Investigating weight-related behaviours in Bahraini adolescents' friendship networks

By

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Abstract

Unhealthy diet, low levels of physical activity, high levels of sedentary behaviour and sleep deprivation are important weight-related behaviours that have contributed to the increased prevalence of adolescent obesity. Numerous interventions have been developed to improve weight-related behaviours but they are usually focused on the individual and they ignore the effects of social networks on these behaviours. Much of the research in obesity has explored the role of social networks in promoting health through social influence and selection. However, little research has examined how the structure of social networks and the position of the individuals in the network could condition behaviour association (regardless of the underlying mechanism being social influence or selection) in adolescent friendship networks. Examining social network structure, individual position in the network and how they interact with individual behaviour in friendship networks can assist in better understanding the development and persistence of weight-related behaviours in adolescent friendship networks and provides valuable insight on how to modify these behaviours.. Hence, this study aims to examine the role of friendship network properties (density, popularity and centrality) on the association between individual's and friends' weight-related behaviours after reviewing the literature and analysing social network and behavioural survey data. Methods are drawn from a set of analytical tools known as 'Social Network Analysis', which uses friendship nomination data from a complete network (socio-metric), along with reported data on diet, physical activity, sedentary behaviour, and sleep deprivation to investigate how friendship network structure is moderating behaviour association between individuals and their friends in the network. Four schools in Kingdom of Bahrain participated in the study with a total of 673 adolescents between the ages of 11 and 15. Findings suggest that there are associations between adolescents and their friends' in multiple weight-related behaviours. There is also evidence for the moderating role of some network properties on these associations. Findings are gender specific, which has implications for gender-tailored interventions.

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List of Acronyms

Acronym	Meaning
ABM	Agent Based Model
Add Health	The National Longitudinal Study of Adolescent Health: a dataset with a representative sample of adolescents in grades 7 through 12 in the U.S that is maintained over time.
BMI	Body Mass Index
CDC	Centres for Disease Control and Prevention, United States of America
CI	Confidence Interval
CIO	Central Informatics Organization, Kingdom of Bahrain
CPR	National ID/smart card for locals and residents in the Kingdom of Bahrain
DF	Degrees of freedom
ERGM	Exponential Random Graph Model
GCC	Gulf Cooperation Council
GSHS	Global School-based Student Health
HIV	Human Immunodeficiency Virus
LNED	Low-Nutrient Energy-Dense
MENA	Middle East and North Africa
MVPA	Moderate to Vigorous Physical Activity
NETDRAW	A program for visualizing social network data

NHS	National Health Service, United Kingdom
NIH	National Institute of Health, United States of America
OECD	Organisation for Economic Co-operation and Development
OR	Odds Ratio
PA	Physical Activity
P-value	In a regression model, a predictor (independent variable) that has a low p-value (< 0.05) or (<0.10) is likely to be a meaningful addition to your model because changes in the predictor's value are related to changes in the response variable (dependent variable)
Rho	Spearman's rank correlation
SAB	Stoachastic Actor Based Model
SB	Sedentary Behaviour
SIENNA	Simulation Investigation for Empirical Network Analysis
SNA	Social Network Analysis
SPSS 23	Statistical package for the social sciences version 23
UCINET 6	Software package for the analysis of social network data version 6
WHO	World Health Organization

Acknowledgements

Declaration

I hereby declare that this thesis is based on my own work and has not been written for me, in whole or in part, by any other person. I also undertake that any quotation or paraphrase from the published or unpublished work of another person has been duly acknowledged. Finally, I declare that this piece of work has not been previously or concurrently submitted for any other degree at Brunel University London or any other academic institution.

Name: …………………………………………………………………..

Date: …………………………………………………………………

Signature: …………………………………………………………

List of Publications

During the course of this PhD, a total of five intellectual contributions (one journal article and four conference articles) whose content was an outcome of the derived material from the PhD research carried out since 2016 to 2018 which are listed below:

Alsayed, N., Eldabi, T., & Lee, H. (2016). Obesity: A Social Epidemic. Ahlia University – The 2016 PhD (WR) Annual Doctorial Symposium. Manama, Bahrain.

Alsayed, N., Eldabi, T., & Lee, H. (2017). Investigating obesity related behaviours in friendship networks among the youth. Ahlia University – The 2017 PhD (WR) Annual Doctorial Symposium. Manama, Bahrain.

Alsayed, N., Eldabi, T., & Lee, H. (2017). Investigating obesity related behaviours in friendship networks among the youth: a systemized review. World Associations for Sustainable Development – WASD 15th International Annual Conference. Manama, Bahrain.

Alsayed, N., Eldabi, T., & Lee, H. (2017). Investigating obesity related behaviours in friendship networks among the youth: a systemized review. *International Journal of Food, Nutrition and Public Health (IJFNPH).* 9(2).

Alsayed, N., Eldabi, T., & Lee, H. (2018). Weight-related behaviours in Bahraini adolescents' friendship networks. Ahlia University – The 2018 PhD (WR) Annual Doctorial Symposium. Manama, Bahrain.

Chapter 1: Introduction

1.1   Introduction

It is widely reported that obesity has reached epidemic proportions in the United States and several developed nations (Wadden, Brownell and Foster, 2002). The number of overweight and obese individuals worldwide is now over 2.1 billion; up from 857 million in 1980, a new analysis has shown, representing a 28% increase among adults and 47% increase among adolescents and children (Ng et al., 2014). The prevalence of overweight and obesity among children and adolescents worldwide is also growing at a disturbing rate (Koehly and Loscalzo, 2015). Unhealthy diet, low levels of physical activity and increased participation in sedentary behaviour are weight-related behaviours that have contributed to the increased prevalence of obesity among adolescents (Wang and Lobstein, 2006). Obesity is defined as a chronic metabolic disease resulting from an imbalance between energy input and energy output (NIH, 2007). Obesity is complex because it is caused by multiple genetic and environmental factors including excessive food intake, insufficient physical activity, genetic predisposition, individual metabolism, medical conditions and other behavioural factors (Hernandez and Blazer, 2006). Obesity is a serious health threat because it is a major risk factor for multiple health problems. The disease is associated with several serious health conditions including: type 2 diabetes mellitus, heart disease, high blood pressure and stroke (Wellman and Friedberg, 2002). It is also linked to higher rates of certain types of cancer (Wellman and Friedberg, 2002). Obesity is an independent risk factor for heart disease, hypoxia, sleep apnea, hernia, and arthritis (Wellman and Friedberg, 2002). Among children and adolescents, obesity has been found to contribute to orthopaedic abnormalities, sleep apnea, asthma, insulin resistance and subsequent diabetes mellitus (Must and Strauss, 1999). Increases in obesity and diabetes among US adults continue in sexes, all ages, all races, all educational levels, and all smoking levels (Mokdad et al., 2003). Chronic diseases and conditions including obesity, heart disease, stroke, cancer, type 2 diabetes, and arthritis are among the most common, costly, and preventable of all health problems (CDC, 2015). In addition to health concerns, obesity burdens the health care system, strains economic resources, and has far reaching social consequences (Wellman and Friedberg, 2002). Therefore

the need for obesity control and prevention is significant, because obesity serves as one of the most important risk factors of various chronic diseases (WHO, 2000). However, health policy makers still know far too little about the causes and effective prevention of obesity, which makes it even more important to acquire this knowledge (Buchner, 2011).

Despite the significant efforts to fight the obesity epidemic, obesity prevalence continues to increase in the United States and many developed nations mainly due to the fact that the current interventions are usually focused on an individual perspective and do not take into account the social environment (Nam, Redeker and Whittemore, 2015). As a result there is a need for a new approach to this problem where the social environment must be considered when addressing obesity because it has been recently discovered that the interactions between a person and others in the same social network will bias their weight (Bahr et al., 2009). Social networks i.e. the webs of interactions between individuals have long been studied by health and behavioural scientists. Research shows that social networks influence various health outcomes including HIV, smoking, depression, alcohol consumption, , and cardiovascular disease; however, our understanding is still limited due to limited information on the influences of social networks on obesity and weight-related behaviours (Nam, Redeker and Whittemore, 2015). Obesity was found to spread over social networks among adults like an infection (Christakis and Fowler, 2007). Obesity was also found to spread in a similar manner through adolescent friendship networks (Burkhauser and Cawley, 2008). There is evidence that the social contagion of obesity may start at a young age therefore interventions to mitigate the obesity epidemic should start from childhood (Nam, Redeker and Whittemore, 2015). Additionally, there is a strong relationship between adolescent and adult obesity with correlations ranging from 0.46 to 0.91 (Power et al., 1997). As a result, it is important to develop effective programs for reducing the rate of adolescent and children obesity (Lawman and Wilson, 2012). The social transmission of weight-related behaviours is a viable explanation for the spread of obesity in adolescent friendship networks that has been documented in recent research and weight reduction interventions may be complemented with strategies that focus on modifying behaviours (Ali, Amialchuk and Heiland, 2011). The literature suggests that friendships are an important factor for the spread and maintenance of weight-related behaviours (de la Haye et al., 2010). There are strong associations between individuals and their peers' behaviours which suggests that health behaviours of an individual's peers plays a role in shaping their own health behaviours (Barclay,

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Edling and Rydgren, 2013). Peers have a crucial influence on development and behaviour throughout childhood and adolescence (Prinstein and Dodge, 2008). Friends are expected to be more influential than peers since friendships are characterized with intense feelings, frequent interactions, and interactions of longer duration (Berten and Van Rossem, 2011). Social influence or socialization among peers and friends will result in behavioural similarity; however peer selection or homophily is another potential mechanism that could explain the similarity in behaviour (Brechwald and Prinstein, 2011). Peer selection is different from social influence and it refers to choosing friends with similar behaviours. Friends are chosen based on pre-established behaviours or attitudes (Valente, 2010). The similarity in behaviour could be explained by multiple processes and to pinpoint the specific mechanism that could explain the similarity in behaviour is not a simple process and is the focus of a growing body of research (Shoham et al., 2012; Simpkins et al., 2013; Wang et al., 2014). More research is needed on how the structure and function of networks impacts the individuals' health (Nam, Redeker and Whittemore, 2015). Especially, that involving friends in treatment is very much feasible, desired by adolescents and may be a novel approach for obesity treatment (Giannini et al., 2017).

1.2   Research problem

Much of the research in obesity has explored the role of social networks in promoting health through social influence and selection. However, little research has examined how social networks themselves condition health behaviour (Haas, Schaefer and Kornienko, 2010). There are some evidences suggesting that there are associations between friendship network properties (e.g. network size and density) and individual behaviour. For example, among adolescents, *popularity* was found to be positively associated with consumption of unhealthy snacks among boys, where popular boys were the highest consumers of unhealthy snacks (de la Haye et al., 2010). Additionally the *size* of children/adolescents' friendship groups was found to be positively associated with physical activity (de la Haye et al., 2010). Network *density* was positively associated with sedentary behaviour among boys so boys in dense networks were found to be highly sedentary (Sawka et al., 2014). Despite the evident above-mentioned links between friendship networks properties and weight-related behaviours; the network properties have not been examined in detail similar to socially linked issues such as alcohol consumption, drug use, tobacco use, and delinquent behaviour (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). In the past decade, research has addressed more

detailed questions regarding peer socialization process and network properties (Brechwald and Prinstein, 2011). One of these questions is the role of network properties to the relationship between the individual and his/her peers behaviours (Mathys, Burk, and Cillessen, 2013). We find that some network properties play a moderating role on peer selection and socialization of adolescent alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour has been investigated (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). For example, network *density* was found to moderate socialization with delinquent behaviour which means that in denser networks individuals were more likely to change their behaviour to match their friends' delinquent behaviour (Jose et al., 2016). Additionally, *popularity* was found to moderate peer selection based on alcohol use which means that popular adolescents were more likely to select friends who consume high levels of alcohol (Mathys, Burk, and Cillessen, 2013). Examining the moderating role of network properties can provide more details about the interaction between network properties and behaviour associations in friendship networks which can assist in better understanding the development and persistence of weight-related behaviours in adolescent friendship networks. The moderating role of network properties on behaviour association regardless of the underlying mechanism being socialization or selection has not been addressed in the obesity literature and has been identified as a gap.

1.3   Research aim and objectives

This study aims to examine the role of friendship network properties on the associations between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation after reviewing the existing literature and analysing social network and behavioural survey data. Examining the role of network properties can assist in better understanding the interaction between network properties and behaviour associations in friendship networks in order to gain insight into the role of properties of friendship networks in the development and persistence of obesity and weight-related behaviours in adolescents' friendship networks. The following objectives will aid in achieving the research aim and outlining the structure of the research:

- **Objective 1:** To critically review the existing literature on obesity and weight-related behaviours in the social context (i.e. the effect of social networks) to have a better understanding

of the associated social science theories with a particular focus on social networks in order to identify the existing knowledge and to pinpoint a research gap.

- **Objective 2:** To propose a conceptual model after identifying the building blocks for conceptualising to examine the role of friendship network properties on the association between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation after reviewing the existing literature.

- **Objective 3:** To evaluate the conceptual model after defining an appropriate research approach followed by implementing the research methodology through data collection, analysis and finally a discussion of the empirical findings.

- **Objective 4:** To finalise the conceptual model based on the empirical findings in order to propose a modified conceptual model that will assist in future research in the field of obesity and social networks in addition to assisting policy makers to design more effective public health interventions that could leverage friendship networks to help improve the weight-related behaviours of adolescents and promote healthy weight.

1.4   Research context

Most of the research on obesity and social networks was conducted in Australia, Europe, North America and the United Kingdom. Whereas none of the studies on obesity and social networks were conducted in the Middle East or the GCC countries. Obesity has reached epidemic levels in most of countries in the GCC including the Kingdom of Bahrain (Musaiger, 2011). The prevalence of obesity in GCC countries is reaching alarming rates not just among adults but also among children and adolescents (Ng, Zaghloul, Ali, Harrison, and Popkin, 2011). Multiple dietary, lifestyle, social, and cultural factors that are associated with obesity in the GCC (Musaiger, 2011). The GCC countries underwent a nutrition transition after the discovery of oil and economic development which came along increases in nutritional health problems and related diseases (Ng, Zaghloul, Ali, Harrison, and Popkin, 2011). Lack of physical activity and sedentary lifestyle also contribute to obesity among Arab adolescents especially among girls (Obermeyer, Bott and Sassine, 2015). Previous studies conducted in the Kingdom of Bahrain found that girls were less likely to be physically active when compared to boys which may expose them to higher risk of adult obesity (Musaiger, Al-Mannai and Al-Marzog, 2014). Arab girls including Bahraini girls face many cultural related problems that may be hindering physical

activity practice including: 1) Public sports facilities are male oriented and very few are available to females 2) Most girls cannot practice exercise outdoor with sport dress due to cultural or religious reasons 3) In the Kingdom of Bahrain, the majority of girls who are allowed to practice exercise outdoor by their families, do such with traditional attire which may be uncomfortable (Musaiger, Al-Mannai and Al-Marzog, 2014). The GCC countries also have a unique demographic nature, according to a report published by "Markaz" or Kuwait Financial Centre in 2012, more than half of the Arab Gulf states population are under the age of 25 (Markaz, 2012). This of course has implications for an early intervention to control obesity among the youth, since the majority of the population is under the age of 25. The majority of the Arab Gulf states' population have a big number of expatriates consisting up to 86.5% of Qatar's population and lower percentages in other countries averaging 53.43% of the entire GCC region compared to an average of 9.5% in the Middle East North Africa (MENA) region (Markaz, 2012). As a result these countries become highly multicultural with individuals from dozens of countries around the world. Obesity is a problem of concern among Bahraini school children and calls for school interventions (Musaiger, Al-Mannai and Al-Marzog, 2014). This study was conducted in the Kingdom of Bahrain where data was collected from four private and public schools (2 of each). Public schools in the Kingdom of Bahrain are gender segregated whereas the majority of private schools are mixed-gender which may have some interesting implications on the results.

1.5   Methodology

Methods are drawn from a set of analytical tools known as 'Social Network Analysis', which uses friendship nomination data from a complete network (socio-metric), along with reported data on diet, physical activity, sedentary behaviour, and sleep deprivation to investigate how friendship network structure is conditioning behaviour association in adolescent friendship network. Socio-metric studies use census sampling so it is desirable to interview all members of the network (Valente, 2010). The study followed a quantitative approach and a cross sectional design, which utilises a non-experimental survey. The survey instrument was constructed to help understand the role of friendship network properties on associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours. In addition to the survey, measurements of the participants' body weight and height were recorded which allowed the calculation of the participants' body mass index (BMI). Social network analysis will be paired with regression models to empirically test the proposed conceptual model.

1.6   Thesis structure

This research began with a general interest in social networks and obesity. The research problem was described and the research aim and objectives were presented in Chapter One. The literature was reviewed for the effect of social networks on three different but interrelated areas of research in Chapter Two. The first area is health behaviours in general, the second area is obesity and the third area is weight-related behaviours specifically in adolescent friendship networks where the research gap was identified. A model pinpointed by social network theory was proposed to answer the research questions and help fill the research gap in Chapter Three. The proposed conceptual model is a relational model to examine how properties of friendship networks are interacting with the weight-related behaviours (diet, physical activity, sedentary behaviour and sleep) of friends in the network. The design of the empirical study including the identification of the approach (quantitative non experimental), the study variables (individual's weight-related behaviours, friends' weight-related behaviours and friendship network properties), instrument (survey), sample (Bahraini adolescents in schools) and data collection methods are presented in Chapter Four. This is then followed by the implementation of the empirical study including data collection and analysis. The findings from the data analysis are presented in Chapter Five. A discussion of the findings in the context of the reviewed literature is presented in Chapter Six. Finally, a summary of the research, contributions, limitations, practical implications and future directions of research are presented as shown in the empirical research framework in Figure 1.1.
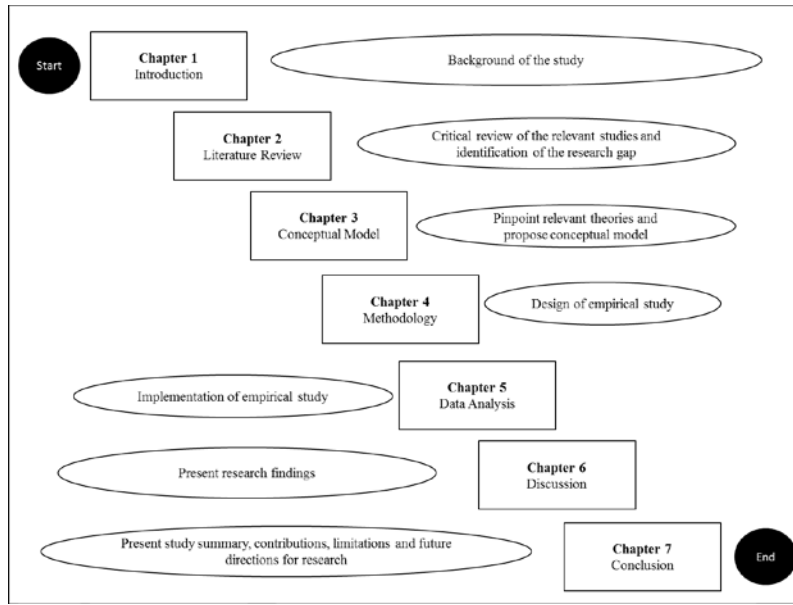
Figure 1.1: Outline of the chapters

1.7   Summary

In this chapter, the research topic is introduced and the research problem is presented which is that obesity prevalence continues to increase because existing interventions aimed at fighting obesity have not been successful. One of the hypothesized causes of the continued increase in obesity prevalence is that existing interventions are focused on the individual and they lack the proper understanding of obesity in the social context (i.e. the effect of social networks). Researchers realized the importance of social networks on obesity prevalence and the need for a new approach to tackle obesity where the social environment must be considered. Although many social network studies were conducted, much of the research has explored the role of social networks in promoting health through social influence and selection. Less research examined how network properties could interact with health behaviour among individuals. Although, there is evidence for behaviour associations between individuals in social networks regardless of the underlying mechanism being social influence or selection. There is a lack of evidence regarding the role of network properties on behaviour associations between individuals. The research aim which is to examine the role of friendship network properties on the associations between individuals and friends' weight-related behaviours in addition to four objectives were presented followed by a discussion of the research context and the research

methodology adopted. Finally, the overall structure of the thesis and the outline of the chapters were presented.

Chapter 2: Literature Review

2.1   Introduction

Obesity has reached epidemic proportions in the United States and other developed countries (Wadden, Brownell and Foster, 2002); and obesity prevalence continues to increase despite the countless efforts to decrease it (Wang et al., 2008). One of the main hypothesized causes of the continued increase in the obesity epidemic is that the current preventative measures are individually targeted and they lack the proper understanding of obesity in the social context (i.e. the effect of social networks on obesity) (Nam, Redeker and Whittemore, 2015). The term social networks refers to a set of individuals and the ties among them (Wasserman and Faust, 1994). Social networks pervade our lives on a daily basis: we interact, influence, and are influenced by our friends and acquaintances (Pinheiro et al., 2014). Social networks have long been studied by health and behavioural scientists in relation to health behaviours. Recently, there has been a growing interest in understanding the effects of social networks on obesity and weight-related behaviours including diet, physical activity, and sedentary behaviour. The purpose of this chapter is to organise the existing literature on obesity and social networks and identify emerging themes and future directions for research in order to examine their relevance as a potential approach to modify the behavioural risk factors of obesity. The literature review was done for the effect of social networks on three different but interrelated areas of research. The first area is health behaviours in general; researchers have studied the positive and negative effects of social networks on different health outcomes prior to obesity and this is why it is important to discuss the effects of social networks on health behaviours in general. The second area is obesity which was the main driver of this research. The third area is weight-related behaviours specifically in adolescent friendship networks where the research gap was pinpointed. In Section 2.2, a discussion of the role of social networks on various health behaviours including smoking behaviour, drinking behaviour, drug use behaviour, and HIV risk behaviour is presented. In Section 2.3, a discussion of obesity in the social context which includes the effects of both social networks, peer socialization, selection, and a description of the reflection problem and its relevance to the obesity epidemic is presented. In Section 2.4, a discussion of weight-related behaviours in adolescent friendship networks is presented where peer and friends behaviours,

networks properties and their relevance to the individual's weight-related behaviours is examined. In Section 2.5, a discussion of the moderating role of friendship network properties on peer selection and socialization in health behaviours is presented in Section 2.5. Finally a discussion of the emerging gaps the future directions of research is presented in Section 2.6 followed by the summary of Chapter Two in Section 2.7.

2.2   Health behaviours in the social context

Health researchers have studied the positive and negative effects of social networks on different health outcomes long before obesity. In health research, social network analysis has increased over the last ten years and has primarily focused on smoking behaviour, drinking behaviour, drug use behaviour, and other infectious disease risk behaviours including HIV risk behaviour (Nam, Redeker and Whittemore, 2015). A number of studies address the negative effects of social networks on health outcomes. Social networks have a strong negative influence on HIV risk behaviours (Latkin et al., 2011). Social network structure (i.e. size and density), social influence, social engagement and social norms impact HIV risk behaviours (Bailey et al., 2007). Social networks also have a positive effect on health outcomes through social support and social integration. It has been found that individuals who lacked social ties were more likely to die than those with more contacts (Berkman and Syme, 1979). Additionally, social networks positively influence mental health outcomes such as depression by increasing social support and social integration (Berkman et al., 2000; Berkman and Glass, 2000). Social isolates are more likely to smoke than those in other social network positions, so peer group isolation which results from the lack of social ties (contacts) is closely related to smoking behaviour among adolescents (Seo and Huang, 2012). Similarly, socially isolated women were more affected by breast cancer than those who are socially integrated (Michael et al., 2002).

There is evidence that social networks are significant to adolescent smoking behaviour through two mechanisms social selection (homophily) and social influence which contribute to the initiation and maintenance of smoking (Seo and Huang, 2012). There is also evidence that alcohol consumption behaviour is influenced by network phenomena and the clustering was not only caused by social selection (homophily) but also seem to reflect social influence (Rosenquist, et al., 2010). Additionally, alcohol consumption renouncement among network members is associated with decreased alcohol consumption among other network members (Rosenquist, et

al., 2010). Both social selection and social influence impact drinking patterns among adults, however, the effect of social selection (homophily) is considerably stronger than the effect of social influence on drinking patterns among adults (Bullers, Cooper and Russell, 2001). Finally, there is some evidence showing a greater improvement of health risk behaviours among network members when the intervention targets the social network (Booth et al., 2011; Latkin et al., 2009). The effects of social networks on health have long been studied by researchers, more recently researchers started investigating the effects of social networks on obesity which will be discussed in Section 2.3 below.

2.3   Obesity in the social context

There has been a growing interest in studying the effects of social networks on obesity. Christakis and Fowler, 2007 published a paper on the spread of obesity in a large social network back in 2007 where they found obese individuals to cluster together and concluded that person's chances of becoming obese increased by having an obese friend(by 57%), sibling(by 40%) or spouse(by 37%). The findings of their study were somewhat controversial as it offered evidence that obesity may spread like an infection. Their study generated a remarkable degree of interest and the idea of communicability (contagiousness) of obesity was originated. So if obesity was contagious then public health policy makers needed to re-evaluate their intervention strategy. In addition to interest their findings brought scrutiny, including critiques that the contagion (social influence) effects were not identifiable from homophily (Shalizi and Thomas, 2011) .Several studies followed to investigate the sensitivity of Christakis and Fowler's claim and assess the nature and extent of the person to person spread of obesity and could not dismiss their findings (Cohen Cole and Fletcher, 2008: Bahr et al., 2009). Researchers started to look at the causes of the observed network clustering. Some researchers argued that it was the shared environment that was causing the appearance of obesity spreading through social networks (names of researchers). Cohen Cole and Fletcher, 2008 argued that the spread of obesity is related to the individuals' environment and that the shared environmental factors may cause the appearance of social network effects. However this did not completely rule out the possibility of person-to-person spread of obesity (Cohen Cole and Fletcher, 2008). Another argument was that social selection or homophily (love of sameness) is what is causing obese individuals to cluster together, and the observed network contagion cannot be distinguished from homophily (i.e. birds of a feather flocking together) (Shalizi and Thomas, 2011). This is a long standing problem in

epidemiology and social sciences that is known as "The Reflection Problem". Three mechanisms were highlighted in the literature that could explain the observed "network contagion": 1) social influence; 2) confounding by shared social environments of network members; and 3) homophily (Shoham et al., 2012). This has been a longstanding problem in epidemiology and social sciences and it is best described by Manski as the "reflection problem" because all of these mechanisms mirror one another (Wasserman and Faust, 1994). The below subsections will address the literature on the infectious nature of obesity and other factors that could explain the clustering of obesity in social networks including shared environment, homophily and social influence and how they could explain the observed network clustering/contagion:

2.3.1 Infectious nature of obesity

There is a substantial amount of literature on infectious disease models for communicable diseases including influenza, bird flu, leprosy, tuberculosis etc. Many behavioural phenomena have been found to spread over social networks in a way similar to infectious diseases (Hill et al., 2010). Obesity like other socio-infectious diseases (sexually transmitted diseases (STD's)) can be considered a social contagious disease (Demongeot and Taramasco, 2014). A number of scholars employed classic epidemic models to have a better understanding of the nature and extent of the spread of obesity over social networks because they believe that obesity spreads in a way similar to an infection. Hill et al., 2010 extended the classical compartmental SIS infectious disease model to include an "automatic" or "spontaneous" factor (SISa) and found that the prevalence of obesity is increasing both spontaneously and transmissively, rather than by decreasing rates of losing weight. Gonzalez-Parra et al., 2010 proposed an extended compartmental model which provides new scenarios of transmission for obesity however their model had many problems that requires investigation. Ejima, Aihara and Nishiura, 2013 also proposed an epidemiological model that describes the obesity epidemic by taking into account the social contagion and non-contagious aspects of obesity in order to compare the effectiveness of different types of interventions. They found that the optimal choice of intervention programs depends on the contagiousness of obesity. Frerichs, Araz and Huang, 2013 devolved a systems dynamic model to assess the sensitivity of childhood overweight and obesity prevalence and the social transmission and to test the effect of treatment, prevention and interventions on the prevalence of childhood overweight and obesity. They found that the social transmission of obesity should be considered when designing prevention and treatment interventions. If obesity

was contagious then filling data gaps of obesity transmission would help better understand and control the obesity epidemic (Ejima, Aihara and Nishiura, 2013). Although there are a number of studies that examined the transmission of obesity, there are other studies that considered other factors that could explain obesity clustering such as the shared environment, social selection and influence which will be discussed in the subsections below.

2.3.2   Obesity and shared environment

In recent years, a major focus in epidemiology has been the study of how residential environments or neighbourhoods may affect health (Auchincloss and Diez Roux, 2008). Some researchers also started studying how sharing the physical environment could explain the observed network contagion. The physical environment is the environment surrounding individuals and haring the same physical environment means having access to the same restaurants, grocery stores, gyms, walkable roads, and other facilities. It has been found that Obesogenic environments may be driving the increase in obesity prevalence by encouraging unhealthy eating behaviours and physical activity (Harrington and Elliott, 2009). Although, shared environmental factors may be causing the appearance of social network effects however this does not completely rule out the possibility of the person to person spread (Cohen-Cole and Fletcher, 2008). Another finding suggests that the importance of the environmental factors depends on the structural properties of the population in terms of networks for instance being small-world or scale-free (Giabbanelli et al., 2012). So, the observation of obesity has to use monitoring of both the social networking, as well as the surroundings (Demongeot and Taramasco, 2014). In order to reduce obesity, the social neighbourhood and physical environment must both be considered when developing health policies and interventions (Franzini et al., 2009). Although there is evidence that the physical environment is a contributing factor to the obesity epidemic however this does not rule out the importance of the social environment. Therefore, the social and physical environment must both be considered when addressing obesity because both the physical environment and the interactions between a person and others in the same social network will bias their weight (Bahr et al., 2009).

2.3.3   Obesity and social selection

Social selection or homophily "love of sameness" is the tendency of individuals to associate with similar individuals. There is evidence for homophily in a large number of social networks'

studies on age, gender, class, religion (McPherson, Smith-Lovin and Cook, 2001). Homophily or selection in obesity research is almost always related to weight or BMI status. Some researchers argued that the clustering of obese individuals is a result of homophily, which results in individuals selecting others that are similar to them and it is not necessarily due to social influence. There is evidence for homophily on weight and on BMI, however social influence on BMI is independent of friend selection so homophily does not rule out social influence (Shoham et al., 2012). One study found partial evidence consistent with social selection but only for the selection behaviour of non-overweight youths, overweight youths were indifferent may be dto the weight status of their friends (Schaefer and Simpkins, 2014). Although adolescents select friends based on similarity, the effect of similarity does not significantly impact overweight prevalence (Zhang et al., 2015). There seems to be evidence of homophily on weight status. However, homophily does not significantly impact overweight prevalence and does not rule out social influence. Human beings have always had the tendency to associate themselves to people who are similar but the rise in obesity has increased rapidly over the last three decades could not be explained by homophily. That being said, a consideration of homophily is still necessary to have a full understanding of obesity.

2.3.4   Obesity and social influence

Christakis and fowler were the first to propose that the social contacts of individuals directly or indirectly influence obesity-related behaviours and therefore social networks structure shapes who becomes obese (Christakis and Fowler, 2007). Shoham, 2015 and his fellow researchers called this the "social influence hypothesis". Social networks work as a medium for spread of behaviour by shared activities or similarities between individuals (Zheng et al., 2012). Social influence also known as socialization occurs when someone's behaviours are affected by others. Social influence is defined in the Blackwell Encyclopaedia of Sociology as change in an individual's thoughts, feelings, attitudes, or behaviours that results from interaction with another individual or a group (Social influence, 2007). Social Influence or socialization is channelled through social networks and can take different forms. The most common forms of social influence in the obesity context include peer influence, social norms and social capital which will be discussed below:

a)   **Peer influence** is a form of social influence and it encourages individuals to change their attitudes, values, or behaviours to conform to the group. Peers are people who you socialize with or that are similar in your age, interests or in some other way. Peer influence is investigated in the context of obesity and social network and is mostly studied in adolescents' age group. Adolescents are more vulnerable to peer influence than adults and children (Steinberg and Monahan, 2007).   Researchers were interested in determining the influence of peers on adolescents' weight in schools and whether overweight adolescents are more likely to have overweight peers. There is evidence that overweight adolescents were more likely to have overweight friends than their normal-weight peers (Valente et al., 2009). Additionally, the mean peer BMI is correlated with adolescent BMI and is more influential among adolescents with the highest BMI (Trogdon, Nonnemaker and Pais, 2008). Adolescents are more responsive to the body weight of their same gender friends (Renna, Grafova and Thakur, 2008). Females are more sensitive to peer BMI than males (Trogdon, Nonnemaker and Pais, 2008). Higher Body Mass Index (BMI) of close friends is correlated with a higher BMI of the respondent adolescent among women (Renna, Grafova and Thakur, 2008). Peer exposure was also positively associated with individuals' health behaviours. The influence of peers on adults' weight was also investigated by some researchers. In the workplace, modest evidence for clustering of some health behaviours (smoking, body mass index (BMI) and physical activity was found within workgroups (Quist et al., 2014). When selected employees in the workplace were trained to promote healthy eating and physical activity amongst their peers as part of a comprehensive obesity prevention program they became role models and helped in creating health-promoting social and environmental changes at the work place (de Souza et al., 2014). The influence on married couples BMI and whether observing a partner's health status explains social learning leading to correlated BMI's has also been investigated. There is significant correlation in partner BMI implying evidence of a social impact even after controlling for individual health, spouse health, marriage length and regional effects (Brown, Hole and Roberts, 2013) and peer influence can diminish prevention programs (Shin et al., 2014).

b)   **Social norms** both body image norms and eating norms, are identified as a major source of social influence through networks (Hammond, 2010). Body image which is defined as the perception of one's own weight may play a role in obesity spread since a high prevalence of obesity may shift people's perception of what is normal (Bagrowicz, Watanabe and

Umezaki, 2013). After assessing the role of body image norms in the spread of obesity over social networks (i.e. the social contagion). It was found that the role of shared body size is only minor in the social contagion of obesity among adults so interventions targeting behaviours may be more beneficial than interventions changing ideas about appropriate body size (Hruschka et al., 2011). Whether or not body weight gain is impacted by changes in body image further investigation is needed to better understand the role of body image in the spread of obesity (Bagrowicz, Watanabe and Umezaki, 2013). Among children, social norms influence children's BMI and high obesity prevalence will lead to an increase in their BMI due to increased socially acceptable mean BMI (Wang et al., 2014).

c)   **Social capital** is an additional type of social influence (Hammond, 2010). Social capital is defined as the actual or potential resources an individual has access to because of belonging to certain groups (Bourdieu, 2005). These resources include recognition, respect and friendship or institutionalized guarantees such as legal claims. There is evidence that low social capital is associated with a high risk of being obese among adults (Muckenhuber et al., 2015). Additionally, individual network social capital is associated with a lower likelihood of increased waist circumference risk and obesity (Moore et al., 2008).

There is evidence for social influence on obesity across different age groups (adults, adolescents and children). Compared to adults and children, adolescents are more vulnerable to peer and friend influence (Steinberg and Monahan, 2007). Compared to peers, friends are expected to be more influential since friendships are characterized with intense feelings, frequent interactions, and interactions of longer duration (Berten and Van Rossem, 2011). The social transmission of weight-related behaviours is a possible explanation for the spread of obesity in friendship networks (Ali, Amialchuk and Heiland, 2011).There is still much to learn about how friends influence each other, under what circumstances, the mechanisms through which influences can occur, and the ways in which programs can involve friends to promote healthy weight (Cunningham et al., 2012). The next section will discuss weight-related behaviours in adolescent friendship networks.

2.4   Weight-related behaviours in adolescent friendship networks

During childhood, adults and parents are the main source of influence on children's behaviours (Markward et al., 2003). Transitioning from childhood to adolescence, children spend less time

with their parents, and more time with their friends (Larson and Richards, 1991). Friendships are an important social context for the spread and maintenance of weight-related behaviours during adolescence (de la Haye et al., 2010). There is evidence suggesting that the weight-related behaviours of the individual are associated with the weight-related behaviours of a friend or group of friends (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). Existing evidence on weight-related behaviours in friendship networks follow two themes; the first examines the associations between peer or friends and individuals' behaviour (i.e whether there is a similarity in diet, physical activity and sedentary behaviour between the individuals and their friends (Ali, Amialchuk and Heiland, 2011; Barclay, Edling and Rydgren, 2013; de la Haye et al., 2010; de la Haye et al., 2011; de la Haye et al., 2013; Finnerty et al., 2009; Garcia et al., 2016; Geller et al., 2013; Sawka et al., 2014; Simpkins et al., 2013) .The second theme examines the associations between individual behaviour and properties of friendship networks (Bot et al., 2016; de la Haye et al., 2010; de la Haye et al., 2013; Marks et al., 2015; Sawka et al., 2014; Simpkins et al., 2013). Both themes will be discussed in the sections below:

2.4.1   Associations between friends and individuals' weight-related behaviours

There is evidence suggesting that the weight-related behaviours of the individual are associated with the weight-related behaviours of their friends (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). A discussion of peer and friends associations for each of the weight-related behaviours that are addressed in the literature is provided below:

1)   Diet

Adolescents' and peers' diet are positively associated (Chung, Ersig and McCarthy, 2017). There is a significant positive association between individual's and their peers' fast food consumption (Ali, Amialchuk and Heiland, 2011). Individuals also have a greater probability of eating healthily if a nominated peer eats healthily (Barclay, Edling and Rydgren, 2013). The findings of some of the studies are gender specific (de la Haye et al., 2010; Finnerty et al., 2009). For instance, Male friends were also found to be similar in their consumption of high calorie foods (de la Haye et al., 2010). A few researchers found no evidence of peer or friend influence on individuals' dietary habits (Finnerty et al., 2009; Geller et al., 2013) and argued that the parents/ guardians had the dominant influence on adolescents' dietary behaviours in comparison to their friends (Geller et al., 2013).

2)   Physical activity

There is significant positive association between individual's and their peers' physical activity (Ali, Amialchuk and Heiland, 2011; Chung, Ersig and McCarthy, 2017). Individual's physical activity level is significantly influence by friends' physical activity level (Sawka et al., 2013). Being active with friends is positively associated with adolescents' overall physical activity (Salvy et al., 2016). Additionally, individuals tend to befriend peers who did similar amounts of physical activity (de la Haye et al., 2011). Findings were not gender specific as both males and females higher levels of friends' MVPA was associated with higher levels of MVPA among peers (Garcia et al., 2016).

3)   Sedentary behaviour

Evidence surrounding friendship influence on individual sedentary behaviour is inconsistent (Sawka et al., 2013). One study found that adolescent girls' sedentary behaviour is associated with their close friends' sedentary behaviour over time (Raudsepp and Riso, 2017). There are different forms of sedentary behaviour but the majority of studies investigating sedentary behaviour in the social context use screen time. One study found female friends to engage in similar screen based behaviours (de la Haye et al., 2010). Another study found that males screen time was associated with higher levels of screen time among their friends (Garcia et al., 2016). Associations between adolescents and their friends' sedentary behaviour including screen time are inconsistent and gender specific

4)   Sleep

Children with late weekday bedtimes were twice as likely to be obese as adolescents in comparison to those with early weekday bedtimes (Yoong, 2017). Sleep deprivation is an important risk factor of obesity but it has generally been neglected in the social networks literature (Maume, 2013). There is only one study that investigated sleep deprivation(sleeping six hours or less) in the social context; and found no evidence on similarity in sleep behaviour among peers(Ali, Amialchuk and Heiland, 2011). Compared to diet, physical activity and sedentary behaviour, sleep is understudied in the literature.

2.4.2   Associations between friendship network properties and weight-related behaviours

Social network analysis allows the examination of connections between individuals and their behaviours, in addition to examining social network position, network structure, and their relationship with individual behaviour (Luke and Harris, 2007). Thus, social network analysis provides a broad list of network properties. Different friendship network and individual level properties appeared to have different consequences on different weight-related behaviours. The various network measures that are of usual theoretical interest and their relevance to the different weight-related behaviours are discussed below:

1)   Network Size

Network size refers to the number of ties in the network (Wasserman and Faust, 1994). In general, poor health is found to be positively associated with network size among adolescents (Haas, Schaefer and Kornienko, 2010). Network size of children/adolescents' friendship groups was found to be positively associated with physical activity (de la Haye et al., 2010). So the bigger the network, the more likely the individual in that network will be physically active. There is no evidence on association between network size and sedentary behaviour among adolescents (Sawka et al., 2014). Individuals with more close friends and a larger social network showed higher levels of vegetables consumption and physical activity in addition to lower levels of sedentary behaviour (Bot et al., 2016).

2)   Network Density

Network density refers to the proportion of ties in the network (Wasserman and Faust, 1994). Network density was found to be positively associated with sedentary behaviour among boys (Sawka et al., 2014). So in dense networks, boys are more likely to be sedentary. There is also no evidence on association between network density, physical activity and diet among adolescents (de la Haye et al., 2010; Sawka et al., 2014). Denser networks also showed higher levels of vegetable consumption and physical activity (Bot et al., 2016).

3)   Popularity (in-degree)

Popularity or in-degree refers to the number of nominations received (Wasserman and Faust, 1994). Popularity was found to be positively associated with some health risk behaviours

(Prinstein et al., 2011). Popularity was found to be positively associated with consumption of unhealthy snacks among males (de la Haye et al., 2010). So popular boys were the highest consumers of unhealthy snacks. There is no evidence on association between popularity, physical activity and diet (de la Haye et al., 2010; de la Haye et al., 2011; Sawka et al., 2014; Simpkins et al., 2013).

4)   Betweenness centrality

Betweenness centrality is a measure of centrality as the name suggests and it refers to the degree an individual lies on the shortest path connecting others in the network (Freeman, 1978). For example central people (betweenness centrality) are found highly influential in group behaviours (Valente, 2010). In general, individual centrality is positively associated with positive health outcomes (Perkins, Subramanian and Christakis, 2015). Adolescents in poor health occupy less central global positions than their healthy peers (Haas, Schaefer and Kornienko, 2010). However, there is no evidence on association between betweenness centrality, physical activity and sedentary behaviour (Sawka et al., 2014).

5)   Clique membership

Clique membership refers to belonging to a set of individuals who communicate with each other more frequently than with other individuals in the community (Valente, 2010). Compared to isolates, clique members are at a lower risk of engaging in unhealthy behaviours (Seo and Huang, 2012). There is no evidence on association between clique membership, diet, physical activity and sedentary behaviour (de la Haye et al., 2010; Sawka et al., 2014).

Among adolescents, popularity (i.e receiving ties) was found to be positively associated with consumption of unhealthy snacks among males so popular boys were the highest consumers of unhealthy snacks (de la Haye et al., 2010). Additionally the size of children/adolescents' friendship groups was found to be positively associated with physical activity (de la Haye et al., 2010). Network density was positively associated with sedentary behaviour among boys so boys in dense networks were found to be highly sedentary (Sawka et al., 2014). Other friendship network measures including centrality (an individual's tendency to connect with other network members) and clique membership (belonging to a set of individuals who communicate with each other more frequently than with other individuals in the community) were also investigated but

there were inconclusive findings on associations between them and weight-related behaviours (de la Haye et al., 2010; Sawka et al., 2014). Generally, centrality is found to be positively associated with positive health outcomes and clique members are at a lower risk of engaging in unhealthy behaviours compared to isolates (Perkins, Subramanian and Christakis, 2015; Seo and Huang, 2012). The next section will present a discussion the role of network properties on friends' behaviour that was addressed in other socially linked health behaviours.

2.5   The role of friendship network properties on peer selection and socialization

There is evidence suggesting that the weight-related behaviours of the individual are associated with the weight-related behaviours of a friend or group of friends (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). However the role of social network ties and their properties on these associations is not clear (Sawka et al., 2013). Despite the evident above-mentioned links between friendship networks properties and weight-related behaviours that were presented in Section 2.4.2; the network properties have not been examined in detail similar to socially linked issues such as alcohol consumption, drug use, and tobacco use (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). Research began to address more detailed questions regarding peer socialization process and network properties (Brechwald and Prinstein, 2011). One of the key questions is whether behaviour association (either peer socialization or selection) is dependent on the local network structure (Jose et al., 2016). In other socially linked behaviours including alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour some network properties were found to play a moderating role on peer selection and socialization among adolescents (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). Building on the insights of a large body of social network literature, it is not surprising that certain network properties are important for moderating peer socialization and selection processes (Jose et al., 2016). Network density was found as an important moderator on delinquency peer association, individuals were found to be more similar in delinquency to their peers in denser networks (Haynie, 2001). In dense networks, ideas and actions are easily viewed by members which helps establish a group identity (Haynie, 2002). Adolescents in denser networks are also more likely to feel a stronger attachment to the network members which increases susceptibility for peer association (Friedkin, 2004). Individual popularity was also found to moderate social selection based on alcohol consumption; popular adolescents were more likely to select friends who were highest consumers of alcohol (Mathys, Burk, and

Cillessen, 2013). Popular adolescents may be compelled to match the behaviours of their peers to maintain their high social status or to raise their existing social status (Dijkstra, Cillessen, and Borch, 2013). Individual centrality was also found to positively moderate the association between friends' expectancies and youths' expectancies on smoking (Lakon and Hipp, 2014). Individual centrality may also affect individual's susceptibility to influence since central individuals are located in a prominent position in the network to interact with most of the network members (Jose et al., 2016). Central adolescents receive regular feedback from the network members, making them more susceptible to influence (Ramirez et al., 2012). Central adolescents also show a greater attachment to the group (Paxton and Moody, 2003).Which may make them more susceptible to the influence of their peers. This suggests the need to consider the underlying structural properties of friendship networks in order to understand how network properties condition the socialization and social selection of adolescent behaviour. The moderating role of network properties on peer/friend association of weight-related behaviours has not been addressed.

2.6   Identifying the research gap

The effects of social networks on health behaviours in general and obesity were discussed in Sections 2.2 and 2.3. In Section 2.4, weight-related behaviours in adolescent friendship networks were presented. Finally in Section 2.5, the role of network properties on other socially similar behaviours was discussed. This section shows how the gaps in the research have been identified which will form the research path. A complete summary for each of the publications with its purpose, approach, major findings and limitations that were used to pinpoint the research gap is presented in Appendix 1. The publications were briefly presented in Sections 2.4 and 2.5 above and evolved around two themes as was already explained. The first theme was on weight-related behaviours in adolescent friendship networks and the second theme was on the moderating role of friendship network properties on peer selection and socialization. The main gap (gap 1) was identified in Section 2.5 after finding that the moderating role of network properties on behaviour associations in weight-related behaviours was not examined before. Another gap (gap 2) was also identified in Section 2.4.1 after finding that sleep was under investigated in the social context in the literature. Other themes were also identified in the literature as knowledge gaps (gaps 3 and 4) and are also discussed below:

- **Gap 1: lack of understanding of the moderating role of friendship network properties on weight-related behaviours associations between friends**

Properties of friendship networks have been linked to weight-related behaviours; however the network properties have not been examined in detail (Sawka et al., 2013). During the last ten years, research has begun to address important questions regarding moderators of the peer socialization process (Brechwald and Prinstein, 2011). One important set of moderators is the properties of the relationship between the individual and his/her peers (Mathys, Burk, and Cillessen, 2013). The moderating role of some network properties on peer selection and socialization of adolescent, drug use, tobacco use, alcohol consumption aggression and delinquent behaviour has been investigated (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). However, the moderating role of network properties on behaviour association (regardless of the underlying mechanisms being socialization or selection) has not been addressed in the obesity literature and remains a gap in the literature. Examining the moderating role of network properties on behaviour associations can provide a better understanding of how network properties interact with behaviour which will assist in gaining insight into the development and persistence of weight-related behaviours in adolescent friendship networks. This thesis will examine the moderating role of friendship network properties on behaviour association in weight-related behaviours in adolescent friendship networks.

- **Gap 2: the need to investigate sleep behaviour in friendship networks**

There is extensive research on diet, physical activity and sedentary behaviour in the social context. Future studies should investigate whether peer influence in obesity operate via other pathways that have not been examined (Ali, Amialchuk and Heiland, 2011). Sociologists recognize the importance of social ties and their effects on health behaviours but have generally neglected sleep (Maume, 2013).Studies to examine sleep effects on obesity are needed in order to establish the central role of sleep in promoting health (Maume, 2013). Only one study investigated sleep in social contexts and found no evidence in support of peer effects on sleeping six or less hours (Ali, Amialchuk and Heiland, 2011). This thesis will investigate sleep behaviour in friendship networks.

- **Gap 3: the need to understand weight-related behaviours in friendship networks in a new context**

Most of the research was conducted in Australia, Europe, North America and the United Kingdom. Whereas none of the studies were conducted in the Middle East or the gulf region. Future studies in different cultural contexts and different clinical samples are required (Tonetti et al., 2014). This thesis will use a new context, one that has not been used before to investigate such phenomenon.

- **Gap 4: the need to describe the conceptual model**

Although there is evidence that peers, friends and broader social networks influence diet and physical activity during childhood and adolescence; research on peer influence effects on youths' diet and physical activity been largely a-theoretical especially research on peers and physical activity (Salvy et al., 2012). Future studies on the effect of friendship on adolescent's physical activity and sedentary behaviour should describe the theoretical frameworks/models underpinning their methodologies (Sawka et al, 2013). This thesis will describe the conceptual model informing the methodology.

In order to address the research gaps, two research questions are proposed to guide this research are listed:

1.   Is there an association between Bahraini adolescents' weight-related behaviours (diet, physical activity, sedentary behaviour and sleep) and their friends' weight-related behaviours?
2.   Are the associations between individuals' weight-related behaviours and their friends' weight-related behaviours moderated by certain friendship network properties (density, popularity and centrality)?

The first research question will address gaps 2 and 3 since associations between individuals' weight-related behaviours and their friends' weight-related behaviours including sleep will be tested in a new context i.e. schools in the Kingdom of Bahrain. The second research question will address gap 1 which is to test the moderating role of network properties on the associations tested in the first research question. Gap 4 will be addressed because the research questions will be answered by testing a conceptual model which will be proposed in Chapter Three.

2.7   Summary

The general purpose of the reviewed articles in this chapter is to understand obesity and specifically weight-related behaviours(diet, physical activity, sedentary behaviour, sleep) in the social context (i.e. the effect of social networks) and identify future directions of research in order to provide recommendations for the policy makes to improve existing interventions to overcome the obesity epidemic. A full understanding of the obesity epidemic is likely to include individual behaviour and interactions between the individuals known as social networks. The literature was reviewed for the effects of social networks on three different but interrelated areas of research which include health behaviours in general, obesity and weight-related behaviour where the research gap was pinpointed. It is evident from the literature that adolescents share similar weight-related behaviours with their friends. It is also evident that properties of the network are important for behaviour associations. However, there is still much to learn about the role of network properties on behaviour associations between friends. Studies on other socially similar behaviours including smoking, drinking and delinquent behaviours found that some network properties act as moderators on behaviours association between individuals and their friends (regardless of the underlying mechanism being social influence and selection). Testing the moderating role of network properties on weight-related behaviour associations between individuals and their friends could aid in better understanding the spread and maintenance of weight-related behaviours in friendship networks. In the next chapter, a conceptual model will be proposed to answer the research questions.

Chapter 3: Conceptual Model

3.1   Introduction

The literature suggests that friendships are an important social context for weight-related behaviours; thus taking into account the complex structure of friendship ties is vital for understanding the role of friendship influences on these behaviours (de la Haye et al., 2010). The main research gap was identified in the previous chapter, this chapter will propose a conceptual model that attempts to fill this gap. The theory underpinning the conceptual model will be discussed in Section 3.2. The development of the conceptual model that is proposed to explore associations between the individual's and his/her friends' weight-related behaviours (diet, physical activity, sedentary behaviour and sleep behaviour) and to examine the moderating role of properties of friendship networks on behaviour associations will be presented in Section 3.3.The proposed conceptual model will be presented in Section 3.4. Finally, a summary of the chapter will be presented in Section 3.5.

3.2   Theory development

Exploring theoretical underpinning of network properties and weight-related behaviours aiming to developing a detailed structure that explains the multitude of associations between friends' weight-related behaviours and whether or not they are amplified by certain network properties. First, we will look at Social Network Theory in order to identify the friendship network properties to be used for developing the conceptual model since it provides the necessary tool to examine network structure position and how they interact with individual behaviour in friendship networks. Following the different mechanisms that could be causing behaviour association i.e. similarity in behaviour between individuals and their friends will be discussed.

3.2.1   Social network theory

 Network analysis is a methodological tool and a theoretical paradigm from Network Theory proposed by Granovetter (Sawka, 2014). Network analysis provides a unique approach of analysing structural and relational aspects of health (Luke and Harris, 2007). The term "social

networks" refers to a set of individuals and the social ties (or relationships) among them (Wasserman and Faust, 1994). Social network analysis is the structural approach based on the social ties between individuals (Freeman, 2004). The approach is focused on the patterns and implications of the social ties between the individuals because these ties have important consequences on their behaviour (Wasserman and Faust, 1994). Specifically, social network analysis allows examining ties between individuals and their behaviours, in addition to examining their network position, their network structure, and their relationship with individual behaviour (Luke and Harris, 2007). This approach provides valuable insight for understanding population-level outcomes (Luke and Harris., 2007). Social network analysis provides different measures at three different levels; the individual level, the sub-Figure level and the overall network level (Wasserman and Faust, 1994). Individual level measures provide information on the individual position and they include betweenness centrality (degree an individual lies on the shortest path connecting others in the network), degree (number of ties an individual sends (out-degree) or receives (in-degree), degree of separation (number of friend of a friend), isolate (individual with no incoming or outcoming connections), popularity (number of nominations received), and reciprocity (returned nominations between two individuals) (Freeman, 1979; Macdonald-Wallis et al., 2011; Valente, 2010; Wasserman and Faust, 1994). Sub level measures include cliques where three or more individuals are all connected (Wasserman and Faust, 1994).Individual and subgraph level measures provide useful information for analysing health behaviour (Sawka, 2014). For example central people (betweenness centrality) are found highly influential in group behaviours (Valente, 2010). Additionally, the relationship between an individual's obesity was found up to three degrees of separation (Christakis and Fowler, 2007). Network level measures provide information on the overall properties of the network and they include network size (number of ties in the network), network density (proportion of ties in the network), network reciprocity (proportion of returned nominations) and network centralization (the extent to which ties are centralized within the network) (Wasserman and Faust, 1994). There is evidence linking overall network properties to individuals' health and health behaviours (Luke and Harris, 2007; Valente, 2010). A description of some of the network measures that often appear in the social networks literature is provided in Table 3.1 below.

Table 3.1: Description of some network measures that often appear in the literature

Network Measure	Description
Size	Refers to the number of ties in the network (Wasserman and Faust, 1994).
Density	Refers to the proportion actual number of ties of all possible ties in the network (Wasserman and Faust, 1994).
Reciprocity	Refers to the proportion of reciprocated ties (Valente, 2010).
In-degree/Popularity	Refers to the number of received ties (Wasserman and Faust, 1994).
Out-degree	Refers to the number of outgoing ties (Valente, 2010).
Centrality	Refers to the extent of the individual being central in the network (Valente, 2010).
Cliques	Refers to subgroups of densely connected individuals (Valente, 2010).

Social network analysis is a powerful tool for examining individuals' ties and relationships in order to analyse, predict, and potentially modify individual behaviour (Sawka, 2014). Social Network Theory and analysis are useful for this research because the purpose of this research is to explore associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours and to examine the moderating role of properties of friendship networks on their weight-related behaviours. Social network analysis provides many different network measures of overall friendship network properties and individual positions in the network; however only some of these properties will be included in the conceptual model because they could act as potential moderators on the socialization and selection processes between peers and friends which will be discussed in Section 3.3.2 below.

3.2.2   Similarity mechanisms

Social network theory provides a description of the network properties, but there are different mechanisms that could explain the similarity in behaviours between individuals and their friends.

These mechanisms which include peer socialization (i.e. peer influence) and selection were briefly introduced in the previous section. Several peer influence mechanisms could explain the behaviour similarity among friends (Prinstein and Dodge, 2008). Prinstein and Dodge provide a description of the different peer influence mechanisms in their book published in 2008. Although the list may not be exhaustive; it is very informative. The first mechanism of socialization i.e. peer influence is "peer pressure" which is described as an antagonistic behaviour that forces the individual to perform a certain behaviour or conform to existing social norms and is sometimes coupled with teasing (Prinstein and Dodge, 2008). The second form is "co-participation" which is described as a supportive behaviour that allows the individual to participate in a behaviour with another individual (Prinstein and Dodge, 2008). Another form is "peer modelling" in which the individual is encouraged or discouraged to imitate a behaviour of a friend (Prinstein and Dodge, 2008). Seeing a friend perform a certain behaviour can increase the individual's self-efficacy, which in turn will encourage this behaviour adoption and maintenance (Bandura, 2004).

Although the different peer influence mechanisms described above provide an explanation for the homogeneity in behaviours among groups of friends. Peer selection or homophily is another potential mechanism that could explain the similarity in behaviour. Peer selection is different from peer influence and it refers to choosing friends with similar behaviours. The argument is that we are not necessarily influenced by our friends; rather we select friends with similar attributes or behaviours. Friends are selected based on pre-established attitudes or behaviours (Valente, 2010). There is evidence for both peer influence and peer selection in the obesity and weight-related behaviours literature as was discussed in Sections 2.3 and 2.4 in Chapter Two. Social influence (including peer influence) may not be identifiable using traditional statistical methods (including regression) because they are not able to distinguish socialization (i.e. social influence) from homophily (i.e. social selection) from shared environment (Shoham et al., 2012).

To pinpoint the specific mechanism that could explain the similarity in behaviour is not a simple process and is the focus of a growing body of research (Shoham et al., 2012; Simpkins et al., 2013; Wang et al., 2014).To overcome the confounding problem, the actor-based stochastic model is used to iteratively model the evolution of social network structure and the behaviour of the individuals in the network (Snijders, van de Bunt and Steglich, 2010). There is also a need for longitudinal data to determine the underlying mechanisms (social influence or social

selection) because cross sectional data will only lead to observed network behaviour associations. This thesis will not examine the underlying mechanism of behaviour associations. However, the underlying mechanism could be any of the mechanisms described above from the literature. The following sections will aim to establish links between the different behaviours and network properties.

3.3   Conceptual model development

There is growing research on weight-related behaviours in friendship networks. This section will present a summary from the literature on the relevant studies on weight-related behaviours in friendship networks that will assist in building the conceptual model. The model has two components a behavioural component and a network component. The first component with the different weight-related behaviours and their significance to the obesity epidemic will be presented in the context of adolescent friendships in Section 3.3.1. The second component with the role of properties of friendship networks on behaviour association will be addresses in Section 3.3.2.

3.3.1   Weight-related behaviours in adolescent friendships

Obesity is complex because it is caused by a myriad of reasons including genetic, environmental and behavioural factors (Hernandez and Blazer, 2006). Genetic and demographic variables such as predisposition to obesity, age, race and sex cannot be altered, on the other hand obesity-associated lifestyle factors including diet and exercise are often modifiable (Al-Hazzaa et al., 2012). Diet and physical activity are the "big two" contributors to the obesity epidemic (Chaput et al., 2010). Sedentary behaviour has also been found to be positively associated with obesity (Mitchell et al., 2009). Sedentary screen behaviour includes watching television, using the computer, playing video games and is considered a favourite for children's leisure time (Olds et al., 2004). Recently, short sleep was found to be associated with an increased risk for becoming obese (Hart, Cairns and Jelalian, 2011). There is extensive research investigating the effect of social networks on diet, physical activity and sedentary behaviour (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2011; Finnerty et al., 2009; Garcia et al., 2016; Geller et al., 2013; Marks et al., 2015). Although social relationships may be a key social factor influencing sleep, sleep has been understudied in the literature in the social context (Ailshire and Bulgard, 2012). Friendships are an important social context for weight-related behaviours (de la Haye et al., 2010). Especially

school friendships, since adolescents spend a large portion of their time at school with their friends (Sawka et al., 2013). There is evidence suggesting that the weight-related behaviours of the individual is influenced by the weight-related behaviours of a friend or group of friends (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). As a result, there is a need to better understand weight-related behaviours in the context of adolescent friendships which will be discussed for each of the behaviours in each of the subsections below:

i.   Diet

Adolescents' and peers' diet are positively associated (Chung, Ersig and McCarthy, 2017). There is a significant positive association between individuals' and friends' fast food consumption (Ali, Amialchuk and Heiland, 2011). Friends being similar on food consumption behaviours is a potential mechanism for the social 'contagion' of obesity (de la Haye et al., 2010). Individuals also have a significantly greater probability of eating healthily if a nominated peer also does so (Barclay, Edling and Rydgren, 2013). Additionally, the degree to which this behaviour is shared is positively correlated with the strength of the relationship between the two individuals (Barclay, Edling and Rydgren, 2013). The findings of some of the studies are gender specific which has implications for gender tailored interventions (de la Haye et al., 2010; Finnerty et al., 2009). Male friends were also found to be similar in their consumption of high calorie foods (de la Haye et al., 2010). Although adolescent intake of unhealthy foods was predicted by their friends' intake; the changes to adolescents' beliefs about unhealthy foods do not appear to be the underlying mechanism of influence from their friends (de la Haye et al., 2013). A few researchers found no evidence of peer or friend influence on individuals' dietary habits (Finnerty et al., 2009; Geller et al., 2013) and argued that the parents/ guardians had the dominant influence on adolescents' dietary behaviours in comparison to their friends (Geller et al., 2013). Unlike other weight-related behaviours, it is difficult to measure diet as a single construct as a result it was broken down into four separate constructs that were found to cause weight change in previous studies. Additionally, some researchers found evidence on similarity among friends only in some of the dietary behaviours like fast food consumption and high calorie food (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). Poor dietary behaviours including skipping breakfast, consuming insufficient amounts of fruits and vegetables, eating at fast food restaurants and consuming calorie dense snacks are all associated with a risk of abnormal weight

gain and among children and adolescents (Niemeier et al., 2006; Pereira et al., 2005; Swinburn et al., 2004). In this study the following hypothesis will be tested and are shown in Figure 3.1 below:

H1a: The individual's breakfast consumption is associated with his/her friends' breakfast consumption among adolescents.

H1b: The individual's fast food consumption is associated with his/her friends' fast food consumption among adolescents.

H1c: The individual's fruits and vegetables consumption is associated with his/her friends' fruits and vegetables consumption among adolescents.

H1d: The individual's calorie dense snacks consumption is associated with his/her friends' calorie dense snacks consumption among adolescents.

ii.   Physical activity

There is significant positive association between individuals' and friends' sports and exercise (Ali, Amialchuk and Heiland, 2011; Chung, Ersig and McCarthy, 2017). Individuals tend to befriend peers who did similar amounts of physical activity and consequently emulated their friends' behaviours (de la Haye et al., 2011). Individual's physical activity level is significantly influenced by their friends' physical activity levels (Sawka et al., 2013). Higher levels of friends' MVPA (moderate to vigorous physical activity) was associated with higher levels of MVPA among males and females (Garcia et al., 2016). There is a mutually dependent relationship between adolescent friendship networks and physical activity (de la Haye et al., 2011). Friends become similar in BMI and physical activity over time however physical activity as measured in this study was not found to explain friendship similarity on BMI, but several other potential mechanisms could be further explored (Simpkins et al., 2013). Being active with friends is positively associated with adolescents' overall physical activity (Salvy et al., 2016). Focus group data revealed that friends positively influenced participants' MVPA through engaging in activities with participants, verbal encouragement, and modelling; the most cited reason for engaging in MVPA with friends was enjoyment (Garcia et al., 2016). Children's physical activity was positively associated with encouragement from friends, friends' own physical

activity and engagement with friends in physical activity (Maturo and Cunningham, 2013). In this study the following hypothesis will be tested and is shown in Figure 3.1 below:

H1e: The individual's physical activity is associated with his/her friends' physical activity among adolescents.

iii. Sedentary behaviour

Evidence surrounding friendship influence on individual sedentary behaviour is limited and mixed (Sawka et al., 2013). One study found that adolescent girls' sedentary behaviour is associated with their close friends' sedentary behaviour over time (Raudsepp and Riso, 2017). There are different forms of sedentary behaviour but studies investigating sedentary behaviour in the social context use screen time. There is no consistent evidence in support of peer effects on TV viewing (Ali, Amialchuk and Heiland, 2011). One study found female friends to engage in similar screen based behaviours (de la Haye et al., 2010). Another study found that males screen time was associated with higher levels of screen time among their friends (Garcia et al., 2016). Friendship network properties were found to be associated with sedentary/screen time in late childhood/early adolescence, however these associations differ by gender (Marks et al., 2015). In this study the following hypothesis will be tested and is shown in Figure 3.1 below:

H1f: The individual's sedentary behaviour is associated with his/her friends' sedentary behaviour among adolescents.

iv. Sleep behaviour

Sleep deprivation is an important predictor of obesity but it has generally been neglected in the social networks literature (Maume, 2013). Only one study investigated sleep in social contexts and found no evidence in support of peer effects on sleeping six or less hours (Ali, Amialchuk and Heiland, 2011). This suggests the need to better understand sleep deprivation as a predictor of obesity in addition to diet, physical activity and sedentary behaviour in the social context.In this study the following hypothesis will be tested and is shown in Figure 3.1 below:

H1g: The individual's sleep behaviour is associated with his/her friends' sleep behaviour among adolescents.
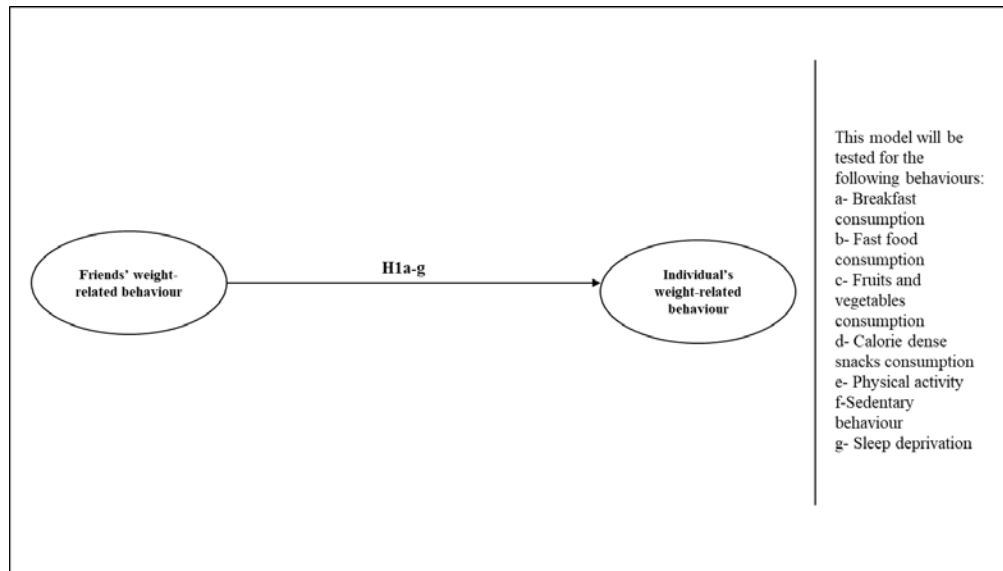
Figure 3.1: Associations between friends and individuals' weight-related behaviours

3.3.2   The role of friendship network properties

In the past decade, research has addressed more detailed questions regarding the role of network properties on the relationship between the individual's behaviour and his/her peers behaviours (Mathys, Burk, and Cillessen, 2013). Research on other socially similar behaviours among adolescents including alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour found that network properties emerge as important moderators on peer selection and socialization which was already discussed in Section 2.5 (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). However, the role of network properties on the socialization and selection process of weight-related behaviours has not been addressed and remains a gap in the literature. Research on peer influence moderators is somewhat rare but is a growing area of work (Brechwald and Prinstein, 2011). The various network measures that could act as potential moderators on the socialization and selection process of weight-related behaviours among adolescents as evident from the literature will be presented in the below subsections. Although, there are many different network properties as was already presented in Section 3.2.1 only three (density, popularity and centrality) could act as potential moderators based on findings from previous studies which were discussed in Section 2.5 in Chapter Two. The role of other network properties such as out-degree or cliques were not investigated on peer

selection and socialization in other behaviours including alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour and thus will not be considered as potential moderators.

i.   Network density

Network density refers to the proportion of ties in the network (Wasserman and Faust, 1994). There is evidence for adolescents' general poor health to be positively associated with network density (Haas, Schaefer and Kornienko, 2010). Dense networks have more pathways which allows attitudes and behaviours to flow (Valente, 2010). In highly dense networks, ideas and behaviours are easily viewed by members which helps establish a group identity or normative group behaviour among adolescents (Haynie, 2002) which amplifies their influence on behaviour and norms (Haynie, 2001). A highly dense network is better able to generate trust among individuals and reinforce conformity (Peng 2010). Further, adolescents in dense local networks are more likely to feel a strong attachment to the group which increases susceptibility to influence (Friedkin, 2004). As a result, being part of a dense network can amplify similarity/homogeneity in weight-related behaviours and reinforce conformity among adolescents. Therefore, the following hypothesis will be tested are and shown in Figure 3.2 below:

H2a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by network density.

H2b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by network density.

H2c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by network density.

H2d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by network density.

H2e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by network density.

H2f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by network density.

H2g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by network density.
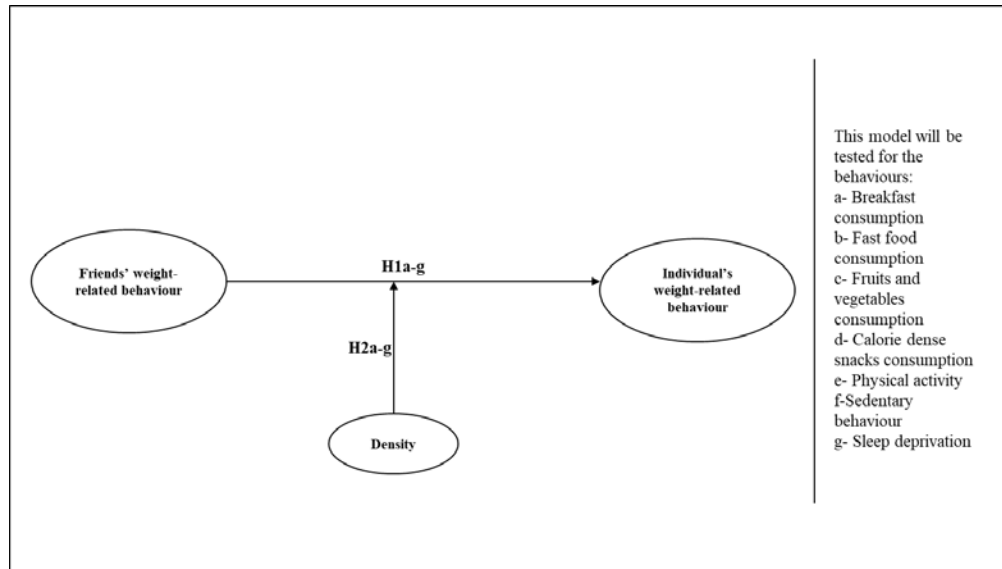
Figure 3.2: The moderating role of network density on associations between friends and individuals' weight-related behaviours

ii. Popularity

Popularity or in-degree refers to the number of nominations received (Wasserman and Faust, 1994). Popularity was found to be positively associated with some health risk behaviours (Prinstein et al., 2011). Popularity is thought to moderate the effects of peer influence among adolescents (Mathys, Burk, and Cillessen, 2013). Popular adolescents are susceptible to peer influence on behaviours that are associated with high status and are accepted in the group which suggests that the popular adolescents will change their behaviours to maintain their high status in the group (Allen, Porter, McFarland, Marsh, and McElhaney, 2005). Additionally, popular adolescents are compelled to match the behaviours of their peers to maintain their high status (Dijkstra, Cillessen, and Borch, 2013). As a result, being popular can amplify similarity/homogeneity in weight-related behaviours and reinforce conformity among

adolescents. Therefore, the following hypothesis will be tested are and shown in Figure 3.3 below:

H3a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by individual popularity.

H3b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual popularity.

H3c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual popularity.

H3d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual popularity.

H3e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual popularity.

H3f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual popularity.

H3g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by individual popularity.
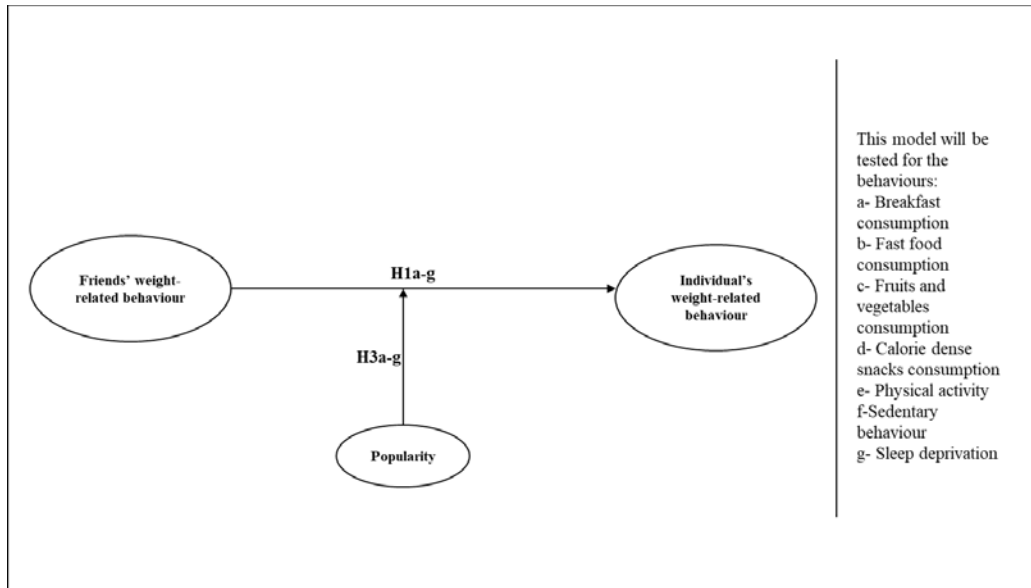
Figure 3.3: The moderating role of individual popularity on associations between friends and individuals' weight-related behaviours

iii.   Centrality

Centrality is a measure of centrality as the name suggests and it refers to the degree an individual lies on the shortest path connecting others in the network (Freeman, 1978). The centrality of an adolescent within a local group could affect their susceptibility to peer influence (Jose et al., 2016). Adolescents in central network positions receive regular feedback from their group peers which subjects them to relatively more peer influence (Ramirez et al., 2012). Additionally, central adolescents will have a greater attachment to the group (Paxton and Moody, 2003). This may make them more vulnerable to the influence of other members in their group (Jose et al., 2016).   As a result, being central can amplify similarity/homogeneity in weight-related behaviours and reinforce conformity among adolescents. Therefore, the following hypothesis will be tested are and shown in Figure 3.4 below:

H4a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by individual centrality.

H4b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual centrality.

H4c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual centrality.

H4d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual centrality.

H4e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual centrality.

H4f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual centrality.

H4g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by individual centrality.
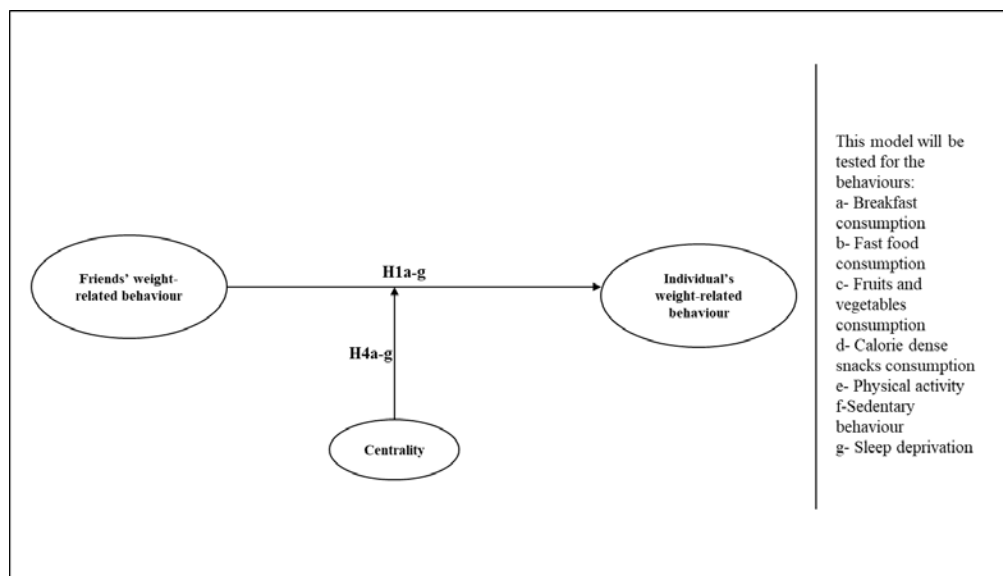
Figure 3.4: The moderating role of individual centrality on associations between friends and individuals' weight-related behaviours

3.4   Proposed conceptual model

A growing body of literature explored associations between peers and individuals' behaviour (i.e whether there is a similarity in diet, physical activity and sleep deprivation between the individuals and their friends (regardless of the underlying mechanisms) that were presented in Section 3.2.2 and they found that there are associations between some weight-related behaviours

of the individual and his/her peers or friends (Ali, Amialchuk and Heiland, 2011; Barclay, Edling and Rydgren, 2013; de la Haye et al., 2010; de la Haye et al., 2011; de la Haye et al., 2013; Finnerty et al., 2009; Garcia et al., 2016; Geller et al., 2013; Marks et al., 2015; Sawka et al., 2014; Simpkins et al., 2013). Additionally, the role of network properties on peer selection and socialization of adolescent alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour has also been investigated and three network properties emerged as moderators (density, popularity and centrality) (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). However, the role of network properties on weight-related behaviour association has not been addressed in the obesity literature and has been identified as a gap in the literature that if addressed will assist in understanding how network properties interact with weight-related behaviours in friendship networks. Additionally, sleep deprivation, a risk factor of obesity has been neglected in the social context (Ailshire and Bulgard, 2012). Figure 3.5 presents a proposed relational structure representing the associations between individuals and their friends' weight-related behaviours and how they are conditioned by their friendship network properties. The basic concept of the model presented in Figure 1 is that each of the network properties (e.g. density) may enhance or supress the similarity in friend's weight-related behaviours (e.g. diet) on the individual's corresponding behaviour. Another way to interpret it, is that individuals who belong to networks with certain properties (for instance highly dense) or hold certain positions in the network (for instance highly central position in the network) might have stronger behaviour association with their friends' (regardless of the underlying mechanism being influenced to match their friends behaviour or to select friends with similar behaviour). Testing the proposed conceptual model will help inform the design of obesity interventions for adolescents that will modify individual behaviour based on their friendship network properties.
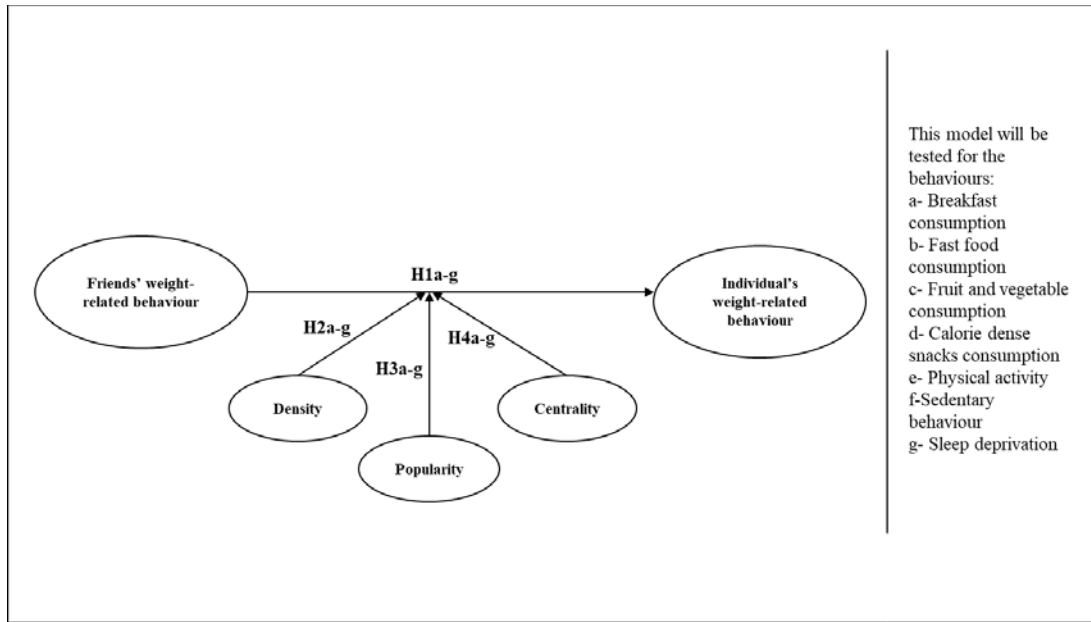
Figure 3.5: Conceptual Model for exploring associations between friends and individuals' weight-related behaviours and the moderating role of friendship network properties

3.5 Summary

Friendships are an important context for the spread and maintenance of weight-related behaviours (de la Haye et al., 2010). A better understanding of the role of friendship networks on weight-related behaviours is important in order to learn how to modify these behaviours. There is extensive research investigating associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours (Ali, Amialchuk and Heiland, 2011; Barclay, Edling and Rydgren, 2013; de la Haye et al., 2010; de la Haye et al., 2011; de la Haye et al., 2013; Finnerty et al., 2009; Garcia et al., 2016; Geller et al., 2013; Marks et al., 2015; Sawka et al., 2014; Simpkins et al., 2013). However there is a lack of evidence regarding the moderating role of friendship network properties on associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours. Additionally, future studies should investigate whether friendship networks influence obesity via other pathways (Ali, Amialchuk and Heiland, 2011). Sleep deprivation (an important predictor of obesity) has generally been neglected in the social networks literature (Maume, 2013). A conceptual model has been proposed to explore potential associations between friendship network properties and weight-related behaviours. Testing this model in different contexts can provide useful findings. Findings are informative for designing more effective network interventions that could utilise behaviour

associations between friends to improve dietary habits, physical activity, sleep behaviour and reduce sedentary time. The next chapter will present the methods used to test the proposed model and achieve the research aim and objectives.

Chapter 4: Research Methodology

4.1   Introduction

The literature suggests that friendships are an important social context for weight-related behaviours; as a result taking into account the complex structure of friendship ties is important for understanding the role of friendship influences on these behaviours (de la Haye et al., 2010). The purpose of this research is to explore associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours and to examine the moderating role of properties of friendship networks on these association through an analysis of social network and behavioural survey data. In Chapter Three, a conceptual model was proposed to explore these associations. This chapter will describe the research methodology of this study which includes the description of the selected research philosophy, methods, the study variables, the design of the instrument, sample selection, data collection and an overview of the statistical procedures that will be used to analyse the data. The research philosophy and the rationale behind it will be discussed in Section 4.2. The research methods will be discussed in Section 4.3. The study variables will be defined in Section 4.4 and the selected research instrument will be presented in Section 4.5. This will be followed by a discussion of the sampling procedure, in Section 4.6, the different data collection stages in Section 4.7 and data analysis in Section 4.8. Finally a summary of the chapter is presented in Section 4.9.

4.2   Research philosophy

This research began with a literature review and identification of a research gap which is to test the moderating role of friendship network properties on associations between the individual's and his/her friends' weight-related behaviours as a result this research is confirmatory and it follows a deductive approach. Confirmatory research tests pre-stated relationships which help informs hypothesis to verify theories and is likely deductive in nature (Bernard, 2011). Confirmatory research is likely to be deductive whereas exploratory research is likely to be inductive (Bernard, 2011). Unlike inductive research which is concerned with the generation of new theory, deductive research is aimed at testing theory and the emphasis is generally on causality. This research's philosophy is positivism since the 1) research is based on statements that explain the relationships between variables known hypothesis and examines causes that

influence outcomes 2) knowledge is shaped from data and evidence 3) claims are initially made that are later refined or abandoned (Creswell, 2002). This research is testing some hypothesis which were proposed to examine associations between individual behaviour (as an outcome) and friends' behaviour and the moderating role of network properties on these associations through an analysis of social network and behavioural survey data.

4.3   Research methods

There are various classifications of research methods but the most common classification is into quantitative, qualitative and mixed methods. This research will follow a quantitative method since it involves the analysis of survey and network data to understand the moderating role of friendship network properties on associations between individual's behaviour (i.e. dependent) and friends' behaviour (i.e. independent). Quantitative research is used to verify theoretical relationships between independent and dependent variables through data analysis using statistical standards and researchers specify quantitative research questions and hypothesis (Creswell, 2002). Qualitative research on the other hand is used to understand a problem whereas mixed methods resides somewhere in the middle between quantitative and qualitative and employs both methods (Creswell, 2002). Quantitative research can be divided into two general categories: experimental and nonexperimental (Baker, 2001). Unlike experimental research, nonexperimental research involves variables that are not altered by the researcher instead are studied as they exist (Baker, 2001). This research will follow a non-experimental design since it involves the analysis of survey and network data. The research will follow a cross-sectional design, where data will be collected from participants at a specific point in time. One important tool that will be implemented in this research is social network analysis which will allow us to determine how network properties may amplify the weight-related behaviour association between friends. Over all there are two types of networks the first type is egocentric networks (also known as personal networks) where an individual being at the centre and they consist of the "ego" (index person) at the centre together with alters (network members) who are directly connected to the ego (Borgatti, Everett, and Johnson, 2013). Egocentric social network analysis is used to capture social influence, social support and accessibility to resources (Valente, 2010). The relevant research questions for egocentric network analysis are concerned with the phenomena affecting the individuals across different networks (Borgatti, Everett, and Johnson, 2013). The second type is socio-metric networks which are integrated networks at the

community level and are used to evaluate the extent to which people who engage in certain behaviours are more likely to have close personal network members who engage in the same behaviours (Valente, 2010). Socio-metric network analysis is a relatively new area and is ideal for assessing the "network of networks" (Valente, 2010). The relevant research questions for socio-metric network analysis are concerned with the different interactions within defined networks. This research will use socio-metric networks where data from all participants (including nominated friends) will be collected. Participants will be asked to provide the names of their five closest friends in their school which will allow building the network of each individual and the complete network for every school. A conceptual model was proposed in Section 3.4 in Chapter Three to examine associations between weight-related behaviours (diet, physical activity, sedentary behaviour and sleep) of the individual and his/her friends' and to test whether these associations are moderated by some friendship network properties (density, centrality and popularity). The design of the empirical study including the description of the approach (quantitative non experimental), the study variables (individual's weight-related behaviours, friends' weight-related behaviours and friendship network properties), instrument (survey), sample (adolescents in schools) and data collection methods are presented in this chapter. An overview of the data analysis will also be presented in this chapter but the actual results from the data analysis will be presented in the next chapter as shown in Figure 4.1 below.
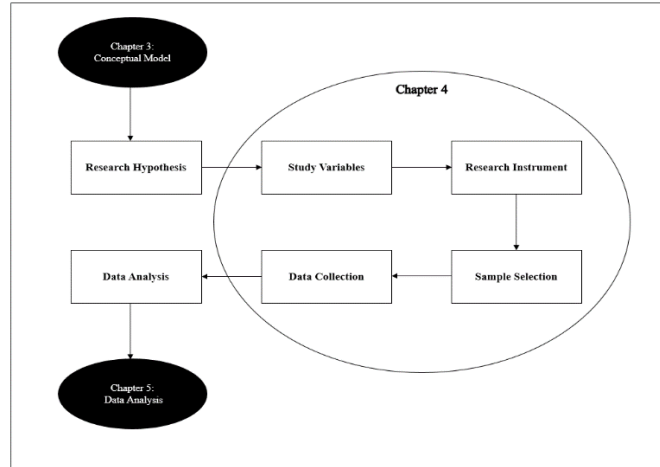
Figure 4.1: Empirical Study Design

4.4 Study variables

The purpose of the conceptual model that was proposed in Section 3.4 in Chapter Three is to explore associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours and to examine the moderating role of properties of friendship networks on these associations. As a result there is a need to define a set of behavioural variables (related to the weight-related behaviours of individuals and their friends) and a set of network variables (related to the friendship network properties). The behavioural variables will act as both dependent (individual's behaviour) and independent (friends' behaviour) variables in the model. The network variables (network properties) on the other hand will act as moderators in the model. Additionally, there is a need to include some control variables in the model which will include some demographic variables and anthropometric variables. A description of each of the variables and which role they play in the model will be provided below:

4.4.1. Dependent variables: individual's behaviour

This research will have seven dependent variables for each of the weight-related behaviours that were presented in the conceptual model in Section 3.4 in Chapter Three:

i. **Individual's diet**: Poor dietary choices such as skipping breakfast, not consuming enough fruits and vegetables, eating at fast food restaurants and consuming calorie-dense snacks regularly are all associated with a risk of abnormal weight-gain among adolescents (Niemier et al., 2006, Swimburn et al., 2004). Diet will be assessed through four behaviours separately eating

breakfast, eating fast food, eating fruits and vegetables and eating calorie dense snacks (Ali, Amialchuk and Heiland, 2011). The reasons behind separating the dietary behaviours is already provided in Section 3.3 in Chapter Three. But it is mainly because researchers found evidence on similarity among friends only in some of the dietary behaviours like fast food consumption and high calorie food (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). The dietary behaviours are described below:

a)   **Breakfast consumption:** a dichotomous variable with options 1) "eats breakfast regularly" for those who eat breakfast regularly and 2) "skips breakfast regularly" for those who do not eat breakfast regularly.

b)   **Fast food consumption:** a dichotomous variable with options 1) "eats fast food regularly" for those who eat at fast food restaurants regularly and 2) "does not eat fast food regularly" for those who do not eat at fast food restaurants regularly.

c)   **Fruits and vegetables consumption:** a dichotomous variable with options 1) "eats 4 to 5 servings per day" for those who eat 4 to 5 servings of fruits and vegetables per day and 2) "eats less than 4 servings per day" for those who eat less than 4 to 5 servings of fruits and vegetables per day.

d)   **Calorie dense snacks consumption:** a dichotomous variable with options 1) "eats calorie dense snacks regularly" for those who eat calorie dense snacks regularly and 2) "does not eat calorie dense snacks regularly" for those who do not eat calorie dense snacks regularly.

ii.   Individual's physical activity: according to World Health Organization (WHO) guidelines children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity (MVPA) daily (Who.int, 2017). Physical activity will be estimated by the average number of days (in the past seven days and in a usual week) the participant achieves a minimum of 60 minutes of MVPA i.e. moderate to vigorous physical activity per day (Prochaska et al., 2001). The average will be calculated as following: ([number of days participant achieves a minimum of 60 minutes of MVPA this week + number of days participant achieves a minimum of 60 minutes of MVPA in a usual week] / 2). A dichotomous variable with options 1) "insufficiently active" for those who achieve 60 minutes of MVPA on less than seven days per week 2) "sufficiently active" for those who achieve 60 minutes of MVPA on seven days per week.

iii.   **Individual's sedentary behaviour:** sedentary behaviour will be estimated based on screen time in this study. According to international guidelines (Australian and Canadian guidelines), adolescents should spend no more than 2 hours per day being sedentary (APASBG, 2017; CSEP, 2017). Sedentary behaviour will be estimated by the average hours spent per day sedentary over the week (weekdays and weekend) (Utter et al., 2003). The average will be calculated as following: ([five days x weekday hours + two days x weekend hours] / seven-days per week). A dichotomous variable with options 1) "high sedentary" for those who spend more than 2 hours per day sedentary on average and 2) "low sedentary" for those who spend 2 hours or less per day on average.

iv.   **Individual's sleep behaviour:**   according the American Academy of Sleep Medicine Teenagers should sleep for a minimum of 8 hours on a regular basis to promote optimal health (Paruthi et al., 2016). Sleep behaviour will be estimated by the average hours of sleep per night over the week (weekdays and weekend). The average will be calculated as following: ([five days x weekday hours + two days x weekend hours] / seven-days per week). A dichotomous variable with options 1) "sufficient sleep" for those who get 8 hours or more of sleep on average 2) "insufficient sleep" for those who get less than hours of sleep on average per day (i.e., insufficient sleep)   based on recommendations for recommended hours of sleep daily (Yamaguchi, Kawamura and Maeda, 2000).

4.4.2. Independent variables: friends' behaviour

This research will have seven independent variables measuring the different weight-related behaviours of the nominated friends of each participant. Each participant will nominate his/her five closest friends. Since, this research will use socio-metric networks as explained in Section 4.3, data from all participants (including nominated friends) will be collected. As a result information on each participant's friends will be available:

i.   **Friends' diet:** diet as described above will be assessed through four behaviours separately which include: eating breakfast, eating fast food, eating fruits and vegetables and eating calorie dense snacks:

a)   **Friends' breakfast consumption:** percentage of friends who "eat breakfast regularly".
b)   **Friends' fast food consumption:** percentage of friends who "eats fast food regularly".

c)   **Friends' fruits and vegetables consumption:** percentage of friends who "eat 4 to 5 servings per day".

d)   **Friends' calorie dense snacks consumption:** percentage of friends who "eat calorie dense snacks regularly".

ii.   **Friends' physical activity:** percentage of friends who are "sufficiently active" i.e. those who achieve at least 60 minutes of MVPA on seven days per week.

iii.   **Friends' sedentary behaviour:** percentage of friends who are "high sedentary" i.e. those who spend more than 2 hours per day sedentary on average.

iv.   **Friends' sleep behaviour:** percentage of friends who are considered getting "sufficient sleep" i.e. those who get at least 8 hours or more of sleep on average.

4.4.3. Moderating variables: friendship network properties

In addition to testing the associations between individual's weight-related behaviours (dependent variables) and friends' weight-related behaviours (independents variables), three network variables (density, popularity and centrality) will be tested as moderators on the associations between the individuals and his/her nominated friends weight-related behaviours. The network variables will be measured by a social network analysis software and will be categorised as following:

i.   Density: will be categorised into "low density" and "high density" based on the sample findings from the network analysis.

ii.   Popularity: will be categorised into "high popularity" and "low popularity" based on the sample findings from the network analysis.

iii.   Centrality: will be categorised into "high centrality" and "low centrality" based on the sample findings from the network analysis.

In addition to the mentioned variables age, nationality, school type and weight status will be used as control variables in the models.

4.4.4. Research hypothesis and study variables

To answer the research questions that were proposed in Section 2.6 in Chapter Two, a set of hypothesis (28 in total) were proposed in Section 3.3 in Chapter Three. The research hypothesis are cross-referenced to the study variables in Table 4.1 below:

Table 4.1: Research hypothesis cross-referenced to the study variables

Research Hypothesis	Study Variables		
	Dependent Variable	Independent Variable	Moderator
H1a: The individual's breakfast consumption is associated with his/her friends' breakfast consumption among adolescents	Individual's breakfast consumption	Friends' breakfast consumption	-
H1b: The individual's fast food consumption is associated with his/her friends' fast food consumption among adolescents	Individual's fast food consumption	Friends' fast food consumption	-
H1c: The individual's fruits and vegetables consumption is associated with his/her friends' fruits and vegetables consumption among adolescents	Individual's fruits and vegetables	Friends' fruits and vegetables	
H1d: The individual's calorie dense snacks consumption is associated with his/her friends' calorie dense snacks consumption among adolescents	Individual's calorie dense snacks	Friends' calorie dense snacks	
H1e: The individual's physical activity is associated with his/her friends' physical activity among adolescents.	Individual's physical activity	Friends' physical activity	-
H1f: The individual's sedentary behaviour is associated with his/her friends' sedentary behaviour among adolescents.	Individual's sedentary behaviour	Friends' sedentary behaviour	-
H1g: The individual's sleep behaviour is associated with his/her friends' sleep behaviour among adolescents.	Individual's sleep behaviour	Friends' sleep behaviour	-
H2a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by network density.	Individual's breakfast consumption	Friends' breakfast consumption	Density
H2b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by network density.	Individual's fast food consumption	Friends' fast food consumption	Density
H2c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by network density.	Individual's fruits and vegetables	Friends' fruits and vegetables	Density

H2d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by network density.	Individual's calorie dense snacks	Friends' calorie dense snacks	Density
H2e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by network density.	Individual's physical activity	Friends' physical activity	Density
H2f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by network density.	Individual's sedentary behaviour	Friends' sedentary behaviour	Density
H2g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by network density.	Individual's sleep behaviour	Friends' sleep behaviour	Density
H3a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by individual popularity.	Individual's breakfast consumption	Friends' breakfast consumption	Popularity
H3b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual popularity.	Individual's fast food consumption	Friends' fast food consumption	Popularity
H3c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual popularity.	Individual's fruits and vegetables	Friends' fruits and vegetables	Popularity
H3d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual popularity.	Individual's calorie dense snacks	Friends' calorie dense snacks	Popularity
H3e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual popularity.	Individual's physical activity	Friends' physical activity	Popularity
H3f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual popularity.	Individual's sedentary behaviour	Friends' sedentary behaviour	Popularity
H3g: The association between individual's sleep behaviour and friends' sleep behaviour is among adolescents moderated by individual popularity.	Individual's sleep behaviour	Friends' sleep behaviour	Popularity
H4a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by	Individual's breakfast	Friends' breakfast	Centrality

individual centrality.	consumption	consumption	
H4b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual centrality.	Individual's fast food consumption	Friends' fast food consumption	Centrality
H4c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual centrality.	Individual's fruits and vegetables	Friends' fruits and vegetables	Centrality
H4d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual centrality.	Individual's calorie dense snacks	Friends' calorie dense snacks	Centrality
H4e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual centrality.	Individual's physical activity	Friends' physical activity	Centrality
H4f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual centrality.	Individual's sedentary behaviour	Friends' sedentary behaviour	Centrality
H4g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by individual centrality.	Individual's sleep behaviour	Friends' sleep behaviour	Centrality

4.5   Research instrument

This research will follow a quantitative non-experimental approach as already mentioned in Section 4.3 above. As a result, a survey instrument was constructed to help facilitate answer the research questions and understand the role of friendship network properties on associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours. The original form was in English which was used for all participants in private schools. Public schools requested for the form to be translated to Arabic. The form was translated after consulting a certified translator and was provided to all participants in public schools as requested by these schools. Due to logistical limitations, both private and public schools were not able to arrange for participants to fill the survey digitally. Hard copies of the survey forms were printed, along with roasters of class lists for each school were available for the participant. The survey forms both in English and Arabic are provided in Appendix 2 and 3. The instrument is made up of twenty items and is divided into four parts:

i.   **Participant information**: This part includes 7 items with general demographic information including the participants' name, national ID, school, age, grade, gender, and nationality. The participant were asked to fill this information.

ii.   **Anthropometric measurements:** This part includes 2 items where measurements of the participants' body weight and height will be recorded which will allow the calculation of the participants' body mass index (BMI). Registered nurses recorded the body weight and height measurements.

iii.   **Weight-related behaviours:** This part includes a total 10 items and it includes information on the participants' weight-related behaviours. The weight-related behaviours will act as dependent and independent variables in the model as explained in Section 4.4 above. Table 4.2 below includes each of the study variables cross referenced to the number of items in the survey instrument and the corresponding hypothesis.

a)   **Diet** was assessed through four multiple choice items separately as was already discussed in Section 4.4.1. Each item asked the participants about how often they eat breakfast, they eat at a fast food restaurant, how many fruits and vegetables do they usually eat daily, and whether or not they usually eat calorie dense snacks with examples are provided including chocolate bars, chips, doughnuts, cookies. Each item will have three choices a) almost every day b) sometimes c) rarely or never. The item on how many fruits and vegetables do they usually eat they get the following three choices a) 0-1 servings per day b)2-3 servings per day c) 4-5 or more servings per day.

b)   **Physical activity** was assessed through two multiple choice items. The first item asked the participants to list how many days were you physically active (example: football, basketball, cycling, swimming, walking etc) for a total of at least one hour per day in the past week. The second item asked the participants to list how many days were you physically active (example: football, basketball, cycling, swimming, walking etc) for a total of at least one hour per day in a usual week. Each item has eight choices   a) 0 days, I was not physically active at all in the last week b) 1 day c) 2 days d) 3 days e) 4 days f) 5 days g) 6 days h) 7 days, I was physically active every single day.

c)   **Sedentary behaviour** will be assessed through two multiple choice items. The first item asked about the number of hours spent doing the following: watching tv, videos, DVD's, using a computer, playing video games on a handheld device (phone, PSP, Nintendo) for playing games

or watching shows or movies in a typical weekday. The second item asked about the number of hours spent doing the following: watching tv, videos, DVD's, using a computer, playing video games on a handheld device (phone, PSP, Nintendo) for playing games or watching shows or movies in a typical weekend day. Each item has seven options a) 0 hours per day b) 1 c) 2 d) 3 e) 4 f) 5 g) more than 5 hours per day.

d)   **Sleep behaviour:** will be assessed through two open ended items. The first item asked about the usual time during weekdays the participant goes to bed at night, and wakes up in the morning. The second item asked about the usual time during weekends the participant goes to bed at night, and wakes up in the morning.

iv.   **Friendship network**: The participant was asked to fill a list of his/her closest friends starting with his/her best friends in the same school. Each one of the participants had access to a roaster with a list of all students in their school in case they are not sure of the full name of their friends. The participant had the option to list up to five of his/her closest friends. The participant provided the friends' name, and grade. The friendship network of the individuals will allow the measurement of network properties which will act as moderators in the model as was already explained in Section 4.3. A description of the study variables cross referenced to question number in the survey instrument and their source is provided in Table 4.2 below.

Table 4.2: Definition of study variables, Item number in the survey instrument and source

Dependent Variables (Individual's weight-related behaviours)			
Study Variable	**Description**	**Item no.**	**Source**
Individual's diet	1-Eats breakfast regularly.	10, 11, 12, 13	Ali, Amialchuk and Heiland. (2011).
	2-Eats at a fast food restaurant.		
	3-Eats 4-5 servings of fruits and vegetables daily.		
	4-Eats calorie dense snacks regularly.		
Individual's physical activity	1- Number of days the participant is physically active for a total of at least one hour per day in the past week.	14, 15	Prochaska et al. (2001).
	2- Number of days the participant is physically active for a		

	total of at least one hour per day in a usual week.		
Individual's sedentary behaviour	1- Number of hours spent sedentary on a weekday.	16, 17	Utter et al. (2003).
	2- Number of hours spent sedentary on a weekend day.		
Individual's sleep behaviour	1-Time the participant goes to bed and time they wake up on weekdays.	18, 19	Yamaguchi, Kawamura and Maeda. (2000).
	2- Time the participant goes to bed and time they wake up on weekends.		

Independent Variables (Friends' weight-related behaviours)			
Study Variable	**Description**	**Item no.**	**Source**
Friends' diet	1-Percentage of friends who eat breakfast regularly.	10, 11, 12, 13, 20	Ali, Amialchuk and Heiland. (2011).
	2-Percentage of friends who eats at a fast food restaurant.		
	3-Percentage of friends who eats 4-5 servings of fruits and vegetables daily.		
	4-Percentage of friends who eat calorie dense snacks regularly.		
Friends' physical activity	Percentage of friends who are "sufficiently active".	14, 15, 20	Sawka et al. (2014).
Friends' sedentary behaviour	Percentage of friends who are "high sedentary".	16, 17, 20	Sawka et al. (2014)
Friends' sleep behaviour	Percentage of friends who get "sufficient sleep".	18, 19, 20	-

Moderating Variables (Network properties)			
Study Variable	**Description**	**Item no.**	**Source**
Density	the proportion of ties in the network	20	Valente. (2010).

Popularity	the number of incoming nominations		
Centrality	the degree an individual lies on the shortest path connecting others in the network		

Since the items were adapted from previous studies as shown in Table 4.2 above, it was unnecessary to measure instrument validity and its four types: (1) face validity which can be assessed by the researcher if the instrument appears appropriate based on their knowledge, (2) content validity which can be assessed by an expert which refers to the items measuring the concept, (3) criterion validity which is used to asses a high degree of correlation between two similar measures of one concept and (4) construct validity which assesses if the instrument measures what it is supposed to measure (Selby-Harrington et al., 1994). The reliability of the instrument will be discussed in section 4.7.

4.6   Sampling

This study will use socio-metric networks also known as complete networks to assess the extent to which adolescents who engage in certain behaviours are more likely to have school friends who engage in the same behaviours and to examine the moderating role of network properties on these associations. Socio-metric studies use census sampling so it is desirable to interview all members of the network (Valente, 2010). The target age group for this study are adolescents between the ages of 11 and 19 but only adolescents between the ages 11 and 15 were included in the study, the reasons for restricting the sample to this age group are discussed in Section 4.7 below. Adolescents between the ages of 11 and 15 are usually middle school students attending grades 6 to 9, middle school is known as intermediate level in the Kingdom of Bahrain. Central Informatics Organization (CIO) in Kingdom of Bahrain latest report on education provided the sampling frame for this study. In their latest report, approximately two thirds attend public schools (125,580 students) and the remaining one third (47,523 students) of students in Kingdom of Bahrain attend private schools (CIO, 2008). Public schools are gender segregated in Bahrain, whereas the majority of private schools are mixed. In the same report, the listed total number of government intermediate schools in Kingdom of Bahrain is 37 with a total of 32, 889 students (CIO, 2008). The total number of private schools (across all levels) listed is 63 with a total of 47,523 students (across all levels) (CIO, 2008). There is no information on whether these private

schools are primary, intermediate, or secondary schools. But the total number of students in government schools is equal to 125,580 and middle (intermediate) school students account for approximately 26% (if we divide 32,889 by 125,580) of all levels. Assuming that middle (intermediate) school students attending private schools also account for 26% of all levels, then the total number of students attending private schools is approximately 12,356(26% multiplied by 47,523) students. Based on the same assumption, the total number of middle school students in Kingdom of Bahrain attending both private and public schools is approximately 45,245(32, 889 plus 12,356) students. As recommended by Saunders et al., 2009, determining sample size was based upon confidence level of data (normally 95% is used), margin of error (normally 5% is used), number of categories to divide your data (data will be segregated by gender) and the total population (approximately 45,245 students). The sample size recommended for 95% confidence and 5% margin of error for approximately 45,245 students is between 370(population of 10,000) and 383(population of 100,000) (Saunders et al., 2009). But since the analysis will be gender segregated with approximately half of the sample accounting for boys and the other half for girls, then approximately twice as much as the recommended sample size will be needed which will be between 740 and 766 participants across both private and public school. The minimum required sample size as recommended by Saunders et al., 2009 will be 740 participants. And since approximately 26% of intermediate level students attend private school then approximately 192 participants (26% multiplied by 740) from the minimum required sample size should be from private schools and the remaining 548 participants (74% multiplied by 740) should be from public schools. Four schools were selected to participate in this study, two of which are public and the remaining two are private with an expected number of 1000 students. The school needed to have students in grades 6 to 9 and at least 100 enrolled students to be eligible for selection. All students in grades 6 to 9 were invited to participate. The expected sample size is shown in Table 4.3 below which is above the recommended sample size.

Table 4.3: Expected sample size and minimum required sample size

School	Type	Gender	Ages	Expected number of students	Minimum required sample size
1	Public	Boys	11 to 15	350	548
2	Public	Girls	11 to 15	350	
3	Private	Mix	11 to 15	100	192
4	Private	Mix	11 to 15	200	
Total				1000	740

4.7   Data collection

Data was collected from both private and public schools in Kingdom of Bahrain for adolescents between the ages of 11 and 15 as was already explained in Section 4.6. The data collection started after receiving the ethical approval from Brunel's College of Business, Arts and Social Sciences Research Ethics committee which is attached in Appendix 4. Another approval was required from the Ministry of Education to collect data from any school operating under the rules and regulations of the Kingdom of Kingdom of Bahrain which is attached in Appendix 5. The approval for the ministry permitted data collection from middle schools and high schools (adolescents in grades 6 to 12). However the government high schools were not willing to participate in the study because they were busy during examination period. Once both approvals were obtained, the schools were invited to participate in the study and provided parent consent forms to send to all the students in grades 6 to 9. The school invitation letter and the parent consent forms are available in Appendix 6 and 7. The parent consent forms were provided to both private and public schools to distribute to all the students. The data collection was administered by the researcher and two registered nurses who took the weight and height measurements of all participating students over a period of 4 weeks.

 The data collection was done over four phases:

1- **Pre-test phase:** during this phase, the English survey form was pretested on a small number of adolescents (3 participants in total) between the ages 11 and 15. This is to make sure that participating adolescents will understand the questions and will not have any difficulties with the language or setup used in the form. Overall, the participants understood the questions and did not have any problems filling the forms. However, two of the participants felt that questions 14 and 15 in Section 3.2 in the form looked very similar which caused some confusion. The difference between the questions is one asks them about their physical activity levels in the last 7 days and the other asks them about their physical activity levels in a usual week. To solve this problem, the text was bolded and underlined as shown in Figure 4.2 below.

Figure 4.2: Changes done to the survey form before (left hand side) and after pre-test phase (right hand side)

2- **Pilot data collection phase:** during this phase, data was collected from one of the grades within one of the private schools that agreed to participate before main data collection phase for a total for 37 participants. The participants were reluctant about participating in the study, and had many questions about the study and whether or not their responses and the anthropometric (height and weight) measurements will be shared with their parents and teachers. Therefore, it was decided that a briefing with the study aim, objectives, the use and the privacy of the data will be presented to all participating students prior to data collection in the school main hall. Details about the study were provided in the parent consent form which is available in Appendix 7, but many of the participants were still concerned about the privacy of the data. The data was analysed to test the reliability of

the scale of the instrument. Cronbach alpha was used to measure the reliability (i.e. internal consistency) of the scale. Internal consistency for the scale was within the acceptable range (Cronbach's alpha=0.71).

3- **Main data collection phase:** during this phase, data was collected from four different schools for all students who got parent's consent attending middle school. Prior to data collection, a briefing with the study aim, objectives, and privacy of the data was presented to all participating students after some participants showed concern during the pilot data collection phase. The internal consistency for the scale was acceptable in the study (Cronbach's alpha=0.76).The complete data analysis will be provided in Chapter Five.

4- **Schools review visit:** after data collection and analysis, there was a need to re-visit the schools to inspect the school facilities including the canteens and sports facilities to better understand the findings of the research in relation to the school policies and facilities. The schools were visited once, and notes were taken on the school canteen opening hours, types of foods sold at the canteens, sports classes, facilities, and after school programmes. The different data collection stages are shown in Figure 4.3 below.

Phase 1: pre-test → Phase 2: pilot study → Phase 3: main data collection → Phase 4: school review visit
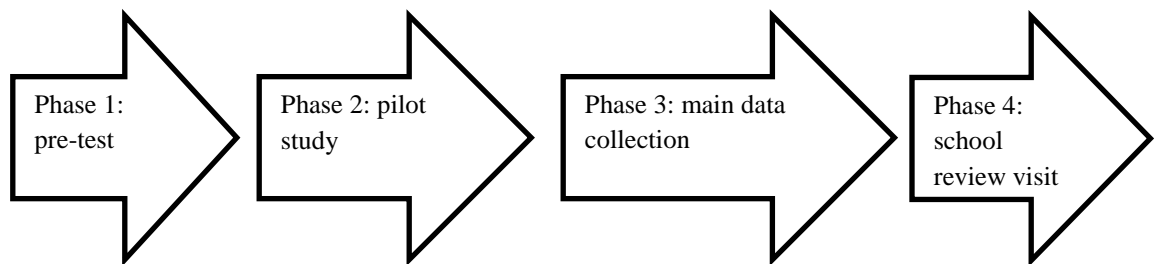
Figure 4.3: Data collection stages

4.8   Data analysis

Social network analysis will be paired with regression models in order to answer the research questions that were proposed in Section 1.3 in Chapter One. Social network analysis will provide measurements of the network properties and the regression models will be used to test for associations/relationships between the variables. Each data analysis method will be discussed below:

4.8.1. Social network analysis

Social network analysis can unveil how relationships enable health behaviours, and how health behaviours shape our relationships (Shoham et al., 2015). Social network analysis is a powerful tool for examining individuals' ties and relationships in order to analyse, predict, and potentially modify individual behaviour (Sawka, 2014). Social network analysis provides many different network measures of overall friendship network properties and individual positions in the network; however only some of these properties were included in the conceptual model because they could act as potential moderators on behaviour association between friends which was discussed in Section 3.3.2 in Chapter Three. The selected friendship network properties, including density, popularity and centrality will be calculated using a social network analysis software UCINET 6 and converted into categorical variables to be tested as moderators for each of the weight-related behaviour association between individuals and their friends.

4.8.2. Regression models

There is more than one method to model associations between friends in weight-related behaviours and how they interact with network properties. A "model" is a simplified representation of reality that discards many details in order to provide a better understanding of a problem (Jones, 2007). In Section 4.4, the study variables were presented as per the conceptual model that was proposed in Section 3.4 in Chapter Three. The dependent variables (one for each of the weight-related behaviours) that were proposed are categorical, more specifically they are binary (outcome was either 1 or 0). Because of the categorical nature of the dependant variables, logistic regression models are suitable to measure the association between the categorical dependent variables and one or more independent variables. When the dependent variable has two outcomes (in the case of this research), then binary logistic regression model is appropriate, but when there are more than two outcomes multinomial logistic regression or ordinal logistic regression depending on whether or not the outcomes are ordered (Walker and Duncan, 1967) . A binary logistic regression model is used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). Gender segregated binary logistic regression models will be used to test the associations between the individual's weight-related behaviours (dependent variables) and friends' weight-related behaviours (independent variables) using SPSS version 23(a software offering statistical solutions commonly used for social sciences). The models are gender segregated because findings from previous research were

gender specific (de la Haye et al., 2010; Finnerty et al., 2009; Sawka, 2014). The binary logistic regression models that are used to test the associations between individual's and their friends' weight-related behaviours and the moderating role of network properties on these associations cross-referenced with the hypothesis are presented in Table 4.4 below. As shown in Table 4.4, there is a total of 14 models, 7 for boys (denoted by the letter a) and 7(denoted by the letter b) for girls for each of the 7 weight-related behaviours (numbered 1 to 7). Each one of these models will address four of the proposed research hypothesis (a total of 28 hypothesis) specific to each of the weight-related behaviour that were presented in Section 3.3 in Chapter Three.

Table 4.4: Regression Models

Model	Behaviour	Gender	Hypothesis
1a	**Breakfast consumption**	Boys	H1a, H2a, H3a, H4a
1b		Girls	
2a	**Fast food consumption**	Boys	H1b, H2b, H3b, H4b
2b		Girls	
3a	**Fruits and vegetables consumption**	Boys	H1c, H2c, H3c, H4c
3b		Girls	
4a	**Calorie dense snacks consumption**	Boys	H1d, H2d, H3d, H4d
4b		Girls	
5a	**Physical Activity**	Boys	H1e, H2e, H3e, H4e
5b		Girls	
6a	**Sedentary Behaviour**	Boys	H1f, H2f, H3f, H4f
6b		Girls	
7a	**Sleep**	Boys	H1g, H2g, H3g, H4g
7b		Girls	

4.9   Summary

In this chapter the details of the empirical study design presented which includes the research approach (confirmatory deductive), philosophy (positivism) and methodology (quantitative non experimental) is explained. This is followed by a definition of the study variables, the instrument (survey) that will be employed and sampling techniques. This is followed by an explanation of the different data collection phases. Finally, the data analysis (social network analysis paired with binary logistic regression models) is presented followed by the summary. The next chapter will present findings from the data analysis i.e. the implementation of the empirical study.

Chapter 5: Data Analysis

5.1 Introduction

A description of the methodology to be applied in this study was presented in Chapter Four. This is a quantitative study, which utilises a non-experimental survey to empirically explore associations between the individual' and their friends' weight-related behaviours and to examine the moderating role of friendship network properties on these associations. This chapter will present the main findings of the data analysis. The response rate will be discussed in Section 5.2 followed by some descriptive statistics in Section 5.3. The friendship network measures of interest including density, popularity and centrality will be discussed in Section 5.4. The main findings from the binary logistic regression models to explore associations between individual' and their friends' behaviours for each of the weight-related behaviours and the moderating roles of network density, individual popularity and individual centrality on these associations will be presented in Sections 5.5 to 5.11. A summary of the findings from the binary logistic regression models will be presented in Section 5.12 followed by an evaluation of the research hypothesis which will be presented in Section 5.13. Finally, a summary of the chapter will be presented in Section 5.14.

5.2   Response rate

Four schools (two public and two private) were invited to participate in the study. From the four schools, all 908 adolescents in grades six through nine were invited to participate in the study, of which 783 provided parental consent which is slightly above the minimum required sample size (740 participants) that was discussed in Section 4.6 in Chapter Four. A total of 673 adolescents were present when the study was conducted and provided complete forms. Forms with missing data were discarded and not used in the data analysis. The response rates in the four schools varied between roughly 70% and 82% and the overall response rate was 74.1% as shown in Table 5.1 below. A main concern in the social network field is missing data and response rates especially with socio-metric studies where it is desirable to interview all members of the network (Valente, 2010). Social network data is usually incomplete, which means that some nodes and links are missing from the dataset (Kossinets, 2006). Response rates of 70% or 80% are considered high by most scientific standards, however it is not clear if they are adequate for

network analysis (Valente, 2010). In practice, it is difficult to estimate the effects of missing data on network measures (Kossinets, 2006). One study was conducted to assess the effects of missing data on different networks and found that when 20% of the people were removed from the network, and the centrality measures were recalculated, they correlated with the original measure (Costenbader and Valente, 2003). Additionally, popularity or in-degree is relatively stable even at low response rates (i.e. 50% missing at random) (Valente and Davis, 1999). When it comes to network-level statistics estimates (including network density); they can dramatically altered by missing actors in the network (Kossinets, 2006). It is unclear how the missing actors in the school networks will alter the results in the models that will be presented in Sections 5.5 to 5.11.

Table 5.1: Response rates by school

School	Type	Number of students	Number of participants	Response Rate
1	Public	290	223	76.9%
2	Public	388	270	69.6%
3	Private	87	71	81.6%
4	Private	143	109	76.2%
Total		**908**	**673**	**74.1%**

5.3   Descriptive statistics

This section will provide a description of the sample demographic, weight status of the participants, prevalence of weight-related behaviours in the sample, types of friendships and some correlations between the variables that were presented in the conceptual model:

5.3.1   Demographics

The sample included 673 adolescents between the ages of 11 and 15 from four schools in Kingdom of Bahrain (two of which are public and two are private) with an average age of 13.04 years. Approximately half of the participants were females (51.0%) and the remaining half were males (49.0%). The majority of the participants were Bahraini nationals (74.5%) and the remaining participants were non-Bahraini (25.5%). The sample was diverse as it included

participants with 26 different nationalities (mainly Egyptian, Jordanian and Pakistani). It is not surprising that the majority of the participants were from public schools (68.8%) and the remaining participants were from private schools (31.2%) since the selected public schools were bigger than selected private schools considering the sampling frame of the study which was discussed in Section 4.6 in Chapter Four. A summary of the results is presented in Table 5.2 below.

Table 5.2: Sample demographics

GENDER	
Female	51.0%
Male	49.0%
NATIONALITY	
Bahraini	74.5%
Non-Bahraini	25.5%
AGE	
11	4.9%
12	20.9%
13	29.6%
14	23.7%
15	20.7%
SCHOOL TYPE	
Public	68.8%
Private	31.2%

5.3.2   Weight status

BMI is routinely used as a measure of a person's weight status in social science research. But BMI can be misleading since it does not differentiate between lean tissue and body fat. BMI was found to misclassify a substantial percentage as obese or non-obese (Burkhauser and Cawley, 2008). However, BMI is the most common measure used in survey data and is used by the NIH (Renna, Grafova and Thakur, 2008). Measurements of the participants' body weight and height were recorded by registered nurses which allowed the calculation of each of the participants' body mass index (BMI). Since the participants were under the age of 18, BMI had to be age and gender specific. The "CDC Children's BMI Tool for Schools" was used in this study to compute the participants' BMIs and BMI percentiles for children and adolescents using height and weight

measurements, sex, date of birth, and date of measurement. Weight status is then determined based on BMI percentile ranges from the following link https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/tool_for_schools.html

[Accessed 1 Jul. 2017]. Participants with BMI percentile ranges below 5th percentile are considered underweight, 5th percentile to less than 85th percentile are considered normal, 85th percentile to less than 95th percentile are considered overweight and 95th percentile or above are considered obese. The percentages of overweight and obesity among the participants were alarmingly high. Around one third (32%) of the participants were either overweight or obese as shown in Table 5.3 below. The percentages of overweight or obesity among boys were almost twice as high compared to girls.

Table 5.3: Sample BMI percentiles and weight status

Weight Status	Boys	Girls	Total
Number of children assessed:	328	345	**673**
Underweight (< 5th %ile)	7%	7%	**7%**
Normal BMI (5th - 85th %ile)	47%	74%	**61%**
Overweight or obese (≥ 85th %ile)*	45%	19%	**32%**
Obese (≥ 95th %ile)	*12%*	*6%*	*9%*

5.3.3   Weight-related behaviours

When it comes to dietary behaviours the majority of the participants skip breakfast regularly (57.9%), eat fast food regularly (83.6%), consume insufficient amounts of fruits and vegetables i.e. less than 5 servings a day (84.4%), and consume calorie dense snacks regularly (89.9%). The percentages are far worst with the boys when compared with the girls especially with skipping breakfast (66.7% vs 48.8%),

The majority of the participants are classified insufficiently active i.e. spend less than an hour per day engaging in moderate to vigorous physical activity (78.2%). The percentage of insufficiently active girls is substantially higher than the insufficiently active boys (83.2% vs 72.9%).

And the majority of the participants are classified high sedentary (78.3%) with the average number of hours spent sedentary being 4.3 hours a day which is more than twice the international

recommended guidelines (which is 2 hours or less per day). Additionaly, the percentage of high sedentary girls is substantially higher than the high sedentary boys (85.4% vs 71.6% vs).

A high percentage of the participants are also sleep deprived i.e. get less than eight hours of sleep per day (44.4%). The percentage of sleep deprived boys is substantially higher than the sleep deprived girls (48.1% vs 40.2%). A summary of the results is presented in Table 5.4 below.

Table 5.4: Weight-related behaviours in the sample

	Boys (n=328)	Girls (n=345)	Total (n=673)
Breakfast			
Does not eat regularly	66.7%	48.8%	57.9%
Eats regularly	35.1%	51.2%	42.1%
Fast Food			
Does not eat fast food regularly	16.8%	16.2%	16.4%
Eats fast food regularly	83.2%	83.8%	83.6%
Fruits and Vegetables			
Insufficient consumption	85.8%	82.9%	84.4%
Sufficient consumption	14.2%	17.1%	15.6%
Calorie Dense Snacks			
Does not consume regularly	8.7%	11.6%	10.1%
Consumes regularly	91.3%	88.4%	89.9%
Physical Activity			
Insufficiently Active	72.9%	83.2%	78.2%
Sufficiently Active	27.1%	16.8%	21.8%
Sedentary Behaviour			
Low Sedentary	28.4%	14.6%	21.7%
High Sedentary	71.6%	85.4%	78.3%
Sleep			
Insufficient Sleep	48.1%	40.2%	44.4%
Sufficient Sleep	51.6%	59.8%	55.6%
Total	**100%**	**100%**	**100%**

5.3.4   Same-gender friendships

The sample of this study is unique in nature since it included both public (gender-segregated) and private (mixed-gender) schools as was already discussed in Section 4.6 in Chapter Four. As a result all friendships (100%) in public school will be same-gender friendships (i.e. boys will only form friendships with boys and girls will only form friendships with girls. The data analysis reveals that the majority of the friendships in the private schools were also same–gender

friendship, meaning the majority of the individuals in private schools were forming friendships with individuals of the same gender. In one of the private schools, 93.6% of the individuals had same-gender friendships, and in the other private school, 70.1% of the individuals had same-gender friendships. Overall, 78.8% of individuals attending private schools in the sample had same-gender friendships. Although, private schools are mixed-gender schools, approximately 4 out of 5 of the individuals attending private schools formed same-gender friendships (i.e. 4 out of 5 individuals nominated same-gender friends only).

5.3.5   Correlations between individual's behaviours and friends' behaviours

Pearson correlation is commonly used to measure correlations between variables. However since the dependent variable is categorical (specifically binary) as already discussed in Section 4.4 in Chapter Four then Pearson correlation is not appropriate since it is used to measure correlations for continues variables. Spearman's rank correlation (Rho) on the other hand is appropriate for both continuous and categorical variables (Lehman, 2005). Spearman's rank correlation coefficient (Rho) is calculated to measure correlation between individual's behaviours and friends' behaviours as shown in Table 5.5 below and can take values between -1(perfect negative correlation) and +1(perfect positive relationship) for boys and girls. The correlations were calculated for boys and girls separately since the regression models will be gender segregated as already discussed in Section 4.8.2 in Chapter Four. There is a positive correlation between individual's and their friends' breakfast consumption among both boys (Rho=.173) and girls (Rho=.154). Boy's fast food consumption is also positively correlated with their friends' fast food consumption (Rho=.214). Girl's calorie dense snacks consumption is positively correlated with their friends' calorie dense consumption (Rho=.117). There is also a positive correlation between individual's and their friends' physical activity levels among both boys (Rho=.189) and girls (Rho=.216). Finally, with sedentary behaviour and sleep, only girl's behaviour is positively correlated with their friends' (Rho= .156, Rho=.136). Correlations only provide a description of the type and direction of relationship between the variables. Regression models on the other hand can predict relationships between the dependent and independent variables which will be used to answer the research questions and test the conceptual model that was proposed in Section 3.4 in Chapter Three. The findings from the regression models will be presented in Sections 5.5 to 5.11 with a summary in Section 5.12.

Table 5.5: Spearman rank correlation co-efficient (Rho) between individual's behaviours and friends' behaviours

Individual Behaviour	Friends' Behaviour	
	Rho Boys(n=328)	Rho Girls (n=347)
Breakfast	.173*	.154*
Fast Food	.214*	-.077
Fruits and Vegetables	.095	.093
Calorie Dense Snacks	-.085	.117*
Physical Activity	.189*	.216*
Sedentary Behaviour	.025	.156*
Sleep	.017	.136*

* Correlation is significant at the 0.05 level

5.4   Network analysis

As discussed in Section 4.3 in Chapter Four, this research uses socio-metric networks also known as complete networks which rely on data collected from all participants in the study. In addition to providing weight and height measurements and filling a survey on their weight-related behaviours, the participants were asked to provide the names of their five closest friends in their school which will allow building the social network of each individual and the network of the school as a whole. Each one of the four schools is considered a closed network, and each individual has a local network with up to five friends. The majority of the participants nominated 5 friends (70.9%) followed by 4 friends (16.5%), 3 friends (7.4%), 2 friends (2.7%) and 1 friend (2.5%). The data was then entered for each school in a social network analysis statistical tool known as UCINET 6 to provide the measures of the network properties including network density (an overall network property), individual popularity and centrality (individual level properties) which will be used as inputs (moderators) in the regression model which was briefly discussed in Section 4.8 in Chapter Four. Another tool called Netdraw 2.161 was also used to visualize the networks. The visualization of the networks was not necessary as it did not provide

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any additional inputs that will be used in the regression models. However, visualizing the networks assists the reader in understanding the meaning of the network properties including network density, individual popularity and individual centrality. A summary of the measures of network density for each network and the measures of individual popularity and individual centrality for the participating individuals will be discussed in the below subsections:

5.4.1 Density

Network density (an overall network property) is defined as the number of ties in the network divided by the number of all possible ties (Wasserman and Faust, 1994). The density of each network (i.e. school) was measured using UCINET 6 (a social network analysis statistical tool). The values of the network density measures for each network (i.e. school) ranged between .04 to .23 with an average of 0.11 and a median of .09. To test the moderating role of network density, the density values were converted into a categorical variable (high density, low density) based on the median of all four networks (i.e. schools). Two of the schools were classified as high density (private schools) and the other two were classified as low density (public schools). It is important to note here that the selected private schools are smaller than the selected public schools but with further investigation the overall number of nominations were higher in private schools when compared to public schools which resulted in higher density measures for the private schools. Screen shots from the sample Netdraw output of a high density network and a low density network are provided in Figure 5.1 below which show that a highly dense network is more connected when compared to a low density network.
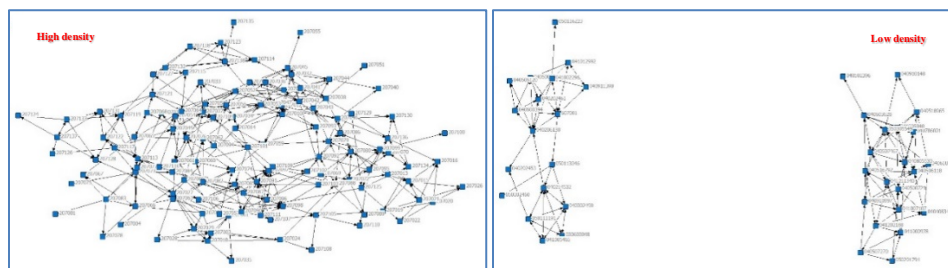
Figure 5.1: Examples of high density and low density networks

5.4.2 Popularity

Individual popularity or in-degree (an individual level property) is defined as number of received nominations (Wasserman and Faust, 1994). The popularity of each individual was measured

using UCINET 6 (a social network analysis statistical tool). Individual popularity values ranged between 0 and 11 nominations across all four schools. To test the moderating role of individual popularity, the popularity measure converted into a categorical variable (high popularity, low popularity) based on the median popularity of each network. Screen shots from the sample Netdraw output of a high popularity individual and a low popularity individual are provided in Figure 5.2 below which shows a highly popular individual who receive more nominations (incoming arrows) compared to a low popular individual who receive less nominations or in the case highlighted in Figure 5.2 no nominations at all.
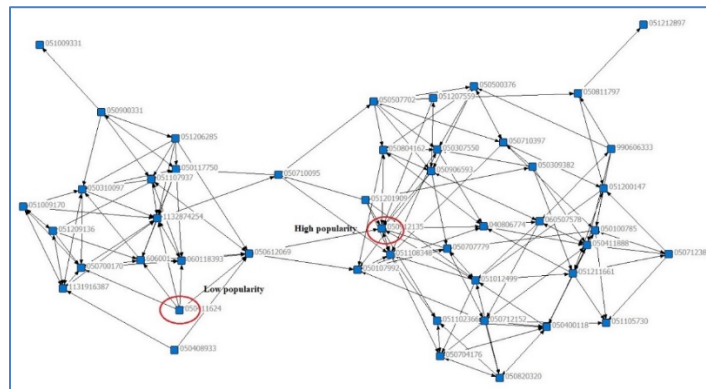
Figure 5.2: Examples of high popularity and low popularity individuals in the network

5.4.3 Centrality

Individual centrality (an individual level property) refers to the extent the individual is linked to others in the defined as number of received nominations (Valente, 2010). The centrality of each individual was measured using UCINET 6 (a social network analysis statistical tool). Similar to individual popularity, the centrality value was converted into a categorical variable (high centrality, low centrality) based on the median of each network to test the moderating role of individual centrality. Screen shots from the sample Netdraw output of a high centrality individual and a low centrality individual is shown in Figure 5.3 below which show a highly central individual who holds a central position in the network in comparison to a low central individual who is on the edge of the network and is less connected to members of the network.
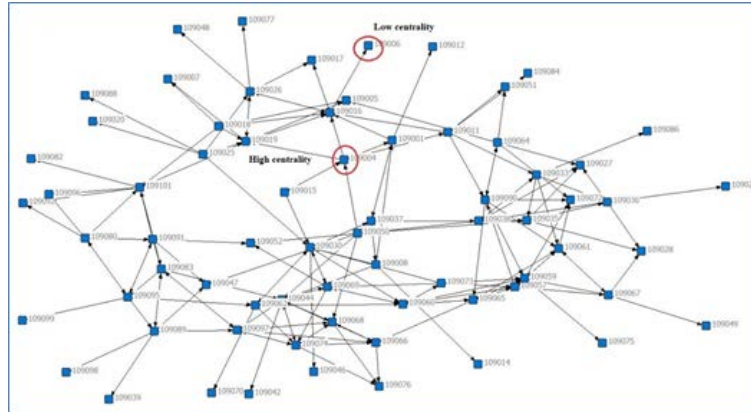
Figure 5.3: Examples of high centrality and low centrality individuals in the network

5.5 Breakfast consumption regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's breakfast consumption and his/her friends' breakfast consumption and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression models were run in SPSS version 23. A justification for using gender segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.6 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.6: binary logistic regression models for testing associations between individual's and friends' breakfast consumption and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
1a	**Breakfast**	Boys	21.819	13	.058**	.086	328	64.3
1b	**Breakfast**	Girls	22.340	13	.050*	.053	345	66.4

*Model is significant at the 0.05 level

**Model is significant at the 0.10 level

5.5.1. Model 1a: breakfast consumption among boys

A binary logistic regression model was performed to test the association between boys' breakfast consumption and their friends' breakfast consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as shown in Table 5.6 above. The model explained 8.6% (Nagelkerke R2) of the variance in breakfast consumption and correctly classified 64.3% of cases also shown in Table 5.6 above. Increasing the percentage of friends consume breakfast regularly was associated with an increased likelihood of breakfast consumption among boys (OR=1.861) and it was positively moderated (strengthened) by network density (OR=2.559) and individual popularity (OR= 4.384) as shown in Table 5.7 below.

Table 5.7: Odd ratios from binary logistic regression models for breakfast consumption among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Breakfast	.021*	1.861	.849	4.080
Density(1)	.801	1.124	.454	2.782
Popularity(1)	.928	.955	.349	2.608
Centrality(1)	.914	.943	.329	2.705
School	.219			
School(1)	.219	1.711	.727	4.027
AGE	.236	.886	.724	1.083
Nationality(1)	.289	1.348	.776	2.342
Weight Status	.105			
Weight Status(1)	.320	.626	.249	1.574
Weight Status(2)	.317	.613	.235	1.599
Weight Status(3)	.023**	.279	.093	.839
Friends BreakfastxDensity	.030*	2.559	1.093	5.992
Friends BreakfastxPopularity	.048*	4.384	1.012	19.001
Friends BreakfastxCentrality	.665	.673	.112	4.045
Constant	.274	4.946		

*Independent variable is significant at the 0.05 level

5.5.2. Model 1b: breakfast consumption among girls

A binary logistic regression model was performed to test the association between girls' breakfast consumption and their friends' breakfast consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model

was statistically significant as shown in Table 5.7 above. The model explained 5.3% (Nagelkerke R2) of the variance in breakfast consumption and correctly classified 66.4% of cases also shown in Table 5.7 above. Increasing the percentage of friends consume breakfast regularly was associated with an increased likelihood of breakfast consumption among girls (OR=13.329) and it was positively moderated (strengthened) by network density (OR=4.679) and individual centrality (OR= 4.211) as shown in Table 5.8 below.

Table 5.8: Odd ratios from binary logistic regression models for breakfast consumption among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Breakfast	.001*	13.329	3.016	58.895
Density(1)	.117	2.206	.821	5.928
Popularity(1)	.784	.889	.384	2.058
Centrality(1)	.245	1.721	.689	4.295
School	.455			
School(1)	.455	.680	.247	1.872
AGE	.670	.953	.762	1.190
Nationality(1)	.953	.984	.575	1.683
Weight Status	.925			
Weight Status(1)	.510	.742	.306	1.800
Weight Status(2)	.671	.792	.270	2.321
Weight Status(3)	.594	.705	.195	2.549
Friends BreakfastxDensity	.003*	4.679	1.686	12.983
Friends BreakfastxPopularity	.689	1.482	.216	10.162
Friends BreakfastxCentrality	.007*	4.211	1.487	11.924
Constant	.695	.541		

*Independent variable is significant at the 0.05 level

5.6 Fast Food consumption regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's fast food consumption and his/her friends' fast food consumption and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression models were

run in SPSS version 23. A justification for using gender segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.9 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.9: binary logistic regression models for testing associations between individual's and friends' fast food consumption and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
2a	**Fast Food**	Boys	27.522	13	.011*	.137	328	83.5
2b	**Fast Food**	Girls	29.041	13	.006*	.077	345	83.2

*Model is significant at the 0.05 level

5.6.1. Model 2a: fast food consumption among boys

A binary logistic regression model was performed to test the association between boys' fast food consumption and their friends' fast food consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model

was statistically significant as shown in Table 5.9 above. The model explained 13.7% (Nagelkerke R2) of the variance in fast food consumption and correctly classified 83.5% of cases also shown in Table 5.9 above. Increasing the percentage of friends consume fast food regularly was associated with an increased likelihood of fast food consumption among boys (OR=2.798) and it was positively moderated (strengthened) by network density (OR=2.545) and individual popularity (OR= 1.699) as shown in Table 5.10 below.

Table 5.10: Odd ratios from binary logistic regression models for fast food consumption among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Fast Food	.000*	2.798	1.603	4.883
Density(1)	.752	1.115	.567	2.193
Popularity(1)	.200	.125	.005	3.013
Centrality(1)	.834	1.054	.642	1.730
School	.595			
School(1)	.595	.689	.175	2.719
AGE	.160	.789	.567	1.098
Nationality(1)	.823	1.081	.546	2.138
Weight Status	.362			
Weight Status(1)	.870	1.101	.350	3.462
Weight Status(2)	.521	.644	.168	2.468
Weight Status(3)	.353	.489	.108	2.210
Friends Fast FoodxDensity	.030*	2.454	1.091	5.517
Friends Fast FoodxPopularity	.082**	1.699	.935	3.088
Friends Fast FoodxCentrality	.160	12.403	.369	417.029
Constant	.098	67.885		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.6.2. Model 2b: fast food consumption among girls

A binary logistic regression model was performed to test the association between girls' fast food consumption and their friends' fast food consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model

was statistically significant as shown in Table 5.9 above. The model explained 7.7% (Nagelkerke R^2) of the variance in fast food consumption and correctly classified 83.2% of cases also shown in Table 5.9 above. Increasing the percentage of friends who consume fast food regularly was not associated with an increased likelihood of fast food consumption among girls and was not moderated by any of the network properties as shown in Table 5.11 below.

Table 5.12: Odd ratios from binary logistic regression models for fast food consumption among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Fast Food	.811	.431	.000	420.778
Density(1)	.989	1.020	.057	18.141
Popularity(1)	.123	.084	.004	1.965
Centrality(1)	.613	2.216	.102	48.264
School	.910			
School(1)	.910	1.067	.342	3.332
AGE	.862	.976	.738	1.290
Nationality(1)	.283	.667	.319	1.396
Weight Status	.542			
Weight Status(1)	.811	.865	.263	2.840
Weight Status(2)	.920	1.066	.304	3.741
Weight Status(3)	.365	2.073	.429	10.020
Friends Fast FoodxDensity	.852	.734	.028	18.953
Friends Fast FoodxPopularity	.130	19.237	.417	887.003
Friends Fast FoodxCentrality	.953	.896	.023	35.439
Constant	.874	1.403		

5.7   Fruits and vegetables consumption regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's fruits and vegetables consumption and his/her friends' fruits and vegetables consumption and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression models were run in SPSS version 23. A justification for using gender

segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.13 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.13: binary logistic regression models for testing associations between individual's and friends' fruits and vegetables consumption and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
3a	Fruit and vegetable	Boys	31.124	13	.003*	.052	328	83.2
3b	Fruit and vegetable	Girls	23.176	13	.040*	.116	345	85.8

*Model is significant at the 0.05 level

5.7.1. Model 3a: fruits and vegetables consumption among boys

A binary logistic regression model was performed to test the association between boys' fruits and vegetables consumption and their friends' fruits and vegetables consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality

(Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as shown in Table 5.13 above. The model explained 5.2% (Nagelkerke R^2) of the variance in fruits and vegetables consumption and correctly classified 83.2% of cases also shown in Table 5.13 above. Increasing the percentage of friends consume sufficient amounts of fruits and vegetables was associated with an increased likelihood of sufficient consumption of fruits and vegetables among boys (OR=7.248) and it was positively moderated (strengthened) by network density (OR=14.462) and individual popularity (OR= 3.413) as shown in Table 5.14 below.

Table 5.14: Odd ratios from binary logistic regression models for fruits and vegetables consumption among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Fruits and Veg	.001*	7.248	2.178	24.119
Density(1)	.397	1.495	.590	3.789
Popularity(1)	.134	.506	.208	1.234
Centrality(1)	.264	1.720	.665	4.451
School	.835			
School(1)	.835	1.109	.419	2.931
AGE	.972	.995	.767	1.291
Nationality(1)	.370	.696	.315	1.537
Weight Status	.768			
Weight Status(1)	.630	.764	.256	2.281
Weight Status(2)	.364	.583	.182	1.869
Weight Status(3)	.456	.605	.161	2.274
Friends Fruits and VegxDensity	.084**	14.462	.697	300.146
Friends Fruits and VegxPopularity	.007*	3.413	1.393	8.364
Friends Fruits and VegxCentrality	.185	.562	.240	1.316
Constant	.419	.232		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.7.2. Model 3b: fruits and vegetables consumption among girls

A binary logistic regression model was performed to test the association between girls' fruits and vegetables consumption and their friends' fruits and vegetables consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality

(Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as shown in Table 5.13 above. The model explained 11.6% (Nagelkerke R2) of the variance in fruits and vegetables consumption and correctly classified 85.8% of cases also shown in Table 5.13 above. Increasing the percentage of friends consume sufficient amounts of fruits and vegetables was associated with an increased likelihood of sufficient consumption of fruits and vegetables among girls (OR=3.222) and it was positively moderated (strengthened) by network density (OR=6.896) and individual centrality (OR= 1.713) as shown in Table 5.15 below.

Table 5.15: Odd ratios from binary logistic regression models for fruits and vegetables consumption among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Fruits and Veg	.008*	3.222	1.358	7.646
Density(1)	.056**	.123	.014	1.060
Popularity(1)	.643	.803	.318	2.028
Centrality(1)	.992	1.005	.384	2.634
School	.519			
School(1)	.519	.687	.220	2.149
AGE	.042*	.739	.552	.990
Nationality(1)	.976	.988	.463	2.108
Weight Status	.311			
Weight Status(1)	.283	3.089	.394	24.245
Weight Status(2)	.368	2.761	.302	25.210
Weight Status(3)	.062**	.041	.001	1.178
Friends Fruits and VegxDensity	.096**	6.896	.711	66.915
Friends Fruits and VegxPopularity	.701	.481	.012	20.090
Friends Fruits and VegxCentrality	.092*	1.713	.916	3.205
Constant	.746	2.070		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.8   Calorie dense snacks consumption regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's calorie dense snacks consumption and his/her friends' calorie dense snacks consumption and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary

logistic regression models were run in SPSS version 23. A justification for using gender segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.16 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.16: binary logistic regression models for testing associations between individual's and friends' calorie dense snacks consumption and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
4a	Calorie dense snacks	Boys	24.093	13	.030*	.068	328	88.4
4b	Calorie dense snacks	Girls	23.902	13	.032*	.150	345	91.6

*Model is significant at the 0.05 level

5.8.1. Model 4a: calorie dense snacks consumption among boys

A binary logistic regression model was performed to test the association between boys' calorie dense snacks consumption and their friends' calorie dense snacks consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on

these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as shown in Table 5.16 above. The model explained 6.8% (Nagelkerke R2) of the variance in calorie dense snacks consumption and correctly classified 88.4% of cases also shown in Table 5.16 above. Increasing the percentage of friends who consume calorie dense snacks regularly was associated with an increased likelihood of calorie dense snacks consumption among boys (OR=2.694) and it was positively moderated (strengthened) by network density (OR=1.072) and individual popularity (OR= 1.621) as shown in Table 5.17 below.

Table 5.17: Odd ratios from binary logistic regression models for calorie dense snacks consumption among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Snacks	.026*	2.694	.194	37.396
Density(1)	.701	2.312	.032	167.012
Popularity(1)	.553	4.158	.038	459.359
Centrality(1)	.149	53.829	.239	12147.223
School	.800			
School(1)	.800	.861	.272	2.732
AGE	.966	1.007	.744	1.362
Nationality(1)	.791	1.128	.462	2.754
Weight Status	.603			
Weight Status(1)	.196	.252	.031	2.033
Weight Status(2)	.287	.314	.037	2.644
Weight Status(3)	.231	.251	.026	2.413
Friends SnacksxDensity	.007*	1.072	.370	3.110
Friends SnacksxPopularity	.035*	1.621	.517	5.083
Friends SnacksxCentrality	.175	.019	.000	5.857
Constant	.308	13.111		

*Independent variable is significant at the 0.05 level

5.8.2. Model 4b: calorie dense snacks consumption among girls

A binary logistic regression model was performed to test the association between girls' calorie dense snacks consumption and their friends' calorie dense snacks consumption and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and

obese). The logistic regression model was statistically significant as shown in Table 5.16 above. The model explained 15.0% (Nagelkerke R^2) of the variance in calorie dense snacks consumption and correctly classified 91.6% of cases also shown in Table 5.16 above. Increasing the percentage of friends who consume calorie dense snacks regularly was associated with an increased likelihood of calorie dense snacks consumption among girls (OR=2.086) and it was positively moderated (strengthened) by network density (OR=1.602) and individual centrality (OR= 2.316) as shown in Table 5.18 below.

Table 5.18: Odd ratios from binary logistic regression models for calorie dense snacks consumption among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Snacks	.030*	2.086	.318	13.692
Density(1)	.280	22.395	.079	6333.391
Popularity(1)	.127	80.577	.288	22510.821
Centrality(1)	.546	2.380	.143	39.701
School	.483			
School(1)	.483	1.944	.303	12.465
AGE	.701	1.080	.729	1.600
Nationality(1)	.610	1.293	.482	3.468
Weight Status	.078			
Weight Status(1)	.960	.959	.190	4.840
Weight Status(2)	.826	1.257	.164	9.645
Weight Status(3)	.103	.200	.029	1.384
Friends SnacksxDensity	.011*	1.602	.730	3.512
Friends SnacksxPopularity	.592	1.284	.515	3.198
Friends SnacksxCentrality	.011*	2.316	.625	8.582
Constant	.568	.174		

*Independent variable is significant at the 0.05 level

5.9   Physical activity regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's physical activity level and his/her friends' physical activity levels and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression models were run in SPSS version 23. A justification for using gender segregated binary logistic regression

models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.19 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.19: binary logistic regression models for testing associations between individual's friends' physical activity levels and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
5a	Physical activity	Boys	26.654	13	.014*	.113	328	73.5
5b	Physical activity	Girls	39.915	13	.000*	.183	345	84.1

*Model is significant at the 0.05 level

5.9.1. Model 5a: physical activity among boys

A binary logistic regression model was performed to test the association between boys' physical activity levels and their friends' physical activity levels and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as shown in Table 5.19 above. The model

explained 11.3% (Nagelkerke R2) of the variance in physical activity and correctly classified 73.5% of cases also shown in Table 5.19 above. Increasing the percentage of friends who are sufficiently physically active was associated with an increased likelihood of being sufficiently active among boys (OR=1.192) and it was positively moderated (strengthened) by network density (OR=3.092) and individual popularity (OR= 1.253) as shown in Table 5.20 below.

Table 5.20: Odd ratios from binary logistic regression models for physical activity among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends PA	.035*	1.192	.189	7.511
Density(1)	.777	.872	.338	2.249
Popularity(1)	.881	.841	.087	8.157
Centrality(1)	.823	1.134	.377	3.405
School	.827			
School(1)	.827	.900	.350	2.314
AGE	.159	.844	.666	1.069
Nationality(1)	.859	1.058	.569	1.968
Weight Status	.229			
Weight Status(1)	.383	.661	.261	1.673
Weight Status(2)	.438	.678	.254	1.810
Weight Status(3)	.044*	.264	.073	.964
Friends PAxDensity	.065**	3.092	.934	10.234
Friends PAxPopularity	.038*	1.253	.578	2.717
Friends PAxCentrality	.260	.208	.014	3.191
Constant	.706	1.873		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.9.2. Model 5b: physical activity among girls

A binary logistic regression model was performed to test the association between girls' physical activity levels and their friends' physical activity levels and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic

regression model was statistically significant as shown in Table 5.19 above. The model explained 18.3% (Nagelkerke R2) of the variance in physical activity and correctly classified 84.1% of cases also shown in Table 5.19 above. Increasing the percentage of friends who are sufficiently physically active was associated with an increased likelihood of being sufficiently active among girls (OR=4.698) and it was positively moderated (strengthened) by network density (OR=3.066) and individual centrality (OR= 2.834) as shown in Table 5.21 below.

Table 5.21: Odd ratios from binary logistic regression models for physical activity among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends PA	.000*	4.698	2.318	9.518
Density(1)	.091**	.170	.022	1.329
Popularity(1)	.736	1.178	.454	3.058
Centrality(1)	.274	1.820	.623	5.318
School	.426			
School(1)	.426	1.589	.509	4.964
AGE	.203	.840	.643	1.098
Nationality(1)	.697	1.153	.562	2.367
Weight Status	.119			
Weight Status(1)	.887	.919	.286	2.953
Weight Status(2)	.142	.310	.065	1.478
Weight Status(3)	.394	1.945	.421	8.990
Friends PAxDensity	.032*	3.066	.625	15.026
Friends PAxPopularity	.285	3.979	.316	50.164
Friends PAxCentrality	.041*	2.834	1.042	7.707
Constant	.766	.566		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.10   Sedentary behaviour regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's sedentary behaviour level and his/her friends' sedentary behaviour levels and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression

models were run in SPSS version 23. A justification for using gender segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.22 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.22 binary logistic regression models for testing associations between individual's and friends' sedentary behaviour levels and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
6a	Sedentary behaviour	Boys	27.191	13	.012*	.141	328	85.1
6b	Sedentary Behaviour	Girls	33.420	13	.001*	.132	345	71.6

*Model is significant at the 0.05 level

5.10.1. Model 6a: sedentary behaviour among boys

A binary logistic regression model was performed to test the association between boys' sedentary behaviour level and their friends' sedentary behaviour levels and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic

regression model was statistically significant as shown in Table 5.22 above. The model explained 14.1% (Nagelkerke R^2) of the variance in sedentary behaviour and correctly classified 85.1% of cases also shown in Table 5.22 above. Increasing the percentage of friends who are sedentary was not associated with an increased likelihood of being sedentary among boys and was not moderated by any of the network properties as shown in Table 5.23 below.

Table 5.23 Odd ratios from binary logistic regression models for sedentary behaviour among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends SB	.539	8.354	.009	7346.763
Density(1)	.871	1.353	.035	52.340
Popularity(1)	.798	.558	.006	48.240
Centrality(1)	.151	19.082	.340	1071.169
School	.213			
School(1)	.213	.466	.140	1.551
AGE	.002*	.613	.451	.832
Nationality(1)	.384	1.443	.632	3.298
Weight Status	.021*			
Weight Status(1)	.847	1.205	.181	8.031
Weight Status(2)	.884	.917	.285	2.947
Weight Status(3)	.935	1.056	.282	3.960
Friends SBxDensity	.899	1.290	.025	66.753
Friends SBxPopularity	.584	3.910	.030	514.973
Friends SBxCentrality	.179	.048	.001	4.022
Constant	.008	621.961		

*Independent variable is significant at the 0.05 level

5.10.2. Model 6b: sedentary behaviour among girls

A binary logistic regression model was performed to test the association between girls' sedentary behaviour level and their friends' sedentary behaviour levels and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic

regression model was statistically significant as shown in Table 5.22 above. The model explained 13.2% (Nagelkerke R2) of the variance in sedentary behaviour and correctly classified 71.6% of cases also shown in Table 5.22 above. Increasing the percentage of friends who are sedentary was associated with an increased likelihood of being sedentary among girls (OR=1.893) but was not moderated by any of the network properties as shown in Table 5.24 below.

Table 5.24: Odd ratios from binary logistic regression models for sedentary behaviour among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends SB	.045*	1.893	1.014	3.534
Density(1)	.166	6.350	.464	86.858
Popularity(1)	.861	.863	.167	4.470
Centrality(1)	.233	2.727	.524	14.188
School	.213			
School(1)	.213	.448	.127	1.586
AGE	.763	1.037	.818	1.314
Nationality(1)	.206	31.557	.150	6653.934
Weight Status	.052*			
Weight Status(1)	.046*	.218	.049	.971
Weight Status(2)	.027*	.160	.032	.814
Weight Status(3)	.593	.598	.091	3.940
Friends SBxDensity	.447	.327	.018	5.849
Friends SBxPopularity	.423	2.386	.284	20.025
Friends SBxCentrality	.214	.262	.032	2.162
Constant	.984	1.038		

*Independent variable is significant at the 0.05 level

**Independent variable is significant at the 0.10 level

5.11 Sleep regression models

To be able to address the research questions, binary logistic regression models are used to test the associations between each of the individual's sleep and his/her friends' sleep and to test the moderating role of network properties(density, popularity, centrality) on these associations. Two gender segregated binary logistic regression models were run in SPSS version 23. A justification

for using gender segregated binary logistic regression models was already provided in Section 4.8 in Chapter Four. Binary logistic regression models are used to estimate the probability of a binary outcome based on one or more independent variables (Freedman, 2009). The dependent variable being individual behaviour (a dichotomous variable) and the independent variables include: friends' behaviour (percentage of friends engaging in the behaviour), density (low vs high), popularity (low vs high) and centrality (low vs high) after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). Interaction terms (network property*friends behaviour) were also added to the binary logistic regression models to test the moderating role of each of the network properties (density, popularity, centrality) on the associations. The measures of each binary logistic regression model are presented in Table 5.25 below. The common reported measures include Chi-square, significance of the model, Nagelkerke R Square which measures the goodness of the fit of the model and the percentage of correctly predicted responses by these models. Each model will be presented in the below subsections and the measures will be discussed:

Table 5.25: binary logistic regression models for testing associations between individual's and friends' sleep and the role of network properties on these associations

Model	Weight-related Behaviour	Gender	Chi-square	Df	Significance of model	Nagelkerke R Square	N	% Correct
7a	**Sleep**	Boys	16.313	13	.233	.066	328	60.4
7b	**Sleep**	Girls	29.235	13	.006*	.109	345	59.6

*Model is significant at the 0.05 level

5.11.1. Model 7a: sleep among boys

A binary logistic regression model was performed to test the association between boys' sleep and their friends' sleep and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was not statistically significant as

shown in Table 5.6 above. The model explained 6.6% (Nagelkerke R2) of the variance in sleep and correctly classified 60.4% of cases also shown in Table 5.25 above. Increasing the percentage of friends who are getting sufficient sleep was not associated with an increased likelihood of getting sufficient among boys and was not moderated by any of the network properties as shown in Table 5.26 below.

Table 5.26: Odd ratios from binary logistic regression models for sleep among boys

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Sleep	.956	1.136	.012	109.662
Density(1)	.165	2.767	.659	11.630
Popularity(1)	.502	1.520	.448	5.164
Centrality(1)	.215	.397	.092	1.711
School	.082**			
School(1)	.082**	2.237	.903	5.544
AGE	.885	.985	.803	1.209
Nationality(1)	.444	.808	.468	1.395
Weight Status	.214			
Weight Status(1)	.380	.649	.248	1.701
Weight Status(2)	.259	.563	.207	1.527
Weight Status(3)	.055**	.332	.108	1.022
Friends SleepxDensity	.246	.278	.032	2.412
Friends SLeepxPopularity	.294	.360	.053	2.429
Friends SLeepxCentrality	.122	5.344	.638	44.783
Constant	.389	3.916		

**Independent variable is significant at the 0.10 level

5.11.2. Model 7a: sleep among girls

A binary logistic regression model was performed to test the association between girls' sleep and their friends' sleep and the moderating role of density (low vs high), popularity (low vs high) and centrality (low vs high) on these associations after controlling for school (private vs public), age (between 11 and 15), nationality (Bahraini vs non-Bahraini), and weight status (underweight, normal, overweight and obese). The logistic regression model was statistically significant as

shown in Table 5.25 above. The model explained 10.9% (Nagelkerke R2) of the variance in sleep and correctly classified 59.6% of cases also shown in Table 5.25 above. Increasing the percentage of friends who are getting sufficient sleep was not associated with an increased likelihood of getting sufficient among girls and was not moderated by any of the network properties as shown in Table 5.27 below.

Table 5.27: Odd ratios from binary logistic regression models for sleep among girls

	p-value	Odd Ratio	95% CI for odd ratio	
			Lower	Upper
Friends Sleep	.482	4.815	.061	383.165
Density(1)	.474	1.823	.352	9.456
Popularity(1)	.979	.987	.373	2.613
Centrality(1)	.530	1.398	.492	3.968
School	.923			
School(1)	.923	1.056	.348	3.199
AGE	.138	.832	.653	1.061
Nationality(1)	.661	.892	.534	1.488
Weight Status	.501			
Weight Status(1)	.772	1.137	.477	2.710
Weight Status(2)	.448	.661	.226	1.929
Weight Status(3)	.749	1.232	.344	4.415
Friends SleepxDensity	.651	1.764	.151	20.606
Friends SleepxPopularity	.473	.523	.089	3.067
Friends SleepxCentrality	.497	.537	.089	3.226
Constant	.260	6.984		

5.12   Main findings from the regression models

The findings from the binary logistic regression models presented in Sections 5.5 to 5.11 indicate that there is evidence for associations between friends in breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity among both boys and girls. Among boys, there is evidence for associations between friends in fast food consumption. Among girls, there is evidence for associations between friends in sedentary

behaviour. Additionally, network density emerges as a moderator on the associations between friends in breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption and physical activity. In addition, individual popularity emerges a moderator on the associations between friends in breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity among boys only. Finally, individual centrality emerges as a moderator on the associations between friends in breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity among girls only. A summary of the main findings from the binary logistic regression models is presented in Table 5.28 below. Each model tested for four things: 1) association between individuals and their friends for each one of weight-related behaviours 2) whether or not network density acts as a moderator on these associations 3) whether or not individual popularity acts as a moderator on these associations 4) whether or not network individual centrality acts as a moderator on these associations. Since, the models were segregated by gender, then each behaviour (numbered 1 to 7) had two models ("a" for boys and "b" for girls). The cells highlighted in grey reflect statistical significance for an existing relationship from the findings of the regression models that were presented in Sections 5.5 through 5.11.

Table 5.28: Main findings from the models

Model	Behaviour	Gender	Association between individual and friends	Density acts as a moderator	Popularity acts as a moderator	Centrality acts as a moderator
1a	Breakfast	Boys	▓	▓	▓	
1b	Breakfast	Girls	▓	▓		▓
2a	Fast Food	Boys	▓	▓	▓	
2b	Fast Food	Girls				
3a	Fruit and vegetable	Boys	▓	▓	▓	
3b	Fruit and vegetable	Girls	▓	▓		▓
4a	Calorie dense snacks	Boys	▓	▓	▓	
4b	Calorie dense snacks	Girls	▓	▓		▓
5a	Physical activity	Boys	▓	▓	▓	
5b	Physical activity	Girls	▓	▓		▓
6a	Sedentary behaviour	Boys				
6b	Sedentary Behaviour	Girls	▓			
7a	Sleep	Boys				
7b	Sleep	Girls				

5.13 Evaluating the research hypothesis

The findings from Section 5.12 suggest that there is evidence for associations between the individual and his/her friends in breakfast consumption, fruits and vegetables and calorie dense snacks consumption among both boys and girls as a result hypothesis H1a, H1c and H1d are accepted. When it comes to fast food consumption, there is evidence for associations between the individual and his/her friends among boys only as a result hypothesis H1b is accepted for boys only. There is also evidence for association between the individual and his friends in physical activity among boys and girls and sedentary behaviour among girls only as a result hypothesis H1e is accepted and H1f is accepted for girls only. When it comes to network density, there is evidence for the moderating role of density on the association between individual behaviour and friends' behaviour for breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption and physical activity as a result hypothesis H2a, H2c, H2d, H2e are accepted while H2b is accepted for boys only. When it comes to individual popularity, there is evidence for the moderating role of popularity on the on

the association between boys' behaviour and friends' behaviour for breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity only as a result hypothesis H3a, H3b, H3c, H3d, H2e are accepted for boys only. Finally, when it comes to individual centrality, there is evidence for centrality to act as a moderator on the association between girls' behaviour and friends' behaviour for breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity as a result hypothesis H4a, H4c, H4d, H4e are accepted for girls only. A table with each of research hypothesis and the decisions based on the research findings is presented in Table 5.29 below.

Table 5.29: Research hypothesis with the decisions based on the findings

Research Hypothesis	Decision
H1a: The individual's breakfast consumption is associated with his/her friends' breakfast consumption among adolescents	Accepted
H1b: The individual's fast food consumption is associated with his/her friends' fast food consumption among adolescents	Accepted for boys only
H1c: The individual's fruits and vegetables consumption is associated with his/her friends' fruits and vegetables consumption among adolescents	Accepted
H1d: The individual's calorie dense snacks consumption is associated with his/her friends' calorie dense snacks consumption among adolescents	Accepted
H1e: The individual's physical activity is associated with his/her friends' physical activity among adolescents.	Accepted
H1f: The individual's sedentary behaviour is associated with his/her friends' sedentary behaviour among adolescents.	Accepted for girls only
H1g: The individual's sleep behaviour is associated with his/her friends' sleep behaviour among adolescents.	Rejected
H2a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by network density.	Accepted

H2b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by network density.	Accepted for boys only
H2c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by network density.	Accepted
H2d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by network density.	Accepted
H2e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by network density.	Accepted
H2f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by network density.	Rejected
H2g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by network density.	Rejected
H3a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by individual popularity.	Accepted for boys only
H3b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual popularity.	Accepted for boys only
H3c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual popularity.	Accepted for boys only
H3d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual popularity.	Accepted for boys only
H3e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual popularity.	Accepted for boys only
H3f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual popularity.	Rejected
H3g: The association between individual's sleep behaviour and friends' sleep	Rejected

behaviour is among adolescents moderated by individual popularity.	
H4a: The association between individual's breakfast consumption and friends' breakfast consumption among adolescents is moderated by individual centrality.	Accepted for girls only
H4b: The association between individual's fast food consumption and friends' fast food consumption among adolescents is moderated by individual centrality.	Rejected
H4c: The association between individual's fruits and vegetables consumption and friends' fruits and vegetables consumption among adolescents is moderated by individual centrality.	Accepted for girls only
H4d: The association between individual's calorie dense snacks consumption and friends' calorie dense snacks consumption among adolescents is moderated by individual centrality.	Accepted for girls only
H4e: The association between individual's physical activity and friends' physical activity among adolescents is moderated by individual centrality.	Accepted for girls only
H4f: The association between individual's sedentary behaviour and friends' sedentary behaviour among adolescents is moderated by individual centrality.	Rejected
H4g: The association between individual's sleep behaviour and friends' sleep behaviour among adolescents is moderated by individual centrality.	Rejected

5.14   Summary

In the sample, one in three adolescents were either overweight or obese and the percentage of overweight and obesity was almost twice as high among boys in comparison to girls. When it comes to dietary behaviours, the majority of the participants' skipped breakfast, consumed fast food and calorie dense snacks regularly and consumed insufficient amounts of fruits and vegetables. The majority of the participants were also insufficiently active, spent long hours being sedentary and a big number are sleep deprived. There is evidence for associations between the individual and his/her friends in breakfast consumption, fruits and vegetables consumption and calorie dense snacks consumption among both boys and girls. Among boys, there is evidence for associations between the individual and his friends in fast food consumption. There is also evidence for association between the individual and his friends in physical activity among both boys and girls. Among girls, there is evidence for associations between the individual and her

friends in sedentary behaviour. Network density acts as a moderator/amplifier on the association between individual behaviour and friends' behaviour for breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption, and physical activity. Individual popularity acts as a moderator/amplifier on the association between boys' behaviour and their friends' behaviour for breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity. Finally, individual centrality acts as a moderator/amplifier on the association between girls' behaviour and their friends' behaviour for breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity. Such findings, have implications for gender-tailored interventions. In the next chapter the findings will be discussed in the context of the literature.

Chapter 6: Discussion

6.1   Introduction

The purpose of this research is to explore associations between the individual's weight-related behaviours and his/her friends' weight-related behaviours and to examine the moderating role of friendship network properties on these associations through an analysis of social network and behavioural survey data. In Section 5.12 in Chapter Five, the findings suggest that there are associations between individuals and their friends in multiple weight-related behaviours, however these associations are gender specific. There is also evidence for the moderating role of network properties on these associations but the findings are also gender specific as was presented in Section 5.12 in Chapter Five. In this chapter the research findings will be discussed in the context of the reviewed literature and the possible explanations as to why the findings only partially supported certain hypothesis that were presented in Section 3.3 in Chapter Three will be presented. In Section 6.2, the prevalence of overweight and obesity in the sample will be evaluated and compared to similar studies conducted regionally and internationally. In Section 6.3 the weight-related behaviours in the sample will be discussed in the context of the literature. In Section 6.4, the findings from the regression models will also be evaluated in multiple areas in the literature including 1) associations between friends in weight-related behaviours 2) the moderating role of network density on these associations 3) the moderating role of individual popularity on these associations 4) the moderating role of individual centrality on these associations and 5) gender specific findings. The conceptual model will be re-visited and modified based on the research findings in Section 6.5 followed by the summary in Section 6.6.

6.2   Evaluating the prevalence of overweight and obesity in the sample

Although it is difficult to reach a concrete conclusion by comparing the prevalence of overweight and obesity in this sample with national or regional data of different sample sizes, age groups and methodologies, it is important to see where our sample stands in comparison. In our sample, nearly one in three of the participants (11-15 years) were either overweight or obese (32%) as was presented in Section 5.3.2 in Chapter Five, this is twice as high when compared to the latest OECD obesity review where only one in six children (3-17 years) were reported as overweight

or obese with the highest prevalence of overweight and obesity in the united states (31%) and lowest in Denmark (10%) (OECD, 2017). In the GCC, the prevalence of overweight and obesity among school children (between the ages of 14-18 years) ranged from 30% to 45% (Musaiger, 2011). In Kingdom of Bahrain specifically, the overweight and obesity rates among children (10-13 years) were found to be between 25% and 28% (Musaiger, Al-Mannai and Al-Marzog, 2014). The overweight and obesity rates in the Kingdom of Bahrain may have increased over the last three years as they were higher in this sample (32%).

Additionally, the overweight and obesity rates in the sample were much higher among boys compared to girls (45% vs 19%) as was shown in Table in 5.3 in Chapter Five. Findings are consistent with a study conducted to find the prevalence of overweight and obesity in seven Arab countries including Kuwait where the prevalence overweight and obesity was higher in males compared to females in all seven countries (Musaiger et al., 2012). Findings are also consistent with findings from a study investigating obesity among Saudi adolescents; males had higher odds to be obese compared when compared with females (Al-Hazzaa et al., 2011). A more recent study found adolescent obesity to have significantly increased between 2008 and 2013 in Saudi Arabia especially among boys (Al-Daghri et al., 2016). This is also consistent with other international studies conducted in Portugal, Spain, Brazil and among Latinos in the United States where the prevalence of obesity among adolescents was always higher among boys in comparison to girls (Campagnolo et al., 2008; Isasi et al., 2012; Marques and Gaspar De Matos, 2014; Sánchez-Cruz et al., 2013). One study on the National Longitudinal Study of Adolescent Health dataset (Add Health) found that boys have a higher body mass index (BMI) than girls in early adolescence but girls have a more rapid increase in BMI over the years and by age 20 the disparity between the boys and girls gets smaller (Harris, Perreira and Lee, 2009). However, the higher prevalence of obesity among adolescent boys in comparison to adolescent girls is not a common trend across all countries (OECD, 2013). So the disparity between obesity rates among boys and girls in this sample may be context related as it is not a global trend. The overweight and obesity rates in the sample are alarmingly high and are far worst among boys compared to girls which emphasizes the need to conduct this study in the first place.

6.3 Evaluating the weight-related behaviours in the sample

The majority of the participants in the sample skip breakfast regularly (57.9%), eat fast food regularly (83.6%), consume insufficient amounts of fruits and vegetables (84.4%), and consume calorie dense snacks regularly (89.9%) as was shown in Section 5.3.3 in Chapter Five. Findings are consistent with previous studies on Arab adolescent's health which documented increasing consumption of fast foods and saturated fats and low consumption of fruits and vegetables in many parts of the region (Obermeyer, Bott and Sassine, 2015). High consumption of sugary and fatty foods and low consumption of dietary fibre by many children in the Kingdom of Bahrain is common and is likely to increase their risk of obesity in later life (Ghareeb and Rasheed, 2011). The majority of the participants in the sample are classified as insufficiently active (78.2%) and are considered high sedentary (78.3%) with the average number of hours spent sedentary being 4.3 hours a day which is more than twice the international recommended guidelines (2 hours per day). Findings are also consistent with the latest statistics from the GSHS (Global School-based Student Health) survey conducted in Bahrain. The percentage of adolescents (13 to 15 years) who were physically active at least 60 minutes per day on all 7 days during the 7 days was as low as 20.7% and the percentage of the same adolescents who spent three or more hours per day sedentary was as high as 58.8% (WHO, 2016). The unhealthy dietary habits, low physical activity levels and high sedentary behaviour among adolescents is not just a regional problem but a global problem. One study in the UK investigating adolescents' dietary behaviours, physical activity and sedentary behaviour found that the vast majority of adolescents were not consuming the recommended amounts of fruits and vegetables(5 servings/day), were not meeting physical activity guidelines (60 minutes of MVPA/ day) and were spending long hours sedentary (Basterfield et al., 2013). In a similar study conducted in Australia, a significant proportion of adolescents fell short of national dietary and physical activity recommendations (Scully et al., 2007). In another study investigating physical activity and sedentary behaviour in the US, the majority of adolescents were participating in minimal MVPA and spending a large portion of their day sitting (Carson, Staiano and Katzmarzyk, 2015).

There was no substantial difference between the percentage of boys and girls consuming fast food, insufficient amounts of fruit and vegetable, and calorie-dense snacks regularly in the sample as was shown in Table 5.4 in Chapter Five. However, a substantially higher percentage of boys seem to engage in skipping breakfast regularly (66.7% vs 48.8%) and sleep deprivation

(48.1% vs 40.2%) when compared to the girls as was shown in Table 5.4 in Chapter Five. Additionally, a substantially higher percentage of girls seem to be insufficiently active (83.2% vs 72.9%) and high sedentary (85.4% vs 71.6%) when compared to the boys as was shown in Table 5.4 in Chapter Five. The difference in boys' and girls' behaviours are not uncommon in other similar regional and international studies especially with physical activity and sedentary behaviour. In a study investigating obesity risk factors among Bahraini adolescents, the lifestyle risk factors of obesity differed among males and females (Musaiger, Al-Roomi and Bader, 2014). Girls were less prone to practice sports and exercises when compared to boys mainly because they are facing more socio-cultural barriers to practice physical activity and because boys in general, have more freedom and places to practice exercise and other recreational activities when compared to girls (Musaiger, Al-Roomi and Bader, 2014). In one study investigating dietary behaviours, physical activity and sedentary behaviour among adolescents in the UK, boys were found to be significantly more active than girls, and girls spent more time being sedentary (Basterfield et al., 2013). In another study investigating physical activity and sedentary behaviour among adolescents in the US, girls were less engaged in MVPA compared boys and spent more time sitting (Carson, Staiano and Katzmarzyk, 2015). Unhealthy diet, low physical activity levels and high sedentary behaviour among adolescents is not just limited to this sample, but seems like a global problem which needs to be taken seriously in policy making.

6.4   Evaluating the main findings from the regression models

In this section, the main research findings from the models will be discussed in the context of the literature in several areas in terms of: 1) associations between friends in weight-related behaviours 2) the moderating role of network density on these associations 3) the moderating role of individual popularity on these associations 4) the moderating role of individual centrality on these associations and finally 5) gender specific findings in the subsections below:

6.4.1   Associations between friends in weight-related behaviours

a)   Breakfast: In the studied sample, there is evidence for positive behaviour association between individuals and their friends in regular breakfast consumption among boys and girls. In a similar study in the UK, there was no evidence in support of peer effects on breakfast consumption since breakfast is primarily consumed at home which limits the extent to which these behaviours are self-directed by friends (Ali, Amialchuk and Heiland, 2011). Bahraini

adolescents may consume their breakfast at school around their friends and peers which may explain the similarity in breakfast consumption among friends, but there is no research to support this statement. However, the schools in the Kingdom of Bahrain start between 7:00 and7:45 am, which is relatively early compared to western countries including the UK where schools start after 8:00 am. To further support this statement, the school canteens at all four schools are open all morning (as early as 7:00 am) until the afternoon (until 1:00 pm). This could be causing the adolescents in the sample to eat breakfast at school surrounded by their friends but further research is needed to support this finding.

b)   **Fast Food:** There is significant positive association between individuals and their friends in fast food consumption (Ali, Amialchuk and Heiland, 2011). Male friends were also found to be similar in their consumption of high calorie foods (de la Haye et al., 2010). There is evidence in the studied sample for association between individuals' and friends' fast food consumption but only among boys. There are potential different reasons to why only male friends are similar in their fast food consumption and one possible explanation for this finding that is specific to the context of this study, is that adolescent boys in Kingdom of Bahrain are more likely to go out when compared to adolescent girls due to the conservative nature of the upbringing of girls in Bahrain. This could explain why boys' fast food consumption is associated with their friends' fast food consumption because they are more likely to go out with their friends and eat outside when compared to girls. But there is no research to support this statement and further research is required. It is important to keep in mind that a high percentage of boys (83.2%) and girls (83.8%) in the sample were found to consume fast food regularly as was shown in Table 5.4 in Chapter Five. So the high prevalence of fast food consumption in the sample may have limited the statistical power of the regression models that was necessary to detect meaningful associations. The associations might not be caused due to friends influence or selection, but because a high percentage of the adolescents in the sample are consuming fast food regularly either way.

c)   **Fruits and Vegetables:** In a similar study, there is no evidence in support of peer effects on the consumption of five servings of fruits and vegetables (Ali, Amialchuk and Heiland, 2011). In another study investigating the effects of perceived fruits and vegetables intake of parents and friends on the intake of adolescents it was found that perceived intake of parents' and friends' fruits and vegetables can impact adolescents intake of fruits and vegetables(Lehto et al., 2016). In the studied sample, there is evidence for association between friends in sufficient consumption

of fruits and vegetables among boys and girls. It is difficult to explain why there is an association between individuals and their friends in fruit and vegetables consumption in this sample. Especially, that the canteens in all four schools that participated in the study sell a very limited selection of fruits and vegetables including apples, bananas and tabbouleh (a green salad). Additionally, a low percentage of boys (14.2%) and girls (17.1%) were consuming sufficient amounts of fruits and vegetables in the sample as was shown in Table 5.4 in Chapter Four. The low prevalence of fruit and vegetables consumption in the sample may have also limited the statistical power of the regression models that was necessary to detect meaningful associations.

d)   **Calorie Dense Snacks**: There is no evidence in support of peer effect on the consumption of calorie dense snacks (Ali, Amialchuk and Heiland, 2011). On the contrary, there is evidence in the studied sample for association between friends in calorie dense snacks consumption. This could be because a wide variety of calorie dense snacks are available in the canteens in all four schools that participated in the study, which may encourage students to purchase calorie-dense snacks and eat them together. Further research is needed to support this finding. Additionaly, a high percentage of boys (91.3%) and girls (88.4%) were consuming calorie dense snacks regularly in the sample as was shown in Table 5.4 in Chapter Four. Similar to fast food consumption, the high prevalence of calorie dense snacks consumption in the sample may have limited the statistical power of the regression models that was necessary to detect meaningful associations.

e)   **Physical Activity:** In the studied sample, there is evidence for positive association between friends in physical activity among boys and girls. This finding complements previous research findings on associations between friends in physical activity (Ali, Amialchuk and Heiland, 2011; Chung, Ersig and McCarthy, 2017; de la Haye et al., 2011; Garcia et al., 2016; Salvy et al., 2016; Sawka et al., 2013; Sawka, 2014; Simpkins et al., 2013). Focus group data suggests that friends positively influenced participants' to be more physically active through engaging in activities with participants, verbal encouragement, and modelling with the most cited reason for engaging in physical activity with friends being enjoyment (Garcia et al., 2016). Similar to fruits and vegetables consumption, a low percentage of boys (27.1%) and girls (16.8%) were sufficiently active in the sample as was shown in Table 5.4 in Chapter Four. The low prevalence of sufficiently active individuals in the sample may have limited the statistical power of the regression models that was necessary to detect meaningful associations.

f) **Sedentary Behaviour:** Evidence surrounding association between friends in sedentary behaviour is limited and mixed (Sawka et al., 2013). Some studies found female friends to engage in similar sedentary behaviour based on their screen based behaviours (de la Haye et al., 2010; Raudsepp and Riso, 2017). Another study found that male friends engage in similar screen behaviours (Garcia et al., 2016). In the studied sample, there is evidence for positive association between girls in sedentary behaviour. There are potential different reasons to why only female friends are similar in their sedentary behaviour levels and one possible explanation which was already mentioned above is related to the context of this study and the culture which is that girls are less likely to go out in comparison to boys due to conservative parenting practices in the kingdom of Bahrain, so they spend more time at home and therefore may be that they are more likely spending their time being sedentary by watching tv, playing on their handheld devices etc. But there is no research to support this and future research is needed to confirm this finding. Similar to fast food consumption and calorie dense snacks consumption, a high percentage of boys (71.6%) and girls (85.4%) in the sample were found high sedentary as was shown in Table 5.4 in Chapter Five. So the high prevalence of high sedentary behaviour in the sample may have limited the statistical power of the regression models that was necessary to detect meaningful associations.

g) **Sleep:** Although sleep deprivation is an important predictor of obesity, it has generally been neglected in the social networks literature (Maume, 2013). There is only one study that investigated sleep in social contexts and found no evidence in support of peer effects on sleeping six or less hours which may be because sleep is a behaviour not directly observable by peers (Ali, Amialchuk and Heiland, 2011).In the studied sample, there is no evidence for association between friends in getting sufficient sleep among both boys and girls which may be because sleep is not directly observable by friends.

6.4.2 The moderating role of network density

Network density refers to the proportion of ties in the network (Wasserman and Faust, 1994). In highly dense networks, ideas behaviours are easily viewed by network members which helps a normative group behaviour among adolescents which amplifies their influence on behaviour and norms (Haynie, 2001; Haynie, 2002). Additionally, a highly dense network is better able to generate trust among individuals and as a result reinforce conformity (Peng 2010). Further, adolescents in dense local networks are more likely to feel a strong attachment to the group

which increases susceptibility to influence (Friedkin, 2004). As a result, being part of a dense network can amplify associations between friends in behaviours and reinforce conformity among adolescents. Network density emerges as an important moderator of the delinquency-peer association, with dense networks containing stronger delinquency peer associations than those that are less dense (Haynie, 2001). Similarly, in the studied sample, there is evidence for the moderating role of network density to amplify/strengthen the association between individual behaviour and friends' behaviour for breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption and physical activity.

6.4.3   The moderating role of individual popularity

Popularity refers to the number of nominations received (Wasserman and Faust, 1994). Popular adolescents are more susceptible to peer influence and are compelled to match the behaviours of their peers compared to less popular adolescents because popular adolescents will change their behaviours to maintain their high status in the group (Allen, Porter, McFarland, Marsh, and McElhaney, 2005; Dijkstra, Cillessen, and Borch, 2013). Popularity is thought to strengthen the effects of peer influence among adolescents (Mathys, Burk, and Cillessen, 2013). As a result, being popular can amplify associations between friends in certain behaviours. Popularity was found to moderate associations between friends drinking behaviours where popular adolescents were more likely to select friends with high levels of drinking behaviours (Mathys, Burk, and Cillessen, 2013). Additionally, popularity condition the delinquency-peer association among adolescents (Haynie, 2001). Similarly, in the studied sample, there is evidence for the moderating role of individual popularity to amplify/strengthen the association between individual behaviour and friends' behaviour for breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity among boys only. Popular boys have stronger behaviour associations with their friends' in weight-related behaviours. This is an interesting finding but more research is needed to confirm this finding and whether or not it is context related.

6.4.4   The moderating role of individual centrality

Centrality refers to the degree an individual lies on the shortest path connecting others in the network (Freeman, 1978). The centrality of adolescents within their network could affect their susceptibility to peer influence (Jose et al., 2016). Adolescents in central network positions

receive regular feedback from their peers which subjects them to more peer influence than less central adolescents (Ramirez et al., 2012). Additionally, central adolescents will have a greater attachment to the group (Paxton and Moody, 2003). As a result, being central can amplify association between friends in weight-related behaviours. In the studied sample, there is evidence for the moderating role of individual centrality to amplify/strengthen the association between individual behaviour and friends' behaviour for breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity among girls only. Girls who hold central positions in the network are more likely to have behaviour associations with their friends' in weight-related behaviours. This is also an interesting finding and more research is needed to confirm this finding and whether or not it is context related.

6.4.5 Gender specific findings

Findings from this research on associations between individuals and their friends' weight-related behaviours are gender specific as was shown in Section 5.12 in Chapter Five. The findings of previous research on behaviour association in weight-related behaviours in adolescent friendship networks were also gender specific (de la Haye et al., 2010; Finnerty et al., 2009; Sawka, 2014). The nature of the sample in this study is unique because it included students from public and private schools; it is important to note that public schools in the Kingdom of Bahrain are gender segregated as was already mentioned in Section 4.6 in Chapter Four. Regardless of school type being public or private in the sample, school type did not have an impact on the results. When the regression models were segregated by school type, the associations remained the same between individuals and their friends. However, when the regression models were segregated by gender, the associations were different between the boys and girls which are reflected in the results in Section 5.12 in Chapter Five. This implies, that both boys and girls have the same behaviour associations with their friends regardless of whether or not they attend public(gender segregated) schools or private(mixed gender) schools and regardless of whether or not they have same-gender friendships or mixed-gender friendships. This may be because the majority of the individuals in the private schools (78.8%) have same-gender friendships (i.e. most of the boys in private schools nominated boys only and most of the girls in private schools nominated girls only) as was already discussed in Section 5.3.4 in Chapter Five.

Findings on the moderating role of network properties on behaviour associations between individuals and their friends were also gender specific which are also shown in Section 5.12 in Chapter Five. Previous studies in other socially similar behaviours did not use gender segregated regression models and thus did not report any differences or similarities in the moderating role of network properties on behaviours associations (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). Further research is needed to understand why popularity emerged as an important moderator for behaviour association with boys only as was discussed in Section 5.12 in Chapter Five. Popular boys had stronger behaviour associations with their friends in breakfast, fast food, fruit and vegetable, calorie dense snacks consumption and physical activity. It may be because gaining popularity (i.e. receiving a higher number of nominations) is different among boys and girls and the underlying factors that constitute popularity is what is causing the behaviour associations to be stronger among boys only. One classic study conducted in the U.S., found that elementary school boys gained popularity based on their athletic ability, toughness, coolness and success in cross-gender relationships (Adler, Kless and Adler, 1992). The same study found that elementary school girls gained popularity based on their parent's socio-economic status, their appearance, and their academic success (Adler, Kless and Adler, 1992). But since there are no regional studies conducted to investigate factors affecting popularity among boys and girls, it is difficult to explain this finding of the research. Similarly, centrality emerged as an important moderator for behaviour association with girls only as was discussed in Section 5.12 in Chapter Five and further research is needed to explain this finding. Central girls had stronger behaviour associations with their friends in breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity.

6.5   Modified conceptual model

Friendships are an important social context for the spread and maintenance of weight-related behaviours (de la Haye et al., 2010). Previous research suggests that the weight-related behaviours of the individual is influenced by the weight-related behaviours of a friend or group of friends (Ali, Amialchuk and Heiland, 2011; de la Haye et al., 2010). Research in other socially similar behaviours among adolescents including alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour found that network properties emerge as important moderators on associations between peers and friends behaviours (Mathys, Burk, and Cillessen,

2013; Meter, Casper and Card; 2014; Jose et al., 2016). The moderating role of network properties on associations between individuals' and their friends' weight-related behaviours has been investigated in this study and the findings were behaviour and gender specific as was presented in Section 5.12 in Chapter Five and discussed in Section 6.4 above. The modified conceptual models are presented for each behaviour below, relationships that were found statistically significant in Sections 5.5 to 5.11 in Chapter Five are presented in the modified conceptual models with their corresponding p-values in the figures below:

a) **Breakfast:** It was hypothesized that individual's breakfast consumption is associated with their friends' breakfast consumption and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Findings in Section 5.5 in Chapter Five suggest that there is statistical significance for these associations, and the associations are amplified by density, popularity (boys only) and centrality (girls only) as shown in Figure 6.1 below.

Figure 6.1: modified consumption model for breakfast consumption

b) **Fast food consumption:** It was hypothesized that individual's fast food consumption is associated with their friends' fast food consumption and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Findings in Section 5.6 in Chapter Five suggest that there is statistical significance for an association among boys only, and this association is amplified by density and popularity as shown in Figure 6.2 below.
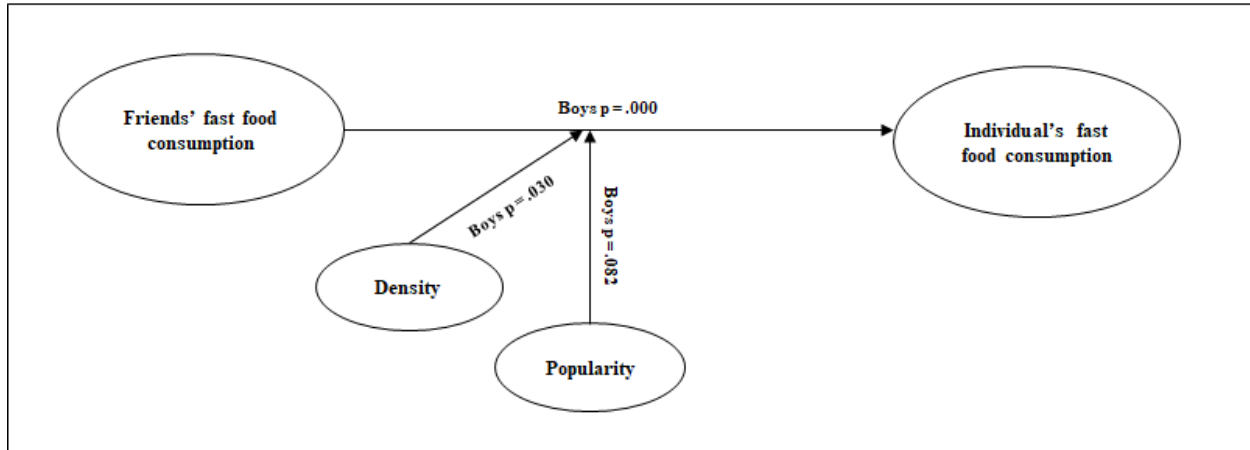
Figure 6.2: modified consumption model for fast food consumption

c)   Fruits and vegetables consumption: It was hypothesized that individual's fruits and vegetables consumption is associated with their friends' fruits and vegetables consumption and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Similar to breakfast consumption, findings in Section 5.7 in Chapter Five suggest that there is statistical significance for these associations, and the associations are amplified by density, popularity (boys only) and centrality (girls only) as shown in Figure 6.3 below.
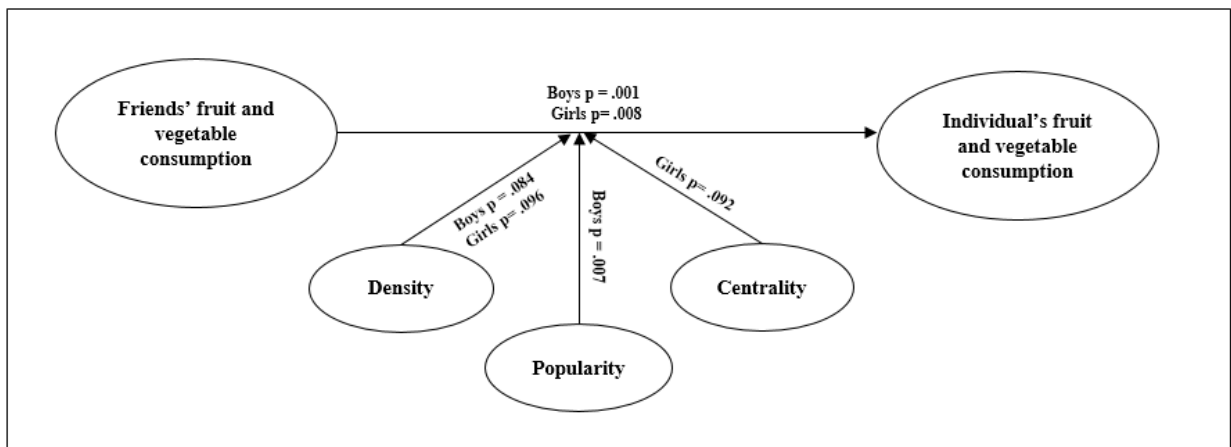
Figure 6.3: modified consumption model for fruits and vegetables consumption

d)   Calorie dense snacks consumption: It was hypothesized that individual's calorie dense snacks consumption is associated with their friends' calorie dense snacks consumption and the

associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Similar to breakfast consumption and fruits and vegetables consumption, findings in Section 5.8 Chapter Five suggest that there is statistical significance for these associations, and the associations are amplified by density, popularity (boys only) and centrality (girls only) as shown in Figure 6.4 below.
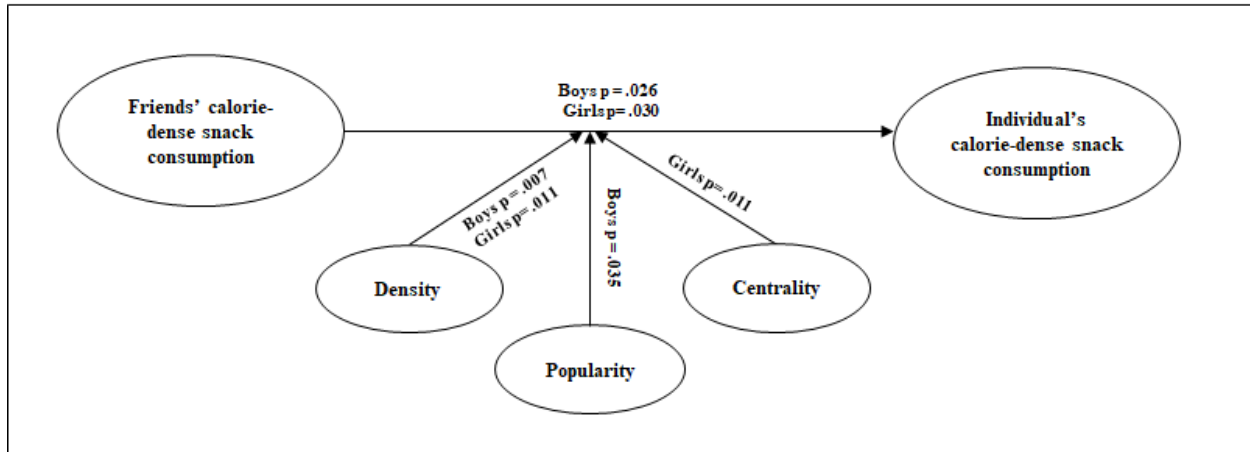
Figure 6.4: modified consumption model for calorie dense snacks consumption

e) **Physical activity:** It was hypothesized that individual's physical activity is associated with their friends' physical activity and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Findings in Section 5.9 Chapter Five suggest that there is statistical significance for these associations, and the associations are amplified by density, popularity (boys only) and centrality (girls only) as shown in Figure 6.5 below.
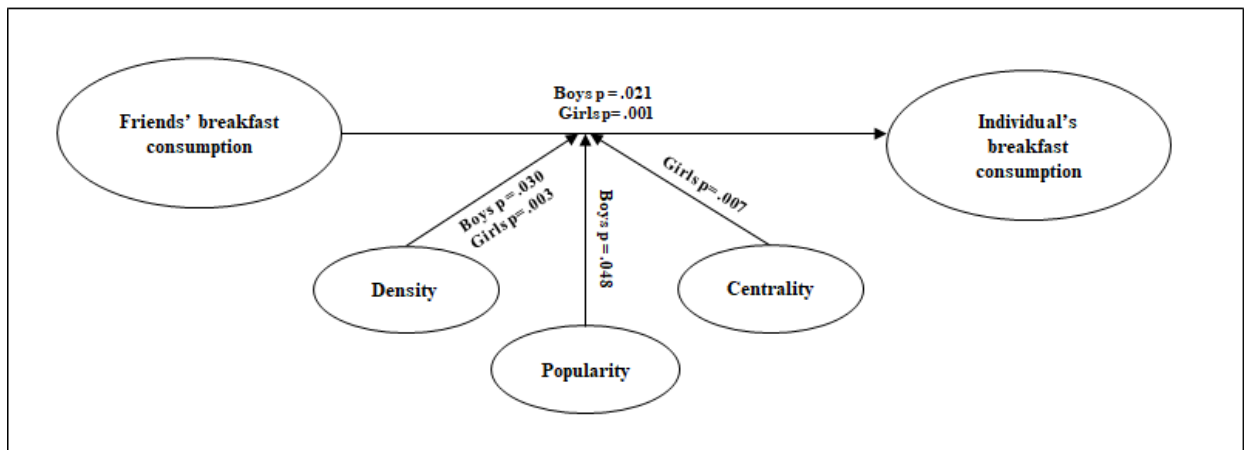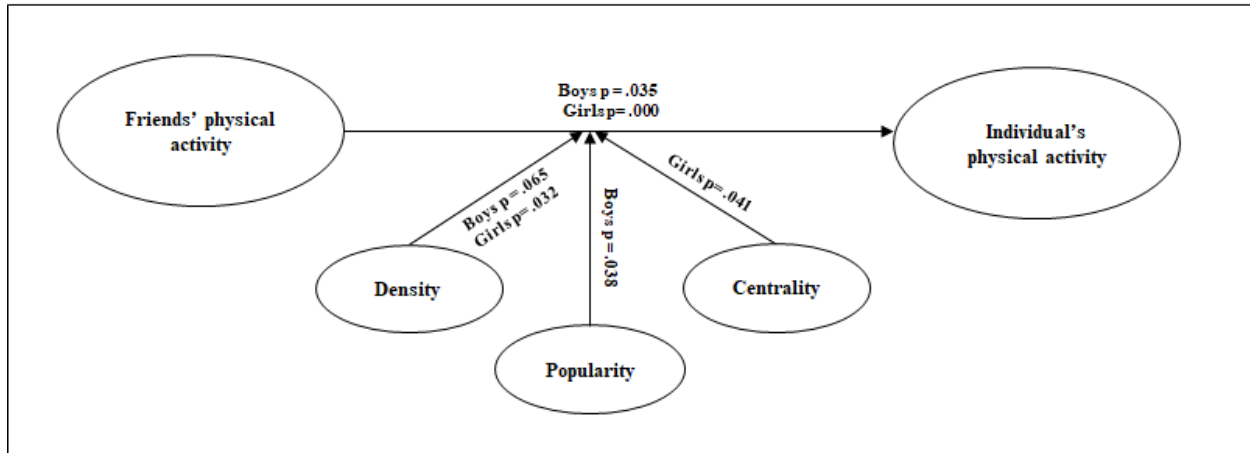
Figure 6.5: modified consumption model for physical activity

f) **Sedentary behaviour:** It was hypothesized that individual's sedentary behaviour is associated with their friends' sedentary behaviour and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Findings in Section 5.10 Chapter Five suggest that there is statistical significance for an association among girls only, and this association is not amplified by any of the network properties as shown in Figure 6.6 below.
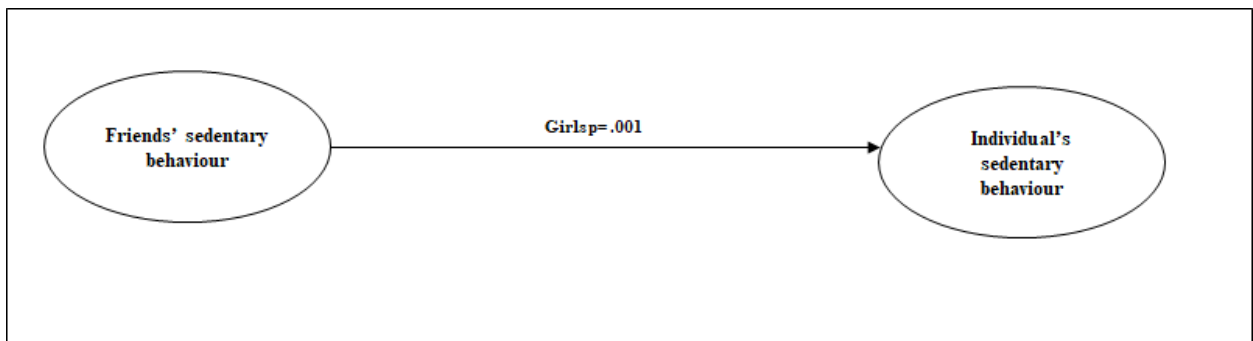
Figure 6.6: modified consumption model for sedentary behaviour

g) **Sleep:** It was hypothesized that individual's sleep is associated with their friends' sleep and the associations are amplified by network density, individual popularity and individual centrality in Section 3.3 in Chapter Three. Findings in Section 5.11 Chapter Five suggest that there is no statistical significance for an association between individuals' sleep and their friends' sleep.

6.6   Summary

In this chapter the research findings were discussed in the context of the literature in multiple areas and the studies that fully supported the findings and those that partially supported the findings of this research were pinpointed. The prevalence of overweight and obesity in the sample was relatively high when compared to the prevalence of overweight and obesity among children (below 18) in OECD countries but not very different when compared to the prevalence of overweight and obesity among adolescents in the GCC region. The majority of the adolescents in the sample consumed an unhealthy diet, were insufficiently active, and high sedentary but these findings are not just limited to this sample but rather seem like a global problem when compared to findings from other international and regional studies. There is evidence for associations between the individual and his/her friends in certain weight-related behaviours in the sample but these associations are gender specific which was also the case in previous studies. Similar to findings from other studies on delinquent behaviour there is evidence for the moderating role of network density to amplify/strengthen the association between the individual's weight-related behaviours and their friends' weight-related behaviour among boys and girls in the sample. Similar to findings from other studies on drinking behaviour and delinquent behaviour there is evidence for the moderating role of individual popularity to amplify/strengthen the association between the individual's weight-related behaviours and their friends' weight-related behaviour but only for boys in the sample. Similar to findings from other studies on delinquent behaviour there is evidence for the moderating role of individual popularity to amplify/strengthen the association between the individual's weight-related behaviours and their friends' weight-related behaviour but only for girls in the sample. Unlike this study, previous studies in other socially similar behaviours did not use gender segregated models and thus did not report any differences or similarities in the moderating role of network properties on behaviours associations among boys and girls. Based on this research findings, the conceptual model that was presented in Section 3.4 in Chapter Three was re-visited and modified in Section 6.5. In the next chapter, a summary of the research will be presented in addition to the research strengths, limitations, practical implications and the future directions for research.

Chapter 7: Conclusions

7.1 Introduction

In Chapter Six, the studies that were fully supported by the empirical findings and those that were partially supported were identified and critiqued to explain why they were in accordance with or differed from the empirical findings of this thesis. The purpose of this chapter is to conclude the study by identifying the achievements, limitations, practical implications, recommendations for policy makers and recommendations for future directions of research. The research summary will be presented in Section 7.2, to highlight the drive of this study and a summary of the purpose and outcomes of each of the seven chapters in this thesis. In Section 7.3 a description of how this study met its research aims and objectives will be presented. The research achievements will be presented in Section 7.4, followed by the research limitations in Section 7.5. The practical implications of the study will be presented in Section 7.6. Finally, recommendations for policy makers and recommendations for future research will be presented in Sections 7.7and 7.8.

7.2 Research summary

An introduction to the research problem was presented in Chapter One, which is that existing interventions aimed at improving weight and lifestyle related behaviours have not been successful mainly because they are targeted at the individual and they lack the proper understanding of the effects of social networks on individual's behaviour. Although many social network analysis studies were conducted to better understand the effects of social networks on individual behaviour, they have been mainly focused on behaviour association and both its mechanisms including socialization and selection. Less research was done to understand how the structure of the social networks themselves and the position of the individuals in the network could amplify behaviour association between these individuals and their friends. The aim of this research is to examine the role of friendship network properties on the associations between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation after reviewing the existing literature and analysing social network and behavioural survey data. In Chapter Two, a literature review was undertaken under three different but overlapping areas of research. The first area was about general health

behaviours in the social context because health researchers have studied the positive and negative effects of social networks on different health outcomes including smoking, drugs and drinking behaviours long before obesity and weight-related behaviours. The second area was about obesity in the social context and how obesity could spread between individuals over social networks. The third and last area was about the spread and maintenance of weight-related behaviours in adolescents' friendship networks. The majority of the studies in the literature review were about adolescents mainly because in comparison to adults and children adolescents are more vulnerable to peer influence, making them more susceptible to conform to their peers and friends behaviours. The literature suggests that there are associations between adolescents and their friends in certain weight-related behaviours, for example having more physically active friends increases the odds of the individual being physically active. Regardless of the underlying mechanism that is causing these associations being either socialization (i.e. social influence) or social selection. However, there is a lack of evidence regarding the role of network properties on these associations. In other socially similar behaviours including adolescent drug use, tobacco use, alcohol consumption, aggression, and delinquent behaviour, network properties were found to moderate peer selection and socialization. The moderating role of network properties on the socialization and selection process has not been addressed in the obesity and weight-related behaviours literature and was identified as a gap in the literature. In Chapter Three, a model was proposed to attempt to fill the gap in the literature which was underpinned by social network theory. The conceptual model was proposed to explore associations between the individual's and his/her friends' weight-related behaviours (diet, physical activity, sedentary behaviour and sleep behaviour) and to examine the moderating role of friendship network properties (density, popularity and centrality) on the associations in weight-related behaviours between friends. In Chapter Four, the design of the empirical study and the adopted methodology was presented. This is a quantitative study that follows a cross-sectional design, which utilises a survey. Methods are drawn from a set of analytical tools known as 'Social Network Analysis', which uses friendship nomination data from a complete network (socio-metric), along with reported data on diet, physical activity, sedentary behaviour, and sleep deprivation to investigate how friendship network structure is interacting with the weight-related behaviours of individuals in the network. The context of the study is completely new, as no previous social network analysis study in health was conducted in the GCC region including Kingdom of Bahrain. Four schools (two of

which are public and two are private) in Kingdom of Bahrain participated in the study with a total of 673 adolescents between the ages of 11 and 15. In Chapter Five, the main findings of the data analysis were presented. Binary logistic regression models were used to empirically explore associations between individual behaviour and friends' behaviour and the moderating role of network properties on these associations. There is evidence for associations between the individual and his/her friends in breakfast consumption, fast food consumption(boys only), fruits and vegetables consumption, calorie dense snacks consumption, physical activity and sedentary behaviour(girls only). Network density acted as a moderator/amplifier on the association between individual behaviour and friends' behaviour for breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption and physical activity. Individual popularity acted as a moderator/amplifier on the association between boys' behaviour and their friends' behaviour for breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity. Finally, individual centrality acted as a moderator/amplifier on the association between girls' behaviour and their friends' behaviour for breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption, and physical activity. In Chapter Six, the research findings were evaluated in the context of the literature and studies that agree and did not agree with the findings were pinpointed. When it comes to associations between individual's and friends' dietary behaviours specifically breakfast consumption, fast food consumption, fruits and vegetables consumption and calorie dense snacks consumption findings from this research are not fully supported by other studies conducted on weight-related behaviours. However, with physical activity, sedentary behaviour and sleep findings are very much similar to findings from other studies on weight-related behaviours. When it comes to the moderating role of network properties on the mentioned above associations, this research is supported by other studies conducted on socially similar behaviours in other parts of the world. Network density, individual popularity and individual centrality were found to moderate behaviour associations for some of the weight-related behaviours. However, one interesting finding in this study is that popularity emerges as a moderator only for boys and their friends' weight-related behaviours and centrality similarly emerges a moderator for girls and their friends' weight-related behaviours. The aim of this research was achieved as network properties were found to amplify behaviour associations between individuals and their friends in some of the weight-related behaviours. The decisions on

the research hypothesis based on the findings were provided. Finally, the conceptual model was re-visited and refined based on the findings from this research.

7.3   Meeting the aim and the objectives of this research

The research aim and objectives defined in Chapter One established a road map for this study. This study aims to examine the role of friendship network properties on the associations between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation after reviewing the existing literature and analysing social network and behavioural survey data. Examining the moderating role of network properties on behaviour associations among friends was identified as a main research gap and can provide a better understanding about the interaction between network properties and behaviour associations in friendship networks in order to gain insight into the role of properties of friendship networks in the development and persistence of obesity and weight-related behaviours in adolescents' friendship networks. The moderating role of network properties was examined and network density, individual popularity and individual centrality were found to amplify behaviour associations among friends in some weight-related behaviours. The first objective was to critically review the existing literature on obesity and weight-related behaviours in the social context (i.e. the effect of social networks) in order to identify existing knowledge and to pinpoint a research gap which is done in Chapter Two. The moderating role of network properties on behaviour association (including peer selection and socialization) was tested and identified in other socially similar behaviours but was not examined in the obesity and weight-related behaviours literature as a result it was identified as a research gap. The second objective was to propose a conceptual model after identifying the building blocks for conceptualising to examine the moderating role of friendship network properties on the association between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation after reviewing the existing literature which is done in Chapter Three. The third objective was to test and evaluate the conceptual model by defining an appropriate research approach followed by implementing the research methodology through data collection, analysis and finally a discussion of the empirical findings which is done in chapters 4 and 5. The fourth and last objective was to refine the conceptual model based on the empirical findings in order to propose a modified model that will assist in future research in the field of obesity and social networks in addition to assisting policy makers to design more effective public

health interventions that could leverage friendship networks to help improve the weight-related behaviours of adolescents and promote healthy weight which is done in chapters 6 and 7. In Section 2.6 in Chapter Two, four research gaps were pinpointed in the literature which formed the research questions that guided this research. Gap 1 which was about the lack of understanding of the moderating role of friendship network properties on weight-related behaviours associations between friends was addressed since the research findings suggest that some network properties moderate behaviour associations between friends in certain weight-related behaviours and the findings are gender specific. Gap 2 which was about the need to investigate sleep behaviour in friendship networks was also addressed since sleep behaviour was investigated in the study but research findings suggest that there are no associations between friends in their sleep behaviour. Gap 3 which was about the need to understand weight-related behaviours in friendship networks in a new context was also addressed since this study was conducted in the Kingdom of Bahrain which is a new context and a clinical sample. Although findings from this study were partially supported by other studies that were conducted in other contexts and clinical samples, friends were still found to share some weight-related behaviours such as physical activity regardless of the culture or the clinical sample. Gap 4 which was about the need to describe the conceptual model informing the methodology was also addressed since a conceptual model was proposed in Chapter 3 and empirically tested in Chapter 5.

7.4   Research contributions

This study has two contributions, the primary contribution of the thesis is the consideration of the network structure and its moderating role on behaviour association between adolescent friends and the secondary contribution is related to the context of the study:

- **Primary contribution: consideration of network structure and its moderating role on behaviour association between friends**

Much of the obesity research has explored the role of social networks in promoting health through social influence and selection. However, little research has examined how social networks could condition behaviour association (regardless of the underlying mechanism which could be peer socialization or selection). In other socially similar behaviours including alcohol consumption, drug use, tobacco use, aggression and delinquent behaviour some network properties were found to moderate peer selection and socialization among adolescents (Mathys, Burk, and Cillessen, 2013; Meter, Casper and Card; 2014; Jose et al., 2016). The aim of this

study is to examine the role of friendship network properties on the associations between individual's and friends' weight-related behaviours including unhealthy diet, physical inactivity, sedentary behaviour and sleep deprivation. Network density, individual popularity and individual centrality emerged as important moderators as was presented in Section 5.12 in Chapter Five. Individuals belonging to a denser network had stronger associations with their friends in breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie dense snacks consumption and physical activity. Boys who are highly popular had stronger associations with their friends in breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity. Finally, girls who are more central in the network had stronger associations with their friends in breakfast consumption, fruits and vegetables consumption, calorie dense snacks consumption and physical activity. There were no associations between individuals in sleep behaviour which may be because sleep is not a behaviour directly observable by friends.

- **Secondary contribution: investigating weight-related behaviours in adolescents friendship networks in a new context**

Most of the research on obesity and social networks was conducted in Australia, Europe, North America and the United Kingdom. Whereas none of the studies on obesity and social networks were conducted in the Middle East or the GCC countries as was already mentioned in Section 1.4 in Chapter One. Obesity and behavioural risk factors, including diet and physical activity has reached worrying levels in both children and adults in the Arab world (Rahim et al., 2014). Obesity has reached epidemic levels in most of countries in the GCC and requires urgent action to combat this epidemic (Musaiger, 2011). The prevalence of obesity in Arab Gulf states is reaching alarming rates not just among adults but also among children (Ng, Zaghloul, Ali, Harrison, and Popkin, 2011). Among adults, overweight plus obesity rates are especially high in Kuwait, Qatar and Saudi Arabia (70–85% among men; 75–88% among women) while adolescent overweight and obesity are among the highest in the world, with Kuwait having the highest estimates (40–46%) (Ng, Zaghloul, Ali, Harrison, and Popkin, 2011). There are multiple dietary, lifestyle, social, and cultural factors associated with obesity in the GCC (Musaiger, 2011). The Arab Gulf States witnessed a massive economic growth after the discovery of oil which came along increases in nutritional health problems and related diseases which is often referred to as the nutrition transition (Ng, Zaghloul, Ali, Harrison, and Popkin, 2011). Lack of

physical activity and sedentary lifestyle also contribute to obesity among Arab adolescents especially among girls (Obermeyer, Bott and Sassine, 2015). Research relevant to non-communicable disease prevention including obesity prevention is underdeveloped in the region (Mabry et al., 2016). Findings from a recent study assessing the quantity and quality of obesity-related research from Arab countries demonstrate that although there are some contributions from Arab gulf countries in obesity research, more efforts are needed by to bridge the gap in this topic and to improve the quality of obesity-related research originating from Arab countries (Sweileh et al., 2014). There is also a need to adapt and test international examples to the local context to help identify culturally tailored interventions for the gulf region (Mabry et al., 2016). There is a lack of research related to childhood obesity in the GCC and a need to carry out national studies on overweight and obesity among schoolchildren and adolescents (Musaiger, 2011). Obesity is a problem of concern among Bahraini school children and calls for school interventions (Musaiger, Al-Mannai and Al-Marzog, 2014). This study is the first to use social network analysis to investigate weight-related behaviours in adolescent friendship networks in this region and specifically in the schools of the kingdom of Bahrain. The nature of the sample in this study is unique as it included students from public and private schools. Public schools in the Kingdom of Bahrain and the majority of GCC countries are gender segregated.

7.5   Research limitations

Although this study has several achievements as was already discussed in the Section 7.4, this study is not without its limitations. Social network analysis is a powerful tool for studying individual behaviour and network interaction, but studies that use social network analysis suffer from common limitations. There are two main limitations with social network analysis, the first is concerned with the trade-off between the use of network analytic techniques and generalizability, and the second is concerned with the problem of confusion of influence by either homophily and/or by environmental factors (El-Sayed, 2011). There are also several other limitations that are not just related to social network analysis, a list of limitations specific to this study that are presented below:

1.   **Data are cross-sectional** – The cross-sectional nature of the data limits the causal inferences we can make about the associations between the individual and the friends' behaviours. The cross-sectional nature of the data also does not enable us to determine the

underlying mechanisms (e.g. socialization or social selection) of behaviour association. Further longitudinal exploration is also needed in order to examine how networks and behaviours change and develop over time and identify which mechanisms could explain behaviour association.

2.   **Missing data-** Missing data from the network and a low response rate has always been a concern for network data (Valente, 2010). It is unclear how students who were eliminated from the study sample because they did not answer the questions or because they did not obtain parent consent or were absent on the data collection affected the findings. The response rates in the sample varied between roughly 70% and 82% across the four schools and the overall response rate was 74.1% as shown in Table 5.1 in Chapter Five. Response rates of 70% or 80% are considered high by most scientific standards, however it is not clear if they are adequate for network analysis (Valente, 2010). It is difficult to estimate the effects of missing data on network measures (Kossinets, 2006). Missing data can dramatically alter network-level statistics including network density (Kossinets, 2006). The effects of missing data are not as dramatic on other individual-level measures including popularity and centrality which are relatively stable even at low response rates (Costenbader and Valente, 2003; Kossinets, 2006). Further discussion of the response rate was already provided in Section 5.2 in Chapter Five.

3.   **Sample size-** Incomplete survey forms were eliminated from the data analysis, which impacted the sample size. The minimum required sample size as recommended by Saunders et al., 2009 for 95% confidence and 5% margin of error is 740 participants as was discussed in Section 4.6 in Chapter Four. Although parental consent was received from 783 adolescents across the four schools, only 673 forms were complete and used in the data analysis. This might have impacted the results as the minimum required sample was not met.

4.   **Within-school friendships** – Friendships are an important social context for weight-related behaviours (de la Haye et al., 2010). Especially school friendships, since adolescents spend a large portion of their time at school interacting with their friends (Sawka et al., 2013). The restriction to within-school friendship was necessary because of the nature of this study as was discussed in Section 4.3 in Chapter Four. This study is a socio-metric study which uses census sampling so it is desirable to interview all members of the network, therefore the network had to be restricted. Because of this restriction, we are unable to study the associations of adolescents' behaviours with friends from outside of school behaviours.

7.6   Practical implications

This study is the first to study the role of social networks on health behaviours in the Arab Gulf region, specifically weight-related behaviours in adolescent friendship networks. The most useful application for network data is to accelerate behaviour change through network interventions by using social network data to identify specific people or groups of people to deliver and/or receive the behaviour change program (Valente, 2010). Network interventions can take different forms each with different implementation considerations they can be defined by two primary tasks (Valente, 2010):

1)   Aiming to change the structure of the network i.e. network restructuring by strengthening or relaxing certain friendship connections (Valente, 2010). For instance to promote physical activity, the focus should be on making existing relationships ties with active adolescents stronger (Macdonald-Wallis et al., 2011).

2)   Aiming to change the functional components of the network, for example an individual's position or function in the network. It is important to consider the behaviours of individuals within each friendship network (Valente, 2010). For instance, the introduction of new ties with active individuals may promote physical activity for inactive individuals that have friendships with mostly inactive individuals.

This research will recommend to utilise the first form i.e. network structuring to accelerate behaviour change after considering the main findings of this research. This research was able to identify associations between friends in breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie-dense snack consumption, physical activity and sedentary behaviour (girls only) as was discussed in Section 5.12 in Chapter Five. In Chapter Two, two social processes were identified to explain the associations in behaviour in friendship networks which are socialization and selection. Interventions focused on utilizing socialization with its different mechanisms including co-participation, modelling and social norms may provide a better means of increasing physical activity levels than selection (Sawka, 2014). Over time, friends' participation in sports was positively associated with the individual's participation in sports as a result of co-participation (Denault and Poulin, 2009). Selection on the other hand can have a positive or negative impact on an individual's physical activity level depending on the individual (Sawka, 2014). Active individuals will select active friends which will re-enforce participation in physical activity. However, inactive individuals will select inactive friends which

will re-enforce physical inactivity. Socialization can be useful to increase physical activity levels through network restructuring on the other hand, selection may be important for continued support and re-enforcement of physical activity (Sawka, 2014).

This research was also able to identify several network properties that amplified weight-related behaviour associations between friends which was presented in Section 5.12 in Chapter Five. Network density was found to amplify associations between friends in breakfast consumption, fast food consumption (boys only), fruits and vegetables consumption, calorie-dense snack consumption, physical activity and sedentary behaviour (girls only). Denser networks re-inforce associations between individuals and their friends. With boys, popularity was found to amplify associations between friends in breakfast consumption, fast food consumption, fruits and vegetables consumption, calorie-dense snack consumption and physical activity. Popular boys had stronger behaviour associations with their friends. With girls, centrality was found to amplify associations between friends in breakfast consumption, fruits and vegetables consumption, calorie-dense snack consumption, physical activity and sedentary behaviour. Central girls have stronger behaviour associations with their friends. Interventions focused on utilizing different mechanisms of socialization including co-participation, modelling and social norms can be more effective in denser networks additionally when popular boys and central girls are targeted. In this section general practical implications where discussed, in the next section specific recommendations for policy makers based on the research findings will be presented.

7.7   Recommendations for policy makers

In the Arab gulf region, very few studies offered recommendations that translate research findings into practice (Mabry et al., 2016). Additionally, there are no comprehensive programmes directed towards combating obesity, only some activities related to the prevention and control of obesity carried out by the Ministry of Health that focus on mass media and producing booklets (Musaiger, 2011). There is an urgent need for policy makers to address risks factors for non-communicable diseases including obesity and to encourage young people to adopt healthier behaviour with regard to diet and physical activity (Obermeyer, Bott and Sassine, 2015). This is especially true because of the obesogenic environment in school children and adolescents in the kingdom of Bahrain which creates the need for establishing an early intervention programme to control obesity (Musaiger, Al-Mannai and Al-Marzog, 2014). Testing international examples in the local context would be helpful to inform policy makers to make

more effective interventions (Mabry et al., 2016). There is growing evidence that supports network based interventions for obesity among adolescents (Giannini et al., 2017). Peers are possible targets for more effective interventions to promote healthier diet and exercise among adolescents (Chung, Ersig and McCarthy, 2017). This study used network data and behavioral data to better understand weight-related behaviours in friendship networks. Findings from this research are worrying since they indicate the vast majority of adolescents are skipping breakfast regularly, consuming insufficient amounts of fruits and vegetables, eating fast food and calorie dense snacks regularly. In addition to poor dietary habits, the vast majority of adolescents are insufficiently active, high sedentary. Such findings explain the high prevalence of overweight and obesity in the sample, where one in three adolescents is either overweight or obese. This research was able to identify associations between friends in certain weight-related behaviours and the role of network properties in amplifying these association, making individuals in networks with certain properties and certain positions in the network at higher risk for behaviour association with their friends. Interventions that could leverage friendship networks have a potential but since the findings from this research are gender specific then this has implications for gender tailored interventions. The below recommendations are provided to policy makers to be implemented in schools based on this research findings:

7.7.1. Recommendations to improve dietary behaviours

i.   A common approach that utilises social network data to come up with effective health interventions is the identification of opinion leaders and having them act as change agents (Valente, 2010). These socially integrated individuals can act as role models and reach out to a higher number of individuals in the network (Valente, 2010).Popular boys had stronger behaviour association with their friends in breakfast consumption, fast food consumption, calorie-dense snack consumption and fruits and vegetables consumption which makes them ideal opinion leaders to promote adopting the healthy behaviours instead of the unhealthy behaviours. Central girls had stronger behaviour association with their friends in breakfast consumption, calorie-dense snack consumption and fruits and vegetables consumption which makes them ideal opinion leaders to promote adopting the healthy behaviours instead of the unhealthy behaviours.

ii.   Create within school policies that only allow selling healthy foods and banning unhealthy foods in school canteens. The majority of the participants in the sample were consuming calorie

dense snacks and not consuming enough fruits and vegetables. There was also an association between individuals and their school friends in calorie dense snacks consumption and fruits and vegetables consumption meaning that they most likely consume these foods together. Providing only healthy options including fruits and vegetables and banning unhealthy foods including calorie dense snacks could encourage adolescents to go for healthier food choices In phase four of this study, the schools were visited to inspect the school facilities including the canteens and all four school canteens served both healthy and unhealthy foods with a wider variety of unhealthy foods including crisps, chocolates, high sugar juices and fizzy drinks. Healthier options were limited to apples, bananas and in some schools a small portion of tabbouleh (a green salad).   A description of the different study phases in provided in Section 4.7 in Chapter Four.

7.7.2. Recommendations to promote physical activity

iii.   Create within school policies that promote interaction between active and inactive individuals to re-inforce support for physical activity. Social network interventions that expose inactive individuals to active individuals could result in an overall increase in the physical activity levels of the friendship network through friendship influence (i.e socialization) (Sawka, 2014). But friendship influence is a reciprocal and transactional process (Prinstein and Dodge, 2008). Meaning that influence, could go both ways and could decrease the activity level of active individual. These negative consequences are referred to as boomerang effects and have been observed in other health behaviours (Dishion, McCord and Poulin, 1999). However, previous research on physical activity showed that individuals tend to increase their physical activity levels to match the levels of their friends (De la Haye et al., 2010; Denault and Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013).

iv.   Similar to dietary behaviours, identify opinion leaders which is a common approach that utilises social network data to health promotion interventions is the identification of opinion leaders, and having these leaders act as change agents (Valente, 2010). Popular boys had stronger behaviour association with their friends which makes them ideal opinion leaders to promote physical activity. Central girls had stronger behaviour associations with their friends which makes them ideal opinion leaders to promote physical activity.

7.7.3. Recommendation to discourage sedentary behaviour

v.   Create after-school activities that promote social engagements where girls can be active together. The percentage of girls who are insufficiently active is substantially higher than boys in this sample. Previous studies conducted in the Kingdom of Bahrain found that girls were less likely to be physically active when compared to boys which may expose them to higher risk of adult obesity (Musaiger, Al-Mannai and Al-Marzog, 2014). Arab girls are facing many cultural related problems that may be hindering physical activity practice including: 1) Public sports facilities are male oriented and very few are available to females 2) Most girls cannot practice exercise outdoor with sport dress due to cultural or religious reasons 3) In the Kingdom of Bahrain, the majority of girls who are allowed to practice exercise outdoor by their families, do such with traditional attire which may be uncomfortable (Musaiger, Al-Mannai and Al-Marzog, 2014). Findings from this research also suggest that there is an association between girls and their friends' sedentary behaviour levels, and the percentage of high sedentary girls is substantially higher than boys. This was already discussed in Section 6.4 in Chapter Six and attributed to the conservative nature of the culture and upbringing of girls in the Kingdom of Bahrain. Generally, speaking girls are not allowed to go out as much as boys did so they are more likely to stay at home and be sedentary. So interventions aimed at promoting physical activity in after-school activities can have a potential to promote lower levels of sedentary behaviour among girls since interventions increasing physical activity will most likely assist in decreasing sedentary behaviour levels. Additionally, parents may feel more comfortable with their daughters being at school and getting involved in after-school activities rather than going out with their friends. After-school activities that promote social engagements where girls can be active together may help overcome this problem.

7.7.4. Recommendation to create a health index for schools

vi.   Finally, to create a health index for schools that indicates compliance to the health policy regulations, allowing these institutions to compete to achieve these objectives and publish the ranking on a regular basis publicly. Although, this recommendation is not directly linked to a finding related to the research aim and objectives. Three out of four schools asked about the prevalence of obesity and prevalence of healthy and unhealthy behaviours in their schools, and how they did in comparison to other schools that were included in the study. Creating a health index may encourage schools to promote healthy behaviours and discourage unhealthy behaviours by competing with other schools locally.

7.8 Recommendations for future research

Our understanding of the processes by which friendship network properties moderate peer socialization and selection in weight-related behaviours is still in the early stages. Future research that will build upon the gaps in the knowledge presented below will lead to more informed public health interventions:

1- Further longitudinal exploration is needed in order to determine the underlying mechanism of behaviour association being either peer socialization or selection as this may have important intervention implications. For instance to increase the individuals physical activity levels when peer socialization emerges as an underlying mechanism then interventions should focus on adjusting physical activity levels among friends; whereas if social selection emerges as an underlying mechanism then interventions should focus on creating friendships with active individuals. If both, socialization and selection emerge as underlying mechanisms then interventions should focus on a combination of both of the above strategies. Future longitudinal work would also benefit from understanding which mechanisms either peer socialization or selection are more influential by taking gender into account. It may be that either socialization or selection may be stronger among girls but not among boys or vice versa. This has important implications since interventions may need to be tailored differently for boys and girls. Finally, future longitudinal research could benefit from understanding how network structure interacts with individual behaviour over time.

2- Future work would benefit from considering other types of friendships including outside of school friendships. Outside of school networks may be important for examining associations with sedentary behaviour and sleep deprivation as these types of activities generally occur outside of the school.

3- This research investigated the role of density, popularity and centrality on peer selection and socialization. Future research should explore the moderating role of other network properties since social network analysis provides measurements of several network properties. Other network properties may be important and worthy of future investigation. For example out-degree or reciprocity are additional properties networks that may condition behaviour association.

4- Future research could benefit from investigating if the type of certain activities or behaviours is influenced by peer selection and socialization and is conditioned by certain

network properties including type of physical activity (individual sports or team sports), and type of sedentary behaviours (watching tv, online gaming, using smart devices).

5-   Future qualitative research along with quantitative analyses may also be useful to provide additional insight into adolescents' diet, physical activity and sedentary behaviour in relation to their friends.

6-   Future work may benefit from understanding why individual popularity emerges as an important moderator for behaviour association for boys only and individual centrality emerges as an important moderator for behaviour association for girls only in this sample.

7-   Finally, future work would benefit from confirming why there are associations between individuals and their friends in dietary behaviours like breakfast consumption and fruits and vegetables consumption in the Kingdom of Bahrain and not in other countries where these associations   were   stronger   between   individuals   and   their   parents.

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APPENDIX 1: Table with studies used to pinpoint the research gap

Weight-related behaviours in adolescent friendship networks						
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**
Ali, Amialchuk and Heiland, 2011	To investigate whether interactions in friendship networks influence the weight-related behaviours of adolescents which include exercising, playing sports, hours of TV/Video viewing, sleeping deprivation, eating breakfast, frequency of eating fast food, eating fruits/vegetables daily, and consuming calorie-dense snacks.	Multivariate regression	National Longitudinal Survey of Adolescent Health(Add Health) dataset/Adolescents/USA	The social transmission of weight-related behaviours is a viable explanation for the spread of obesity in friendship networks and it has been documented in recent research. Interventions focused on weight reduction interventions may be complemented with strategies that focus on leveraging peer support for behaviour modification.	The reliance on self-reported behaviours.	Future studies should examine how friendship connections are formed. Additionally, there is a need to examine whether there is a relationship between the spread of one behaviour in social networks (e.g. fast-food consumption) with another behaviour another (e.g. unhealthy snacking). Finally, to look into whether peer influence in obesity operate via other pathways that has not been examined in this study.
Barclay, Edling and Rydgren, 2013	To investigate the clustering phenomenon of exercise and eating behaviours amongst a previously unstudied group, young adults in Sweden. Obesity rates are less severe in this group. Most previous research has mainly been conducted in countries that have higher rates of obesity including the United	Logistic Regression/Cross-sectional design	Adolescents(19 year olds)/Sweden	Consistent with previous research, there are strong associations between individual's behaviours and their peers' behaviours for young adults. This suggests that health behaviours of an individual's peers may play a role in shaping their own health behaviours.		There is a need to better understand the mechanisms by which obesity is spread through social networks. Future research should go beyond documenting correlations between peers and to investigate the diffusion of actual health behaviours.

Author(s)/Year	Purpose	Approach	Dataset/Age Group/Country	Major Finding(s)	Limitation(s)	Future Research
				States and Britain.		
de la Haye et al., 2010	To examine obesity-related behaviours in adolescent friendship networks. This is because adolescent peers have been identified as being important determinants of the individuals' different health related behaviours.	ERGM selection models Cross Sectional design	Male and female students from independent middle schools/Adolescents/Australia	Friends' leisure activities and food consumption behaviours (as early as 13–14 years old) were found to be similar. This is a potential mechanism for the social 'contagion' of overweight and obesity. Same-sex friends were found to be similar in organised physical activity in two out of the three schools. Female friends were found to engage in similar screen-based behaviours, and male friends tended to be similar in their consumption of high-calorie foods. Finally, individual popularity (incoming ties) was associated with some behaviours, however these associations were gender specific and inconsistent across the networks.	The data is cross Sectional which makes it difficult to assess the causal effect of the hypotheses.	It is important to consider contextual factors in the future such as school policies or the facilities that could impact food consumption and physical activity and how they may be mediating social influence in a school setting.
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**
de la Haye et al., 2011	To examine the role of school-based friendship networks on adolescents' engagement in physical activity.	Stochastic actor-based models	Two cohorts of grade eight students/Adolescents/Australia	Participants tended to select fruends who did similar amounts of physical activity, and as a result consequently emulated their friends' behaviours. However, friends' influence on physical activity was not found to be mediated through cognitions about physical activity. The findings show that there is a mutually dependent relationship between adolescent friendship networks and physical activity. This indicates how network-based strategies may be effective in supporting adolescents to be physically	Study addressed school based friendships and ignored other friendships, parent influences and siblings' influences.	Future studies should be longer in duration to study the lasting effect of friendship. Additionally the use of objective measures such as accelrometers should be used instead of self-reported measures on physical activity.

Author(s)/Year	Purpose	Approach	Dataset/Age Group/Country	Major Finding(s)	Limitation(s)	Future Research
				active.		
de la Haye et al., 2013	To test whether observed similarities in low-nutrient energy-dense (LNED) food consumption among friends is a result of social influence and to explore the underlying psychological mechanisms.	Longitudinal social network models	Three waves of grade eight students/Adolescents/Australia	Adolescent intake was predicted by their friends' intake and changes to adolescents' beliefs about LNED food do not appear to be the underlying mechanism of influence from their friends.	The reliance on self-reported measures.	Future work should investigate whether or not friends influence LNED food consumption among a more diverse sample of youth (not just grade eight students). Additionally, to investigate whether these effects persist outside of the school setting or have a lasting effect on dietary behaviours.
Finnerty et al., 2009	To investigate the diet and physical activity of adolescents and children aged 9–13 years, and the influence of peers on these behaviours.	Non-parametric data analyses/ Cross-sectional study	Nine primary and secondary schools/Adolescents and Children/United Kingdom	Low physical activity levels and high saturated fat intakes are found among boys and girls across all age groups which emphasizes the importance of promoting both physical activity and healthy food choices. Peers are found to have a crucial effect on physical activity levels but not on dietary intake which offers an important approach for the design of health promotion interventions and obesity prevention programmes and a need for gender specific interventions because of a new finding on boys and girls mean daily step counts being closer to their gender specific cut-off.	The cross Sectional design in addition to the risk of measurement bias which results from self-report measures. .	Future studies should undertake longitudinal research in order to design more effective interventions to promote healthy behaviours in school children.
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**

Garcia et al., 2016	To examine the association between adolescent's and their friends moderate-to-vigorous physical activity (MVPA) and screen time and to explore the potential mechanisms of friends' social influences on MVPA and screen time.	Quantitative(Multiple Regression Analysis) and Qualitative approach(Focus Group)	High school and middle school students/Adolescents/USA	Findings revealed that higher levels of friends' MVPA was associated with higher levels of MVPA in inviduals (both males and females). Additionally, higher levels of friends' screen time was associated with higher levels of screen time in males only. Among females, psychosocial variables, such as increased screen time enjoyment, were associated with increased screen time. School level being high or middle was not associated with either MVPA or screen time.		Future studies should investigate family influences and peer influences (not just friends) on physical activity and sedentary behaviour.
Geller et al., 2013	To understand the influence of parent and friends on the dietary, physical activity, and sedentary behaviours of Pacific Islander high school students.	Quantitative (Descriptive Analysis) and Qualitative approach(Focus Group)	High school students/Adolescents/Hawaii, USA	Findings revealed that the parents/ guardians of pacific islander high school students had the dominant influence on adolescents' dietary behaviours. Time me spent with parents was almost exclusively sedentary, and adolescents were more active with their friends, but shared less healthy dietary habits. Results provide implications for similar examinations and culturally tailored interventions among similar adolescent populations.	Reliance on self-reported data. The inability to generalize the findings since the sample was from a private school.	
Marks et al., 2015	To report on associations between personal network characteristics, physical activity (PA), sedentary and screen-	Regression Models/Cross Sectional design	Students(11-13 years old) from fifteen randomly selected Victorian primary	Friendship network characteristics are associated with physical activity and sedentary behaviour in late childhood and early adolescence. However, these	The reliance on self-reported measures. The low participation rate	

related behaviours for early adolescents.			schools/Adolescents/Australia	associations are gender specific. A promising avenue is the positive influence of active peers that could be leveraged to increase physical activity levels and reduce sedentary behaviour.	did not permit analysis of complete network characteristics such as in-degree, density or reciprocity. Finally the inability to determine the underlying mechanisms (e.g. social influence or selection) that lead to observed network-behaviour associations, due to the cross-sectional design of the study.	
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**
Maturo and Cunningham, 2013	To examine evidence for friendship influences on children's physical activity through a systematic searches of online databases	Systematic Literature Review		Children's physical activity was positively associated with encouragement from friends, friends' physical activity and finally engagement with friends in physical activity. These findings are consistent with friends influencing physical activity. However, most of the studies included in the review did not distinguish influence from other mechanisms explain similarity. Future programs aimed at promoting physical activity should consider friendships.		More research is required to understand the magnitude of influences and to explore the potential for using friendship to promote healthy physical activity habits.

Maume, 2013	To examine whether social ties affect sleep behaviours among adolescents in comparison to developmental factors.	Regression Models/Cross Sectional design	The Study of Early Child Care and Youth Development/Adolescents	Social ties outperform developmental factors as a determinant of adolescents sleep patterns. This emphasizes the importance of parental, peer, and school ties in promoting healthy sleep behaviours.	Lack of measure for school start time.	Future studies to examine sleep effects on obesity are needed in order to establish the central role of sleep in promoting health during adolescence.
Sawka et al., 2013	To review existing literature on friendship networks, physical activity and sedentary behaviour among children and adolescents.	Systematic literature review		Friends' physical activity level have a significant influence on individual's physical activity level. Evidence surrounding sedentary behaviour is limited and mixed. Results from this review could inform effective public health interventions that harness the influence of friends to increase physical activity levels among children and adolescents.		Future work must describe the theoretical framework used in their methodologies and the interpretation of results. Only three of the studied studies mentioned the use of a theoretical framework. .
Sawka et al., 2014	To broadly examine adolescent friendships network characteristics, physical activity levels and sedentary behaviour.	Cross Sectional analysis	Adolescents (11–15 years)/Canada	Different network characteristics (including density; proportion of active/sedentary friends; betweenness centrality; popularity; clique membership) have different consequences. The proportion of active close friends was associated with MVPA, on the other hand network density was associated with sedentary behaviour.		
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**
Shoham et al., 2012	To test the hypothesis that social influences on adolescent body size and weight-related behaviours are independent of	A stochastic actor-based model SABM (R-SIENA framework)	The National Longitudinal Study of Adolescent Health (Add Health dataset/ Adolescents/USA	There is evidence for homophily and social influence on BMI. Results suggest that homophily and social influence are both important to have a better	The reliance on self-reported data. The ABM model is designed for	

	friend selection.			understanding of adolescent obesity.	discrete behaviours, such as smoking and alcohol consumption, and it was also designed for small networks.	
Simpkins et al., 2013	To examine the association between adolescents' friends and health.	Stochastic actor-based (SAB) model referred to as (SIENNA)	The National Longitudinal Study of Adolescent Health (Add Health dataset)/Adolescents/USA	Friends become similar in BMI and physical activity over time. However the specific mechanisms underlying the similarity are not clear. Physical activity was not found to explain friendship similarity on BMI, but several other potential mechanisms could be further examined.	Data limitations (Self-reported weight and height, Objective measures of physical activity, such as accelerometers, or even daily diaries would be better than the measures by the Add health data). More detailed indicators are on health related behaviours required	

The moderating role of friendship network properties on peer selection and socialization

Author(s)/Year	Purpose	Approach	Dataset/Age Group/Country	Major Finding(s)	Limitation(s)	Future Research
Brechwald and Prinstein, 2011	To review empirical and theoretical contributions to a multidisciplinary understanding of peer influence	Literature Review	Adolescents	Research on peer influence has expanded within the last ten years,		There is a need to understand the factors that may be relevant for understanding potential cultural or

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	processes in adolescence over the last ten years.			offering important conceptual, methodological, and empirical contributions to an important area of study.		ethnic differences in peer selection and socialization.
Veenstra et al., 2013	To review conceptual, methodological, and empirical contributions focusing on longitudinal social network modelling.	Literature Review	Adolescents	Research on network–behaviour dynamics has expanded recently and have shown selection and influence processes occur within a dynamic social system. Understanding properties of this system including network characteristics, influence, selection, behavioural processes is important for understanding how networks and behaviours develop over time.		Future studies should look at how interventions aimed at promoting positive behaviours or reducing negative behaviours influenced by network–behaviour dynamics.
Jose et al., 2016	To explore the co-evolution of delinquent behaviours and friendship networks.	Longitudinal Study	National Longitudinal Study of Adolescent Health (Add Health)/USA	Results indicate the presence of both influence and selection. Moderating effects were tested for density, centrality, and popularity, with only an interaction effect for density and influence.		

Author(s)/Year	Purpose	Approach	Dataset/Age Group/Country	Major Finding(s)	Limitation(s)	Future Research
Lakon and Hipp, 2014	To examine the moderating role of friendship network properties on associations between 1) youths' friends smoking behaviour and youths' own generalized expectancies regarding risk and future orientation and 2) generalized expectancies of youths' friends and youths' own generalized expectancies.	Longitudinal Study	National Longitudinal Study of Adolescent Health (Add Health)/USA	The association between friends' generalized expectancies and youths' expectancies is stronger for those more central in the network, and weaker for those in denser friendship networks.	The networks were limited to up to 5 school friends and did not have full information about outside of school friends.	Further examination of how adolescent network characteristics relate to these expectancies is needed.
Tucker et al., 2014	To examine whether the structural properties of friendship network moderate friends' influence on adolescent marijuana use over time.	Longitudinal Study	National Longitudinal Study of Adolescent Health (Add Health)/USA	Friends' influence on youth marijuana use depends on the context of the school.	Examining only within-school friendships and ignoring other friendships.	Future research is needed to better understand the conditions under which properties of friendship networks moderate friends' influence on adolescent marijuana use.
Mathys, Burk, and Cillessen, 2013	To examine the associations between late adolescents' friendships and substance use including alcohol, marijuana and tobacco and the moderating role of popularity on these associations.	Longitudinal Study	450 adolescents (53% female, M age = 15.5 years) who completed surveys in grades 10 and 11/USA	Popularity was found to moderate selection based on alcohol use and popular adolescents were more likely to select friends with high levels of drinking. Popularity did not moderate peer socialization.	The model did not test whether the moderation effects of popularity differed as a function of gender or ethnic group.	
Haynie, 2001	To examine whether the properties of friendship networks condition the association between friends' delinquency and an individual's own	Cross-sectional study	National Longitudinal Study of Adolescent Health (Add Health)/USA	Results indicate that individual's delinquency is associated with friends' delinquency and	The cross-sectional nature of the data limits the causal inferences about the relationships between network characteristics and	Future studies should investigate other network characteristics that may also be moderators.

delinquent behaviour.				properties characteristics of adolescents' friendship networks (density, centrality and popularity) condition the delinquency peer association. These findings suggest that it is important to consider the underlying properties of friendship networks in order to better understand the impact of peer influence and selection on adolescent delinquency	delinquent behaviour.	
Author(s)/Year	**Purpose**	**Approach**	**Dataset/Age Group/Country**	**Major Finding(s)**	**Limitation(s)**	**Future Research**
Meter, Casper and Card, 2015	To examine whether the perception of the positive friendship quality of intimate exchange and friendship reciprocity moderates best friend influence on aggression over time.	Longitudinal Study	243 participants were approximately 12 years old/USA	Findings indicate that reciprocity did not significantly moderate friend influence on aggression in a simple way.		

APPENDIX 2: English Survey Form

Investigating Weight-related behaviours in Friendship networks

Part 1: Participant Information

1)   Name: _____

2)   CPR: _____

3)   Age: _____

4)   School:_____

5)   Grade: _____

6)   Gender: _____

7)   Nationality: _____

Part 2: Anthropometric Measurements

8)   Body weight: _____

9)   Height: _____

Part3: Obesity/Weight-related Behaviours

3.1 Diet

10)   Do you usually eat breakfast?

a)   Almost every day

b)   Sometimes

c)   Rarely or never

11)   How often do you eat at a fast food restaurant?

a)   Almost every day

b)   Sometimes

c)   Rarely or never

12)   How many fruits and vegetables (example: apple, orange, lettuce, cucumber, etc.) do you usually eat?

a)   0-1 servings per day

b)   2-3 servings per day

c)   4-5 or more servings per day

13)   Do you usually eat calorie dense snacks (example: chocolate bars, chips, doughnuts, cookie, etc.)?

a)   Almost every day

b)   Sometimes

c)   Rarely or never

3.2 Physical Activity

14)   In the **past 7 days**, on how many days were you physically active (example: football, basketball, cycling, swimming, walking etc) for a total of at least one hour per day?

a)   0 days, I was not physically active at all in the last week

b)   1 day

c)   2 days

d)   3 days

e)   4 days

f)   5 days

g)   6 days

h)   7 days, I was physically active every single day in the last week.

15)   In a **usual week**, on how many days are you physically active (example: football, basketball, cycling, swimming, walking etc)   for a total of at least 60 minutes per day?

a)   0 days, I am not physically active at all.

b)   1 day

c)   2 days

d)   3 days

e)   4 days

f)   5 days

g)   6 days

h)   7 days, I am physically active every single day.

3.3 Sedentary Behaviour

16)   In your free time on a typical **weekday(Sunday to Thursday),** how many hours do you spend doing the following: watching tv, videos, DVD's, using a computer, playing video games on a handheld device(phone, PSP, Nintendo) for playing games or watching shows or movies?

a)   0 hours per day

b)   1

c)   2

d)   3

e)   4

f)   5

g)   More than 5 hours per day

17)   In your free time on a typical **weekend(Friday and Saturday),** how many hours do you spend doing the following: watching tv, videos, DVD's, using a computer, playing video games on a handheld device(phone, PSP, Nintendo) for playing games or watching shows or movies?

a)   0 hours per day

b)   1

c)   2

d)   3

e)   4

f)   5

g)   More than 5 hours per day

3.4 Sleep

18)   On a typical weekday night (Sunday to Thursday):

What time do you usually go to sleep? _____ What time do you usually wake up? _____

19)   On a typical weekend night(Friday to Saturday):

What time do you usually go to sleep? _____ What time do you usually wake up? _____

Part 4: Friendship Network Data

20)   Who are your five **CLOSEST FRIENDS** in your school?

Write their names and grade on the lines below starting with your best friend. If you cannot think of five people, then leave the extra lines blank. For example, if your friend's name may be

Ali Hasan Al Sayed. Then you would write his name and grade/section and in the Table below. It is written in as an example:

Friend	First Name	Middle Name	Last Name	Grade/Section
example	*Ali*	*Hasan*	*Al Sayed*	*8C*
1				
2				
3				
4				
5				

APPENDIX 3: Arabic Survey Form

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دراسة السلوكيات المتعلقة بالسمنة فى شبكات الصداقة بين المراهقين

الجزء الأول: معلومات الطالب

1. الأسم: ـــــــــــــــــــــ
2. الرقم الطلابي: ـــــــــــــــــــــ
3. العمر: ـــــــــــــــــــــ
4. المدرسة: ـــــــــــــــــــــ
5. الصف: ـــــــــــــــــــــ
6. الجنس: ـــــــــــــــــــــ
7. الجنسية: ـــــــــــــــــــــ

الجزء الثانى: قياسات الوزن والطول

8. الوزن(kg): ـــــــــــــــــــــ
9. الطول(cm): ـــــــــــــــــــــ

الجزء الثالث: السلوكيلت المتعلقة بالسمنة

3.1. النظام الغذائي:

(10) عادة ما تتناول وجبة الإفطار:

(a) كل يوم تقريبا

(b) أحيانا

(c) نادرا أو لا تتناولها على الإطلاق

(11) عادة ما تتناول الوجبات السريعة (fast food) :

(a) كل يوم تقريبا

(b) أ حيانا

(c) نادرا أو لا تتناولها على الإطلاق

(12) كم وحدة من الخضروات والفواكه(على سبيل المثال: التفاح, البرتقال, الخيار, الخس, الخ) تأكل بالعادة؟

(a) 0-1 وحدة في اليوم

(b) 2-3وحدات في اليوم

(c) 4-5 وحدات في اليوم أو أكثر

(13) عادة ما تتناول الأطعمة ذات السعرات الحرارية العالية (على سبيل المثال: الشوكولاته ، الكعك، رقائق البطاطس ، الخ)

(a) كل يوم تقريبا

</div>

(b) أ حيانا

(c) نادرا أو لا تتناولها على الإطلاق

3.2. النشاط البدني والرياضي

14 **خلال الأسبوع الماضي**، كم عدد الأيام التي كنت فيها نشطا جسديا (كأن تكون قد لعبت فيها كرة القدم, كرة السلة، ركوب الدراجات، السباحة، الجري، المشي وغيرها) لمجموع ساعة واحدة على الأقل في اليوم؟

(a) 0 أيام، لم أكن نشطا جسديا على الإطلاق خلال الأسبوع الماضي

(b) 1 يوم

(c) 2 أيام

(d) 3 أيام

(e) 4 أيام

(f) 5 أيام

(g) 6 أيام

(h) 7 أيام، كنت نشطا جسديا كل يوم من أيام الأسبوع الماضي

15 **في العادة أسبوعيا**، كم عدد الأيام التي تكون فيها نشطا جسديا (كأن تكون قد لعبت فيها كرة القدم, كرة السلة، ركوب الدراجات، السباحة، الجري، المشي وغيرها) لمجموع ساعة واحدة على الأقل في اليوم؟

؟

(a) 0 أيام، لا أكون نشطا جسديا على الإطلاق في في العادة أسبوعيا

(b) 1 يوم

(c) 2 أيام

(d) 3 أيام

(e) 4 أيام

(f) 5 أيام

(g) 6 أيام

(h) 7 أيام، أكون نشطا جسديا كل يوم من أيام الأسبوع في المعتاد

3.3. قلة الحركة والجلوس

16 في أوقات فراغك في أيام الأسبوع العادية (من الأحد إلى الخميس)، كم عدد الساعات التي تنفقها على القيام بما يلي: مشاهدة التلفزيون والفيديو وأقراص الفيديو الرقمية باستخدام الكمبيوتر ولعب ألعاب الفيديو على جهاز محمول باليد (الهاتف و PSP و iPad و Tabletو Nintendo) بهدف لعب الألعاب أو مشاهدة العروض أو الأفلام؟

(a) 0 ساعات في اليوم

(b 1

(c) 2

(d) 3

(e) 4

(f) 5

(g) اكثر من 5 ساعات في اليوم

17)   في وقت فراغك في عطلة نهاية الأسبوع (الجمعة والسبت)، كم عدد الساعات التي تنفقها على القيام بما يلي: مشاهدة التلفزيون والفيديو وأقراص الفيديو الرقمية باستخدام الكمبيوتر ولعب ألعاب الفيديو على جهاز محمول باليد (الهاتف و PSP و iPad و Tabletو Nintendo) بهدف لعب الألعاب أو مشاهدة العروض أو الأفلام؟

(a) 0 ساعات في اليوم

(b) 1

(c) 2

(d) 3

(e) 4

(f) 5

(g) اكثر من 5 ساعات في اليوم

3.4. النوم

18)   في الليل في العادة خلال أيام الأسبوع (من الأحد إلى الخميس):

في أي ساعة تذهب عادة إلى النوم ؟_____ في أي ساعة تستيقظ عادة من النوم ؟ _____

19)   في الليل في العادة خلال عطلة نهاية الأسبوع (الجمعة إلى السبت):

في أي ساعة تذهب عادة إلى النوم ؟ _____ في أي ساعة تستيقظ عادة من النوم ؟ _____

الجزء الرابع: بيانات الاصدقاء

20)   من هم أصدقاءك المفضلين في مدرستك (أقرب خمس أصدقاء)؟

في الجدول التالي ضع أسماء والصف الخاص بكل منهم، بحيث تبدأ بأقرب الأصدقاء إليك في مدرستك ، إذا لم تستطيع أن تتذكر أسماء خمسة أصدقاء أترك الأسطر التالية فارغة:

مثال إذا كان اسم صديقك الأقرب هو علي حسن السيد يكتب اسمه و الصف الخاص به كما هو موضح بالمثال التالي:

الصديق	الأسم الأول	الاسم الأوسط	اسم العائلة	الصف/الشعبة
مثال	علي	حسن	السيد	أول أعدادي/ج

				1
				2
				3
				4
				5

APPENDIX 4: Brunel Ethical Approval

College of Business, Arts and Social Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

8 May 2017

LETTER OF APPROVAL

Applicant: Mrs Noor Alsayed

Project Title: Investigating obesity related behaviours in friendship networks among adolscents

Reference: 4874-MHR-Apr/2017- 7121-2

Dear Mrs Noor Alsayed

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor James Knowles

Chair

College of Business, Arts and Social Sciences Research Ethics Committee
Brunel University London

APPENDIX 5: Ministry of Education Approval

KINGDOM OF BAHRAIN

Ministry of Education

مَملَكة البَحريْن

وزارةُ التربيةِ والتَعليمِ

الرقم: ٨ /٤ / ت م ب
التاريخ: ١٠ مايو ٢٠١٧م

الفاضلة الأستاذة نور مصطفى السيد المحترمة

تحية طيبة وبعد،

الموضوع: الموافقة على تطبيق أدوات بحث

بالإشارة إلى طلبكم المقدم بتاريخ ٢٠١٧/٠٤/١٧م بشأن تطبيق أدوات البحث المعنون "دراسة السلوكيات المتعلقة بالسمنة في شبكات الصداقة بين المراهقين"، يسرني إعلامكم بالموافقة على تطبيق أدوات البحث في الإدارات التالية:

● إدارة التعليم الاعدادي
● إدارة التعليم الثانوي

على أن يتم تطبيق الأدوات وفق التعليمات والشروط التالية:

١. الالتزام عند التطبيق بأداة / أدوات البحث التي تمت الموافقة عليها دون إضافة أو حذف.
٢. المحافظة على المعلومات التي يتم جمعها، وعدم استخدامها إلا لأغراض البحث العلمي.
٣. تزويد إدارة المكتبات العامة بوزارة التربية والتعليم بنسخة من البحث بعد الانتهاء منه.
٤. جميع الإجراءات والخطوات اللازمة لتطبيق أدوات الدراسة تقع على عاتق الباحث نفسه ولا يحق له الاعتماد على كوادر الوزارة لأداء هذه المهمة.

مع تمنياتنا لكم بالتوفيق، وتفضلوا بقبول خالص التحية والاحترام،

د. فرزانة عبد الله المراغي
مدير إدارة البحث العلمي
القائم بأعمال إدارة الاعتمادية والتراخيص

إدارة البحث العلمي بالأمانة العامة لمجلس التعليم العالي
هاتف: ١٧٨٧٣٠٦١ (٩٧٣+) – فاكس: ١٧٦٨٠١٦٨ (٩٧٣+) – ص. ب: ٤٣، المنامة
Scientific Research Directorate at the Secretariat-General of the Higher Education Council
Tel.: (+973) 17873061 – Fax: (+973)17680168 – P.O. Box: 43, Manama – Website: www.moedu.gov.bh/hec

APPENDIX 6: School invitation Letter

Dear Sir/Madam,

The school is invited to participate in my Phd study entitled "Investigating Obesity Related Behaviours in Friendship Networks". The study intends to assess the extent to which friendship network structure is related to obesity related behaviours (including diet, physical activity, sedentary behaviour and sleep deprivation) of individuals in the network.

The participants of suitable age for the study are adolescents between the ages of 11 and 19 (grades 6 to 12). The participants will need their parent/guardian written consent before participating in the study (a copy of the parent/guardian consent form is provided). The participants will be asked to fill out a survey and provide some anthropometric measurements (including weight and height). The survey will be asking the participants to answer basic questions about their everyday diet, physical activity, sedentary and sleep behaviour. The survey will also ask the participants to provide the names of their closest friends in school which will assist in building the friendship network. The survey should take each participant between 10 to 15 minutes to complete. All information provided by the participants will remain strictly confidential, the participants' names will be converted to an I.D which will be used in data entry and analysis.

The findings of this research will make up my dissertation and will be produced in a report form and handed in to the University. Participating in this study will help in better understanding the role of friendship on obesity-related behaviours. As a voluntary participant you do have the right to withdraw at any point during the process. If you have any queries or concerns, do not hesitate to contact me (Tel:36246032, E-mail: Noor.Alsayed@brunel.ac.uk) or my supervisor (E-mail: Tillal.Eldabi@brunel.ac.uk).

This study has been reviewed and approved by Brunel Business School Research Ethics Committee. Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Thank you for your time and participation,

Noor Mustafa Alsayed

Researcher at Brunel University London

Brunel University London

The participant should complete the whole of this sheet

Please tick the appropriate box

	YES	NO
Have you read the Research Participant Information Sheet?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Have you received satisfactory answers to all your questions?	☐	☐
Who have you spoken to		
Do you understand that you will not be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study:		
• **at any time?**	☐	☐
• **without having to give a reason for withdrawing?**	☐	☐
• **(where relevant, adapt if necessary) without affecting your future care?**	☐	☐
Do you agree to take part in this study?	☐	☐

Signature of Research Participant:

Date:

Name in capitals:

Witness statement

I am satisfied that the above-named has given informed consent.

Witnessed by:

Date:

Name in capitals:

Researcher name:	**Signature:**
Supervisor name:	**Signature:**

APPENDIX 7: Parent Consent Form

Parent Consent Form

Dear Parent/Guardian,

Your son/daughter is invited to participate in my Phd study entitled "Investigating Obesity Related Behaviours in Friendship Networks". The study intends to assess the role of friendship on obesity-related behaviours (including diet, physical activity, sedentary behaviour and sleep deprivation) of individuals in the network. Your son/daughter will be asked to fill out a survey and provide some anthropometric measurements (including weight and height). The survey will be asking him/her to answer basic questions about their everyday diet, physical activity, sedentary and sleep behaviour. The survey will also ask him/her to provide the names of their closest friends in school which will assist in building the friendship network. The survey should take each participant between 10 to 15 minutes to complete. All information provided by the participants will remain strictly confidential, the participants' names will be converted to an I.D which will be used in data entry and analysis.

The findings of this research will make up my dissertation and will be produced in a report form and handed in to the University. Participating in this study will help in better understanding the role of friendship on obesity-related behaviours. As a voluntary participant your son/daughter has the right to withdraw at any point during the process. If you have any queries or concerns, do not hesitate to contact me (Tel:36246032, E-mail: Noor.Alsayed@brunel.ac.uk) or my supervisor (E-mail: Tillal.Eldabi@brunel.ac.uk).

This study has been reviewed and approved by Brunel Business School Research Ethics Committee. Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

    ☐ Yes, my son/daughter will participate in the study

    ☐ No, my son/daughter will not participate in the study