).

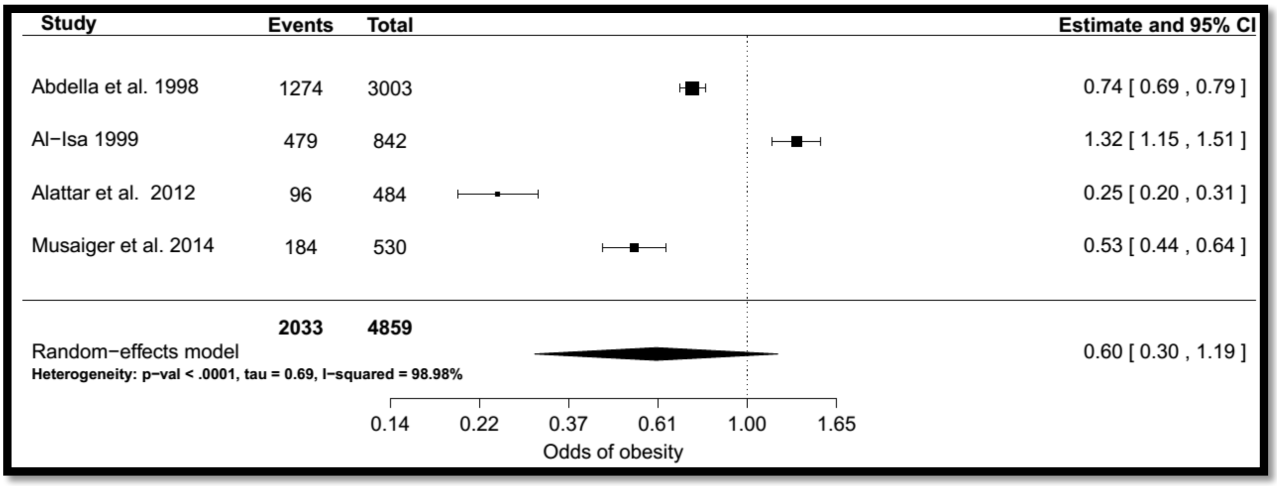

Figure 4.6: Random effects model forest plot of odds of obesity among young (≤ 30 years) Kuwaitis.

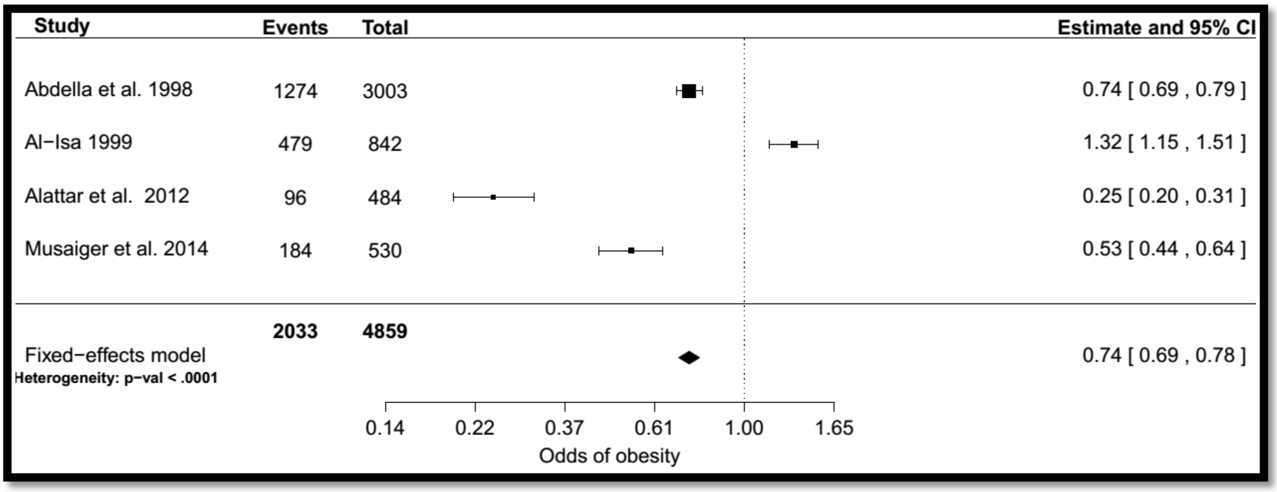

Figure 4.7: Fixed effects model forest plot of odds of obesity among young (≤ 30 years) Kuwaitis.

Figures 4.6 and 4.7 display the results from the random and fixed effects models respectively for studies in the young category. The odds of obesity estimated by the random and fixed effects models were 0.60 (p = 0.1424, 95% CI = 0.30 to 1.19) and 0.74 (p < 0.0001, 95% CI = 0.69 to 0.78) respectively. As shown in the plot, the odds did not overlap but varied considerably. One study (Al-Isa, 1999) produced odds significantly greater than 1. Abdella et al. (1998) used the largest sample, with an odds value of 0.74. Under the fixed-effects model, Abdella et al. (1998) and Al-Isa (1999) were assigned large weights which increased the overall odds to 0.74. By contrast, under the random-effects model, Abdella et al. (1998) and Al-Isa (1999) received a relatively small weighting, influencing the mean less (which was 0.60).

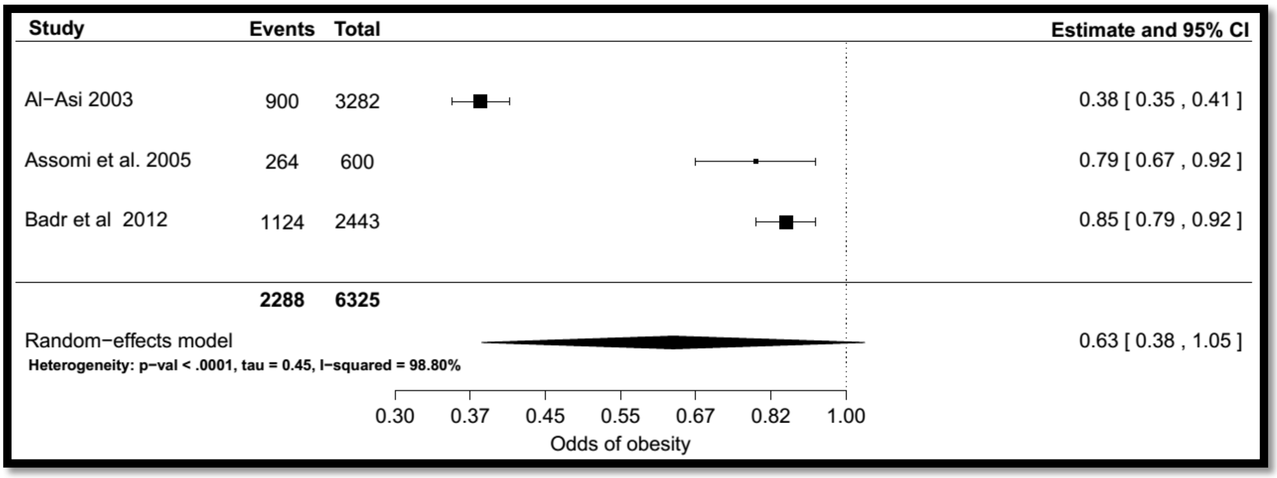

Figure 4.8: Random effects model forest plot of odds of obesity among old (≥ 30 years) Kuwaitis.

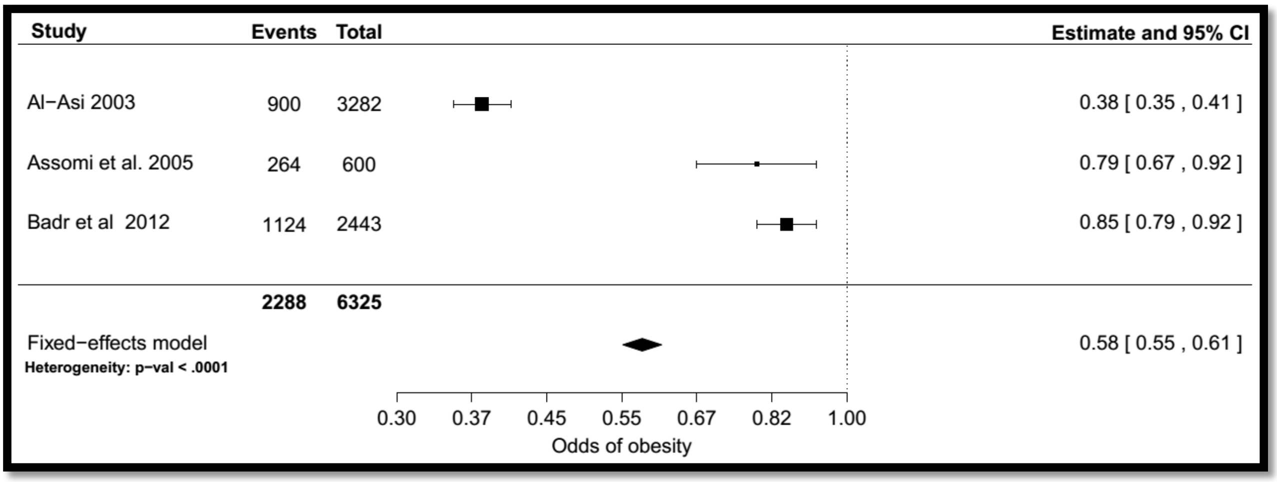

Figure 4. 9: Fixed effects model forest plot of odds of obesity among old (≥ 30 years) Kuwaitis.

The odds of obesity for the old category estimated by the random and fixed effects models were 0.63 (p = 0.0769, 95% CI = 0.38 to 1.05) and 0.58 (p < 0.0001, 95% CI = 0.55 to 0.61) respectively, as displayed in figures 4.8 and 4.9. From the plots, one can observe that the odds of two studies overlap, all being significantly less than 1. Al-Asi (2003) was the largest study and also happened to have odds of 0.38. Under the fixed-effects model, Al-Asi (2003) was assigned a large weight which pulled the overall odds down to 0.58. By contrast, under the random-effects model Al-Asi (2003) was assigned a relatively modest share of the weight, exerting less pull on the mean (which was 0.63).

The odds produced by the subsets varied but in no specific pattern. Under the fixed-effects model, the highest odds were from the young category, while under the random effects model, the highest odds were from the old category. This difference was because few studies used very large samples compared to the rest in each category. However, the random effects model seemed to be a more reliable model since the studies included in the analysis were not functionally identical, and there was evidence of heterogeneity among the studies in each category. Additionally, the goal of this analysis was on the whole to generalise this estimate to a range of scenarios. This implies that it was reasonable to make conclusions based on the random effects model. Therefore, one can reasonably conclude that older age is associated with a higher risk of obesity, contrary to what one would expect due to reduction in youth participation in physical activities with the availability of technology (smartphones, internet, etc.) and accompanying changes in lifestyle (social networking).

Table 4. 8: The summary of the odds obtained from the age category

Age (in Years)	Fixed Effects	Random Effects
Young (≤ 30)	0.74	0.60
Old (> 30)	0.58	0.63

4.3.4 Fixed and Random Effects Models Based on Gender

The studies were further examined with respect to gender. Only 14 studies provided useful information regarding any potential association between obesity and gender. A total sample size of 25 972 was yielded by the 14 studies, ranging from 177 to 7609 participants.

The results from the random effects model showed that the estimated effect size of the odds ratio of obesity of a male relative to a female was 1.0757 (95% CI = 0.6707 to 1.7253, $p = 0.7619$), meaning the odds of obesity in males were on average 1.0757 times that of females. The odds ratio value was close to 1, with high p-value (indicating insignificance), suggested that males and females in Kuwait had equal odds of obesity.

Figure 4.10 is the forest plot showing the odds ratio of the male group versus that of the female group. The individual studies demonstrated 95% confidence intervals. The plot shows that the number of studies that yielded odds ratios less than 1 and the number of studies that yielded odds ratios greater than 1 were the same. The confidence intervals of the individual studies did not overlap, indicating high heterogeneity. This finding was confirmed by the test of homogeneity, which was significant ($Q = 1073.9683$, $d.f. = 13$, $p < 0.0001$). Results arising from addition of year of publication ($b = -0.0561$, $p = 0.1725$), average age ($b = -0.0524$, $p = 0.0987$) and minimum age ($b = 0.0297$, $p = 0.3957$) as moderators suggested that these moderators had no significant effect on the odds ratio and could not account for more significant variation than that accounted for by the estimate of total amount of heterogeneity

($\tau = 0.8778$). However, the funnel plots of the random effects model with and without moderators shown in figure 4.11 suggested that the random effects model with moderators may have been better and more reliable because the residuals of the model with moderators indicated absence of bias.

Table 4. 9: The summary of the odds obtained from the gender category

Odds	95 % Confidence Interval	P-value
1.0757	0.6707 to 1.7253	0.7619

Table 4.9 shows that the odds of obesity in males were on average 1.0757 times that of females. The odds ratio, which was close to 1 with high p value (indicating insignificance), suggested that males and females in Kuwait have equal odds of obesity.

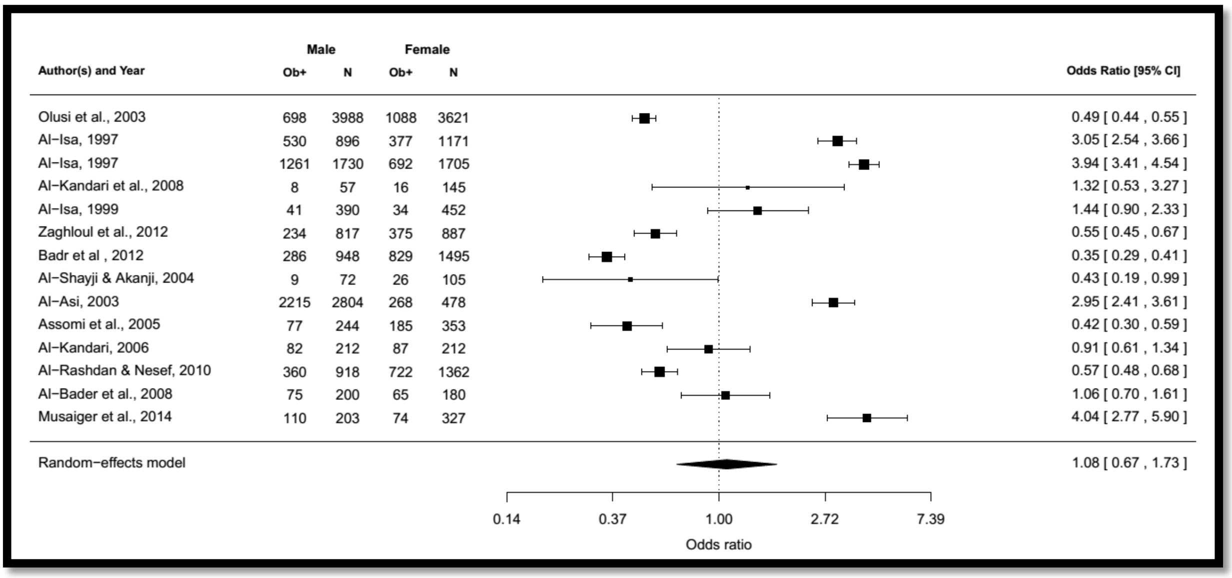

Figure 4.10: Forest plot showing results of 14 studies examining the effect of gender on obesity

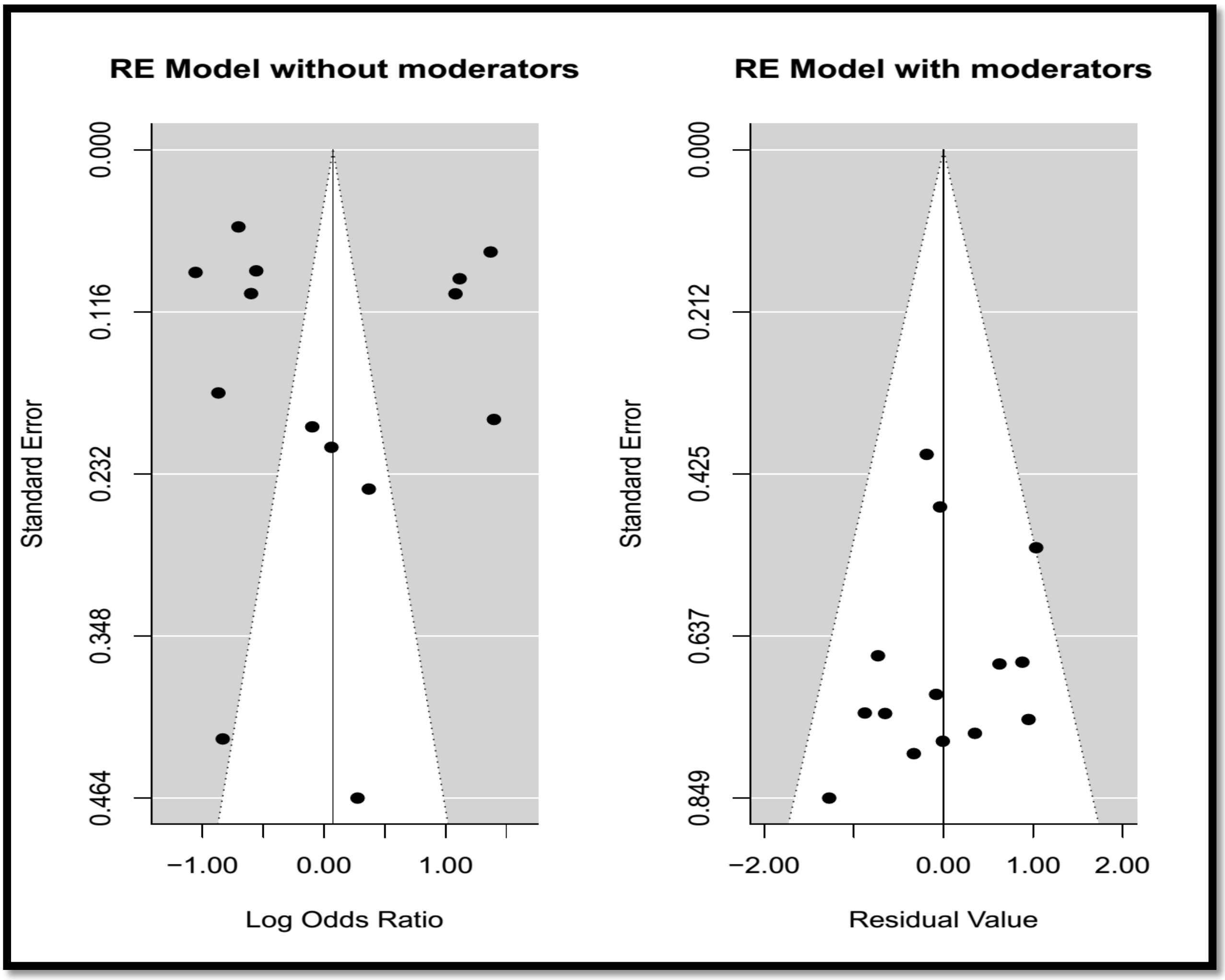

Figure 4. 11: Funnel plots for the random effects models with and without moderators respectively.

4.4 Publication bias

The funnel plots shown in figures 4.12 and 4.13 followed by a test of symmetry checked for publication bias. Figure 4.12 displays the standard errors alone, while figure 4.13 also displays the magnitude of heterogeneity to be explained when plotting the pseudo confidence interval region. The even dispersion of points around the vertical line on both plots indicated that there was no evidence of publication bias. This was confirmed by the regression test for funnel plot asymmetry, which was not significant (z = -1.6306, p = 0.1030).

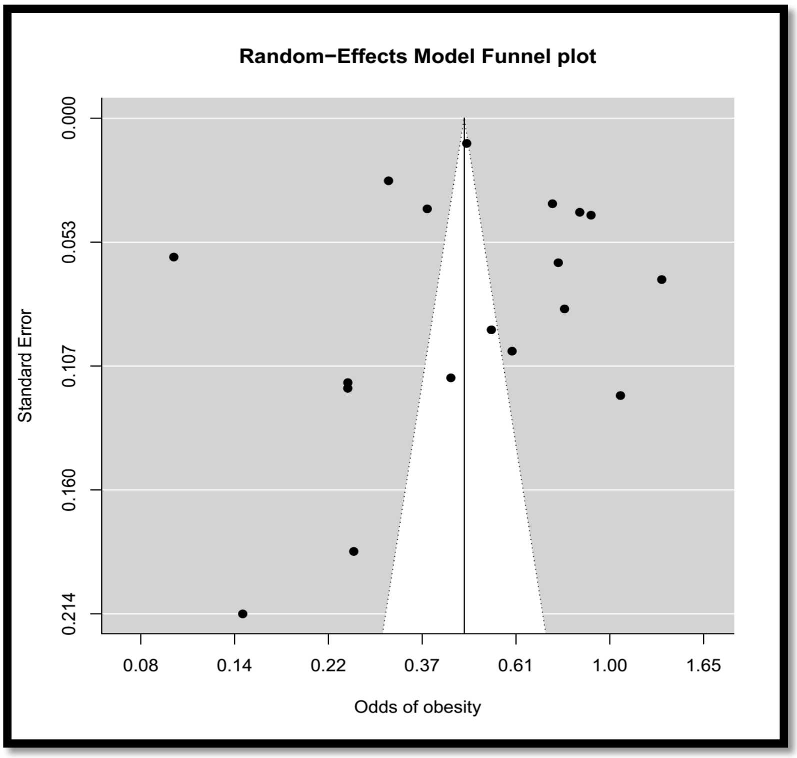

Figure 4.12: Funnel plot for the random effects model using the standard errors alone to compute the pseudo-confidence intervals.

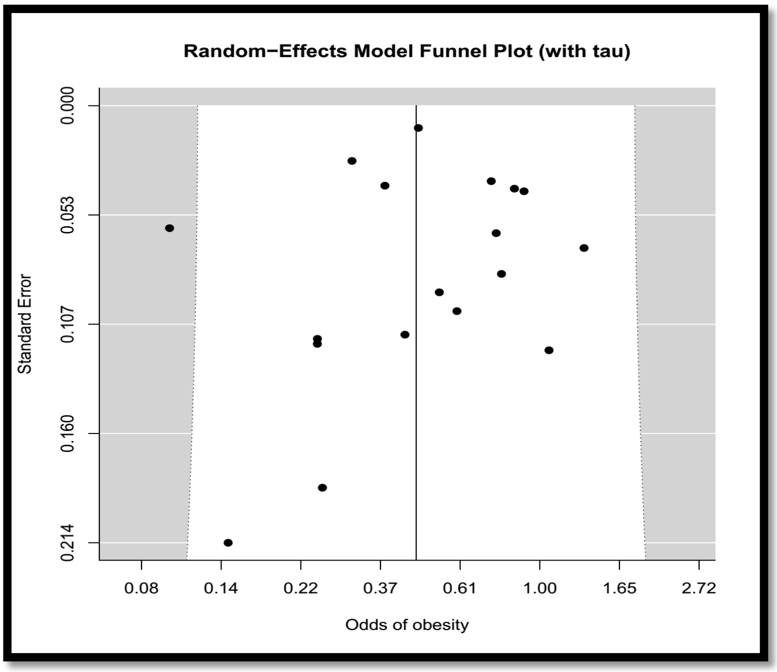

Figure 4.13: Funnel plot for the random effects model using the standard errors and allowing the magnitude of heterogeneity to be explained when plotting the pseudo confidence interval region.

In addition, year of publication, average age, and minimum age of participants in each study were used as moderators to account for the variation in both the random and fixed effects models. This examined whether the odds of obesity might have depended on the age of participants in the study. Moreover, the odds of obesity may have changed over time, which could be examined by considering year of publication as a moderator. All studies provided enough information to calculate average age. The results from the random effects model revealed that year of publication ($b = 0.0175, p = 0.5948$), average age ($b = 0.0262, p = 0.2537$), and minimum age ($b = -0.0110, p = 0.6983$) were not significant.

On the other hand, year of publication ($b = 0.0172$, $p < 0.0001$), average age ($b = 0.0270$, $p = < 0.0001$), and minimum age ($b = -0.0080$, $p = 0.0017$) were significant under the fixed effects model. These findings indicated that year of publication, average age, and minimum age accounted for some of the variation among studies, however they did not need to be considered in the random effects model, because heterogeneity due to these moderators (year of publication, average age, and minimum age) was already accounted for by allowing the true effects to be study-specific, having variance τ, which represented the heterogeneity among the true effects. This meant that the heterogeneity due to the moderators was already accounted for by τ in the random effects model.

The meta-regression plots in figures 4.14, 4.15, and 4.16 reveal the relationship between odds of obesity and year of publication, average age, and minimum age respectively, with predicted values and corresponding 95% confidence intervals based on the random effects model superimposed. Figure 4.17, 4.18, and 4.19 are the same plots based on the fixed effects model. The observed odds of obesity were proportional to the inverse of the corresponding standard errors drawn. In the plots, one can observe that the predicted odds of obesity seemed to increase as the values of the moderators increased. This implied that the odds of obesity increase with age and with year of publication. Also, the confidence intervals generated by the random effects model were wider than those of the fixed effects model, which were very narrow as observed from the meta-analysis, and this was an indication that the random effects model was better. Comparing the funnel plots of both models in figure 4.20 suggests the random effects model was more suitable, since the residuals of the random effects model with moderators indicated absence of bias.

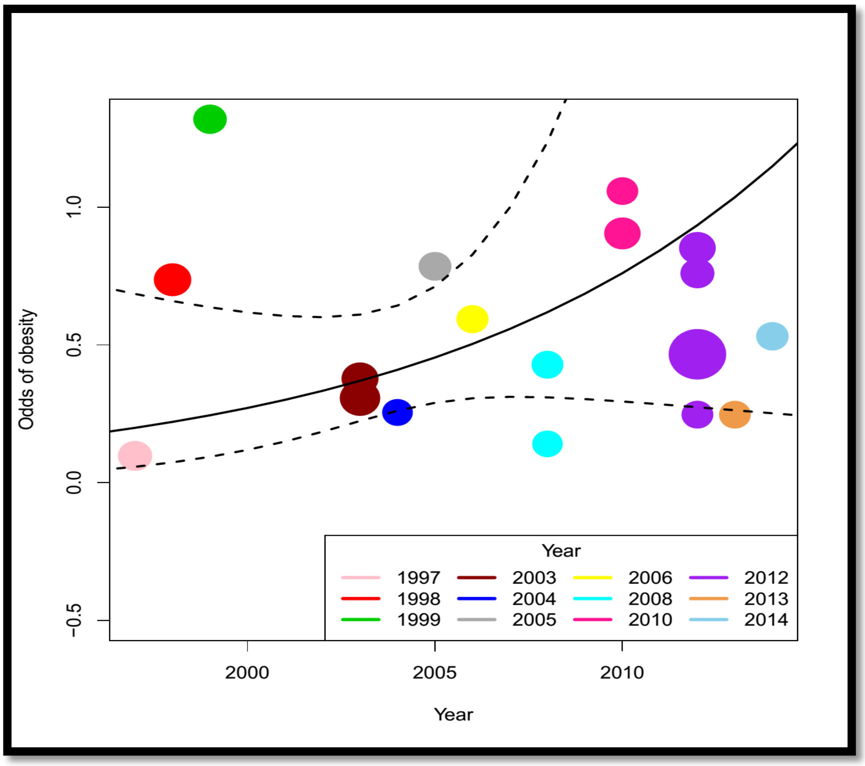

Figure 4.14: Bubble plot of odds of obesity in Kuwait against publication year for the random effects model. The vertical axis represents the odds of obesity. The slope is weighted by the inverse of the variance of the odds of obesity. The size of the circle is in proportion to the weight of the study.

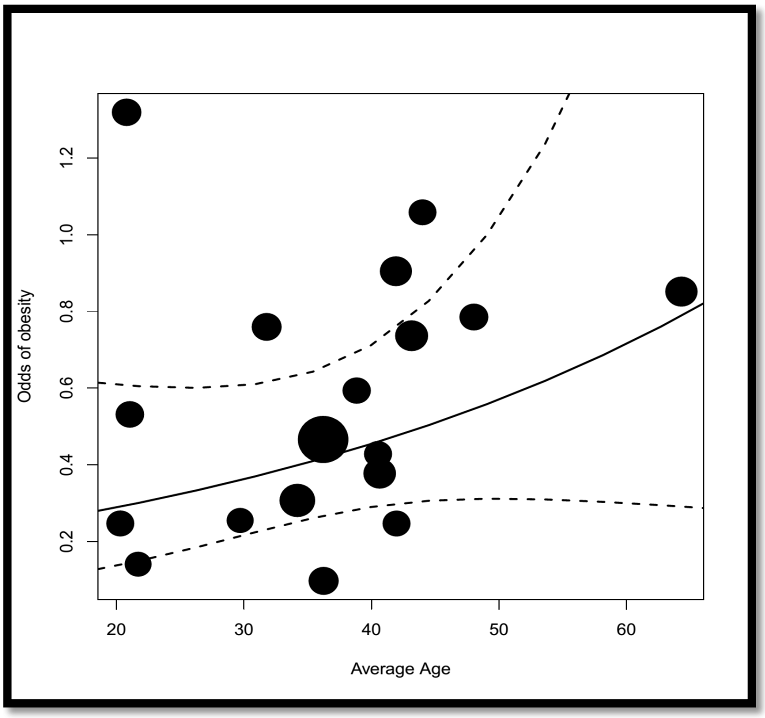

Figure 4.15: Bubble plot of odds of obesity in Kuwait against study average age for the random effects model.

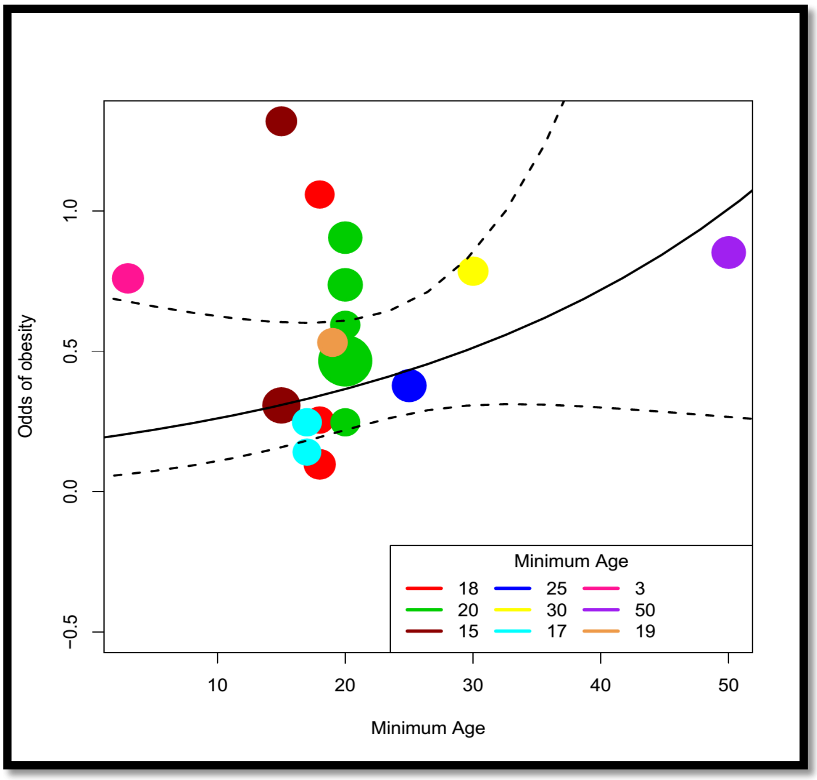

Figure 4.16: Bubble plot of odds of obesity in Kuwait against study minimum age for the random effects model.

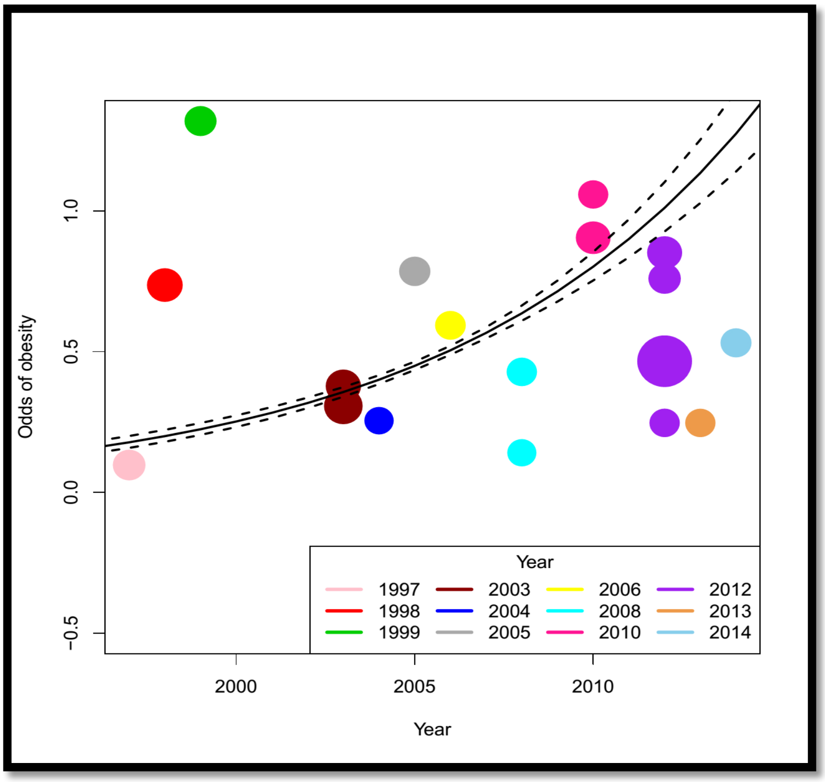

Figure 4.17: Bubble plot of odds of obesity in Kuwait against publication year for the fixed effects model.

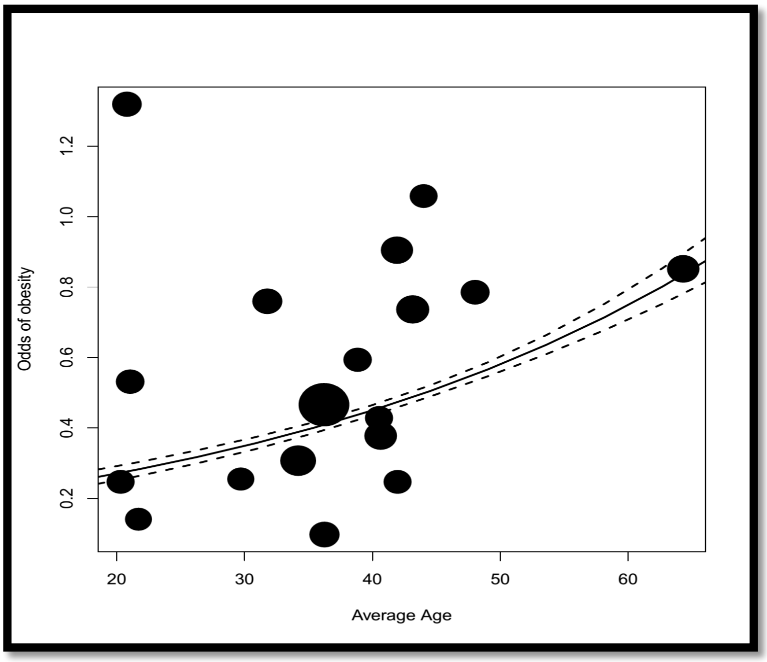

Figure 4.18: Bubble plot of odds of obesity in Kuwait against study average age for the fixed effects model.

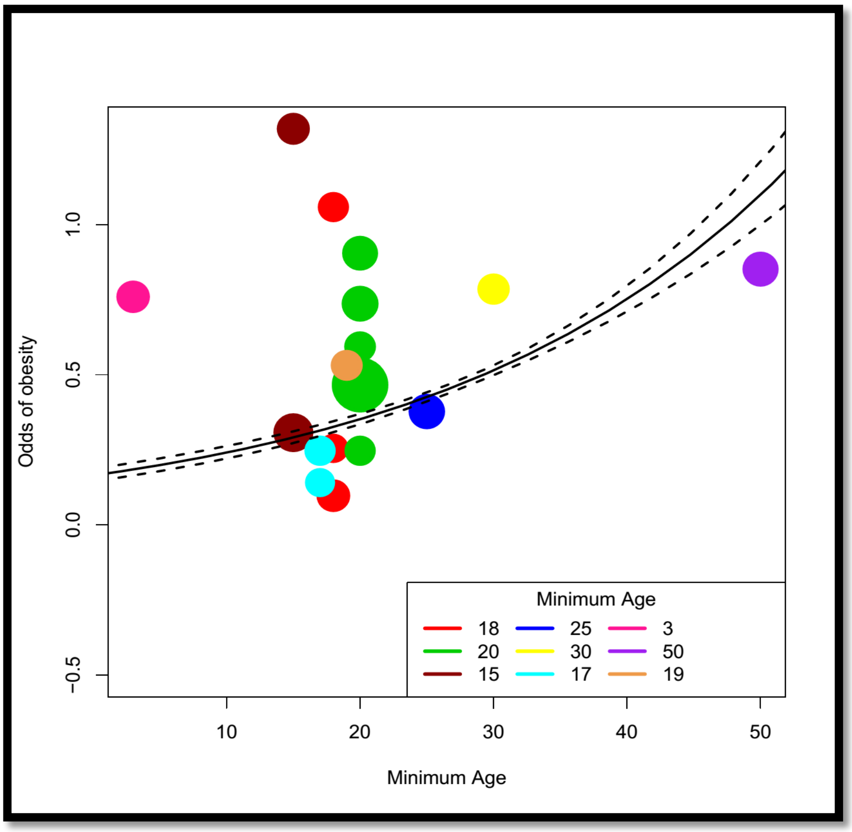

Figure 4.19: Bubble plot of odds of obesity in Kuwait against study minimum age for the fixed effects model.

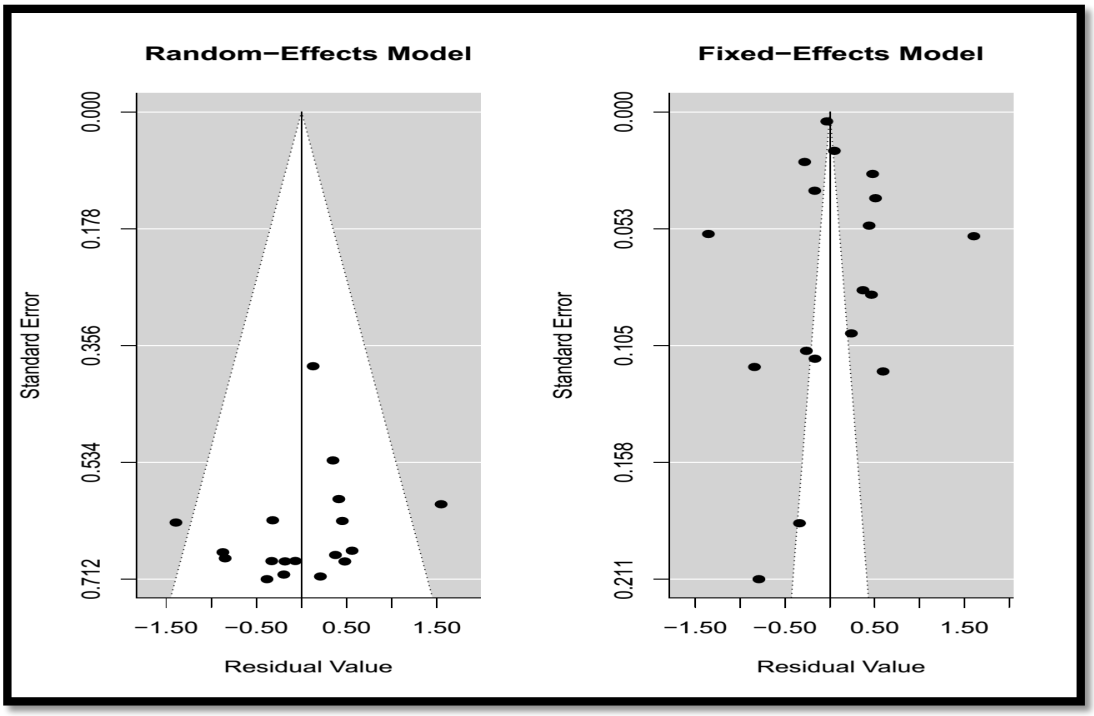

Figure 4. 20: Funnel plots of the random effects and fixed effects models with moderators.

Chapter 5: Summary and Conclusions

The systematic review of adult obesity risk factors, rates, trends, and epidemiological approaches in Kuwait by Karageorgi et al (2013) found that the obesity rate (BMI ≥ 30) of studies with a nationally representative sample ranged from 24% to 48% and had increased from 1980 to 2009, while in adults over fifty years of age it was greater than 52%. Females were found to be more overweight than males. Multiple risk factors contributed to this alarming trend.

It is worthy to note that, Karageorgi et al. (2013) only carried out a systematic review of the results and methodology of studies on the rates, trends, and risk factors of Kuwaiti obesity. Eighteen papers were reviewed, and conclusions were made based on the eighteen papers reviewed. The reason behind the variations in the results of various studies reviewed by Karageorgi et al. (2013) could not be addressed properly through a systematic review. As a result, we carried out meta-analysis on 18 studies of which 17 of the studies were part of the 18 paper reviewed systematically by Karageorgi et al. (2013) and the last paper by Musagier et al. (2014).

For instance, studies such as Al-Isa (1997) and Zaghloul et al. (2012) investigated the demographic profiles of people with obesity and high BMI in Kuwait. Al-Isa (1997) compared two cross-sectional samples and showed that there was an increase in the mean BMI among Kuwaiti men and women at the rates of 10.0 and 6.02% respectively, while Al-isa, et al. (2011) revealed that while the obesity and overweight rates for Kuwaiti adult men and women remained at 48.5% and 19.8% respectively. Also, the prevalence rate of obesity and overweight condition was observed to increase at the rates of 15.5% and 20.6% for women and men respectively.

Similar results were indicated by the study conducted by Zaghloul et al (2012) who reported Kuwaiti adult females were more obese and overweight than the males.

In Chapter 3, the updated systemic review of obesity research in Kuwait was presented. We started by highlighting the problem being investigated in this study and the method to be adopted was explained. The problem being investigated in this study was to conduct a comprehensive search and inclusion of obesity research on Kuwaitis, and the generated was analysed using meta-analysis. The methods used in the primary research is studying an individual with BMI > 30. The criteria for exclusion of study include: unclear publication data, inadequate information on central issue, exclusion of substantiated evidence and inclusion of self-reported weights and BMIs instead of measured indices and presentation of overlapping results.

In Chapter 4, we introduced the findings obesity prevalence and its association with life style and socio-cultural differences in Kuwait. A total of 53 studies were initially extracted from three databases and other sources to examine the prevalence of obesity and its association with life style and socio-cultural effects. 18 studies were retained for meta-analysis since they included sufficient statistical information relevant to the subject of enquiry. The 18 studies yielded a total sample size of 66105 ranging from 177 to 38611. Individual odds of obesity were extracted for each study.

We started by fitted a fixed and random effect model on the 18 studies extracted. Afterwards the random effect model was adopted due to its low AIC and BIC. The pooled odds of being obese is 0.48 and is significantly different from 1 with 95% confidence interval ranging from 0.47 to 0.48 which indicates that the chance of being obese is smaller than that of not being obese. Only one study (Babusik and Duris 2010) produced odds that are not significantly different from 1. Two studies (Babusik and Duris 2010; Al-Isa, 1999) produced odds greater than one. However, only the odds reported by Al-Isa (1999) is significantly greater than 1. In Al-Isa (1999), 842 randomly selected Kuwait University students was studied to examine how dietary and socioeconomic factors relate to obesity. The target group in Al-Isa (1999) is different from those of the remaining studies in that the group consist of University students. In the study, performance grade (G.P.A.) was found to be a significant factor associated with obesity. The study showed that lower G.P.A. Resulted in higher risk of obesity.

The meta-regression plot indicates that the predicted odds of obesity seem to move upward as the values of the moderator's increase. This implies that the odds increases as age increases and as year of publication increases. Also, the confidence intervals produced by the random effects model are wider than those of the fixed effects model which are very narrow indicating that the benefits of the random effects model are higher. The studies were further examined with respect to gender. Only 14 studies provided useful information regarding obesity and gender. The results from a random effects model showed that the estimated effect size of the odds ratio of obesity of a male relative to that a female is 1.0757 (95% CI = 0.6707 to 1.7253, $p = 0.7619$). The results suggest that the odds of obesity in males are on average

1.0757 times that of females. The odds ratio value which is close to 1 with high p value (indicating insignificance) suggests that the both males and females in Kuwait have equal odds of being obese.

We then extracted 7 studies where random sampling was used from the 18 studies and fitted a fixed and random effect model. Based on the random sampling, the overall estimates of odds of being obese by the fixed and random effects model are 0.44 and 0.42 respectively. This indicates that the odds of being obese are approximately 0.4 that is, the chance of a Kuwaiti being obese is a bit lower than the chance of not being obese.

In this thesis, we have not considered other factors contributing to rates of Kuwaiti overweight and obesity, factors such as socio-cultural and lifestyle were not considered. Patterns of distribution of obesity based on age and gender have been found. It was discovered that females are at higher risk of obesity than males in Kuwait. Similarly, older age is associated with higher risk of obesity.

Future work should focus on meta-analysis of relevant studies on obesity in the Middle East where obesity is a critical issue in countries such as Saudi Arabia, Bahrain, the UAE, Qatar, Oman and Kuwait (Ng et al. 2011; ALNohair 2014). The findings obtained from meta-analysis of studies on obesity in these countries can help to reduce the prevalence of obesity and guide policy makers in the region.

Appendices:

Appendix 1:

Table x: Summary of Studies Used in Systematic Review

Author Title	**Study Design**	**Findings**
Ahmed, F., Waslien, C., Al-Sumaie, M., & Prakash, P. (2012).	Cross-sectional survey	• BMI prevalence was higher in females of Kuwait compared to the male population. • for all age groups, the prevalence rate of obesity in females in Kuwait was greater than in males of Kuwait • Gender and age were considered to be direct risk factors for increasing obesity, education was considered as negatively associated with increase in obesity
Assomi et al (2005)	Cross-sectional survey	• a major reason behind this increased prevalence of cholesterol levels was attributed to a greater Body Mass Index and family history of obesity
AlMajed, H.T. Et al. (2010).	Cross-sectional survey	• males were more likely to be obese, whereas females were more likely to be overweight in general

Alattar, A., Al-Majed, H., Almuaili, T., Almutairi, O., Shaghouli, A., &Altorah, W. (2012)	Cross-sectional survey	• glucose regulation impairment can be caused as a result of overweight or obesity in individuals • increased waist circumference was also attributed to impaired glucose regulation
Al-Bader, W., Ramadan, J., Nasr-Eldin, A., &Barac-Nieto, M. (2008)	Cross-sectional survey	• increase in the obesity levels was a prominent signal for increasing severity of the restrictive respiratory impairment
Ghazali et al (2010)	Cross-sectional survey	• 69.9% males were obese and overweight, while a lesser percentage of females were obese
El-Bayoumy, Shady &Lotfy, 2009	Cross-sectional survey	• overall prevalence of 30.7% and 14.6% - for obesity and overweight respectively—was found in the intermediate school student's sample
Musaiger (2011)	Cross-sectional survey	• overall prevalence rate of obesity in Kuwaiti adults ranged from 25% to 81.9%

		• reasons for the prevalence of obesity were mainly identified as transitions in nutrition, inactivity or low activity levels, shorter duration of breastfeeding, marital status and urbanization
Badran and Laher (2011)	Cross-sectional survey	• prevalence rate of obesity in children and adolescents in the country vary from 5 to 14% in males and 3 to 18% in females • Key Reasons: increased food consumption, demographic and socioeconomic factors, multiple pregnancies and physical activity
Olusi et al (2003)	Cross-sectional survey	• obesity rate of 23.5% in Kuwaiti adults • 30.0% adult women obese, 17.5% men obese
An Al-isa (1997)	Cross-sectional survey	• a significant degree of increase in the mean BMI among Kuwaiti men and women at the rates of 10.0 and 6.02% respectively • obesity and overweight condition was observed to increase at the rates

		of 15.5% and 20.6% for women and men respectively
Zaghloul et al (2012)	Cross-sectional survey	• Kuwaiti women to be more obese and overweight compared to the Kuwaiti men • Kuwaiti boys were found to be more obese than Kuwaiti girls
Babusik&Duris (2010)	Cross-sectional survey	• Arab population in Kuwait acquired the condition of obesity in younger years of age compared to the South Asian population • a greater hip size, waist circumference, and waist-to-hip ratio
Al-isa et al (2011)	Cross-sectional survey	• risks to obesity included a lower grade point average among students, having an obese relative characterized by an obese brother, mother or father, increasing levels of age and lack of physical activity

Al-Kandari et al (2008)	Cross-sectional survey	• the males with a normal body mass index were more likely to become obese or overweight in the near future • positive-low health-promoting lifestyle associated with marital status, socio-demographic factors, age and nationality.
Abdella et al (1998)	Cross-sectional survey	• obesity was a major risk factor in inducing non-insulin dependent diabetes among the sample groups.
Al-isa (1999)	Exploratory Study	• a greater prevalence of grade 1 obesity compared to Grade-2 obesity which was more severe • marital status, age, parental obesity, low level of school CGPAs and more frequent meals eaten were recognized as the major risk factors
Badr, Shah &Shah (2012)	Cross-sectional survey	• Obesity found in a total of 81% respondents from the sample of

		2,443 Kuwaiti men and women who were 50 years of age • A mean Body Mass Index of 30. • married individuals were found to be almost 2.3 times at higher risk of becoming overweight or obese.
Al Shayji &Akanji (2004)	Cross-sectional survey	• greater level of either of the three indices including BMI, WHR or WC experienced a considerable degree of increase in their body glucose levels, urate, mean BP, TG, Insulin and IGR.
Al-Asi (2003)	Cross-sectional survey	• 75% prevalence rate of obesity and overweight in the total sample size of 3282 employees of the Kuwaiti oil company • prevalence rate of obesity among males was higher than that of the females

Al-Kandari (2006)	Cross-sectional survey	• obesity is subject to increase with the increase in age • This increase is more likely to occur with age in women compared to men
Al Rashdan&Nesef (2010)	Cross-sectional survey	• adult Kuwaiti population has a high degree of prevalence of obesity, overweight and the metabolic syndrome • higher degree of prevalence of overweight and obesity in women i.e. 81.9% compared to that of men which was 78% • metabolic syndrome were found to be equally distributed among both male and female Kuwaiti adults
Karageorgi, S, Alsmadi, O. &Behbehani, K. (2013)	• Systematic Review	• Sociodemographic, hereditary and sociocultural factors.

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