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The Relationship Between Aspects of Friendship Networks and Physical Activity
and Sedentary Behaviour Among Youth

by

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ABSTRACT

Physical inactivity and sedentary behaviour are two health-risk behaviours that are impacting the health and well-being of Canadian youth. Further investigation into the social determinants of these behaviours, specifically aspects of friendship networks, could provide an additional layer of understanding on the social mechanisms behind patterns of physical activity and sedentary behaviour among youth.

The aim of this thesis was to examine the associations between aspects of friendship networks and physical activity and sedentary behaviour among youth through a review of current literature and through an analysis of social network and behavioural survey data. The purpose of the literature review was to provide a synthesis and assessment of current evidence on friendship networks and physical activity and sedentary behaviour. The purpose of the survey data analysis was to expand the breadth of social network-derived variables so as to provide an additional level of understanding regarding the associations between aspects of friendship networks and physical activity and sedentary behaviour.

The systematized literature review involved a search of peer-reviewed articles that included a measure of a child or adolescent's social network (e.g., close friends) or network position (e.g., popularity) as well as a measure of physical activity and/or sedentary behaviour. Results from this review suggested that best friend's and close friends' physical activity levels were consistently associated with an individual's physical activity level. Longitudinal evidence showed, over time, that an individual's level of physical activity changed to reflect his or her friends' level of physical activity. Adolescents with more friendship nominations were also more physically active, and friends' physical activity was more often associated with boys' physical activity compared with girls' physical activity. Evidence on sedentary behaviour was mixed.

The survey analysis included data from 1,061 adolescents from six Calgary Catholic schools (Alberta, Canada), and examined cross-sectional associations between aspects of friendship networks (i.e., friendship network density, proportion of active close friends, proportion of

sedentary close friends, betweenness centrality, popularity, clique member) and likelihood of being sufficiently active (i.e., achieving at least sixty-minutes of moderate-to-vigorous physical activity (MVPA) every day), as well as likelihood of being highly sedentary (i.e., more than two-hours per day of sedentary behaviour), while controlling for sociodemographic variables and general perceived social support from friends. Potential effect modification of perceived general social support from friends and social network variables was also tested. Results suggested that both boys and girls with a higher proportion of sufficiently active close friends were more likely to be sufficiently active. Adolescents who received no friendship nominations participated in fewer days per week of MVPA compared with adolescents who had at least one friendship nomination. Higher levels of perceived social support from friends modified the effects of social network variables and the likelihood of being sufficiently active and highly sedentary. Higher friendship network density was associated with an increased likelihood of being highly sedentary for boys compared with low friendship network density.

Evidence from this thesis provides support for the presence of associations between aspects of friendship networks (i.e., friends' behaviour, popularity, receiving no friendship nominations) and an individual's physical activity. Network structure (i.e., friendship network density) may also be associated with boys' sedentary behaviour. Associations between aspects of friendship networks and physical activity have been identified for both boys and girls; however, associations with sedentary behaviour may be gender-specific. These results can inform future public health interventions focused on network restructuring to promote co-participation and friendship modeling to harness the impact of friendship influence with the goal of increasing levels of physical activity and reducing time spent participating in sedentary behaviour among Canadian youth.

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To my dad, mom, and sister

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GLOSSARY

Betweenness Centrality: The amount of times an individual lies on the shortest path between two other individuals. If an individual is often the ‘connection’ between two other individual, he or she is said to have high betweenness centrality (Wasserman & Faust, 1994).

Clique: A group of at least three individuals who and are all connected (i.e., adjacent) to each other through friendship nominations (Wasserman & Faust, 1994).

Complete friendship network (sociometric technique): A technique that provides a measure of the entire social network by including all of the individuals within a defined setting (e.g., grade, school, neighbourhood) (Valente et al., 2004).

Ego-based friendship network (egocentric technique): A technique that provides a measure of an individual’s local friendship network (e.g., name your five closest friends) (Valente et al., 2004).

Homophily: The tendency for individuals to affiliate and associate with others like themselves (Valente, 2010).

Incoming Friendship Nomination: A friendship nomination that is received from another individual (Wasserman & Faust, 1994).

Isolate: An individual that has neither incoming nor outgoing friendship nominations (Wasserman & Faust, 1994).

Metabolic Equivalent (METs): A measure expressing the energy cost of physical activities. It is a ratio of the metabolic rate (i.e., energy consumption) during a specific activity compared with a reference metabolic rate, usually 3.5 ml of oxygen per kilogram body weight per minute (i.e., sitting quietly). Low intensity activities are less than 2.9 METs (e.g., sleeping = 0.9 METs),

moderate intensity activity range from 3.0 to 5.9 METs (e.g., stationary biking, <10 miles per hour = 4.0 METs), and vigorous intensity is 6.0 METs and above (e.g., jumping rope, moderate = 10.0 METs) (Ainsworth et al., 1993).

Network Density: The proportion of friendship nominations that are actually present. It is calculated by dividing the number of friendship nominations in a given network by the total number of friendship nominations that are possible (Wasserman & Faust, 1994).

Outgoing Friendship Nomination: A friendship nomination that is sent to another individual (Wasserman & Faust, 1994).

Physical Activity: “Any bodily movement produced by skeletal muscle that results in energy expenditure (Caspersen et al., 1985, p. 126).”

Reciprocated Friendship Nomination: Individual A nominating individual B a friend, and individual B nominating individual A as a friend (Wasserman & Faust, 1994).

Sedentary Behaviour: Activities in which the movement or postural control of large skeletal muscles is very limited, and involves an energy expenditure between 1.0 and 1.5 METs (Mitchell et al., 2009; Pate et al., 2008).

Self-efficacy: The extent or strength in one’s beliefs in his or her own ability to succeed in specific situations. Self-efficacy is one of the focal determinants of Social Cognitive Theory (Bandura, 2004).

Social Network: A web of connections within a defined set of individuals (e.g., family social network, neighbourhood social network, workplace social network) (Tichy et al., 1979).

Social Network Analysis: A quantitative assessment of the structure of a social network. It uses interactional patterns among individuals (e.g., friendship nominations) to quantify and describe

relationships between individuals, identify individuals positioning within the network (e.g., clique members, liaisons, and isolates), describe characteristics of social network (e.g., dense or loose), and assess ties that connect the individuals (e.g., reciprocated nomination) (Hawe et al., 2004; Wasserman & Faust, 1994).

Systematic Review: A review of literature that seeks to systematically search for, appraise, and synthesize research evidence. It aims for an exhaustive and comprehensive search, and includes a quality assessment of literature retrieved (Grant & Booth, 2009).

Systematized Review: A review of literature that attempts to include elements of a systematic review, but may or may not include comprehensive searching, and may or may not include a quality assessment (Grant & Booth, 2009).

Social Cognitive Theory: A theory which posits a multifaceted structure in which cognitive factors, environmental factors, and behavioural factors interact to regulate human motivation, behaviour, and well-being (Bandura, 2004).

CHAPTER ONE

1.0 THESIS INTRODUCTION

1.1 BACKGROUND

For children and adolescents, regular physical activity has been shown to have numerous health benefits, including improvements in cardiovascular health (Meyer et al., 2006), healthy body weight maintenance (Jimenez-Pavon et al., 2010), and reductions in depressive symptoms (Brown et al., 2013). *Physical activity* refers to “any bodily movement produced by skeletal muscle that result in energy expenditure (Caspersen et al., 1985, p. 126).” For children and adolescents, physical activity encompasses a wide range of activities, including unstructured play and games (e.g., hopscotch), sport participation (e.g., soccer), active transportation (e.g., bicycling), chores (e.g., vacuuming), physical education in school, and planned exercise (e.g., skating) (Dollman et al., 2005). Physical activity intensities can be expressed in Metabolic Equivalents (METs). METs provide a measure of the energy cost of an activity, and is a ratio of the metabolic rate (i.e., energy consumption) during an activity compared with a reference metabolic rate, usually 3.5 ml of oxygen per kilogram body weight per minute (i.e., sitting quietly) (Ainsworth et al., 1993). Sleeping has a score of 0.9 METs, while running at 5.6 minutes per kilometer has a score of 11.0 METs. Moderate-intensity physical activity involves energy expenditure between 3.0 to 5.9 METs (Ainsworth et al., 1993) and a perceived personal capacity of five to six on a scale out of ten (Canadian Society for Exercise Physiology, 2014). Vigorous-intensity physical activity refers to energy expenditure of 6.0 METs or higher (Ainsworth et al., 1993), and a perceived personal capacity of seven to eight out of ten (Canadian Society for Exercise Physiology, 2014).

The Canadian Society for Exercise Physiology (CSEP) recommends children and adolescents accumulate sixty-minutes of moderate-to-vigorous intensity physical activity (MVPA) each day (i.e., sufficiently active) (Tremblay et al., 2011b). Unfortunately, only 9% of Canadian boys and 4% of Canadian girls accumulate sixty-minutes of MVPA on at least six days of the week (Colley et al., 2011). Low levels of physical activity have partly contributed to the rise in the prevalence of childhood obesity (Ebbeling et al., 2002), resulting in a higher risk of high blood

pressure, dyslipidemia, impaired glucose tolerance, cardiovascular disease, and type II diabetes in children (Lau et al., 2006; Styne, 2001).

Along with low levels of physical activity, increased time spent participating in sedentary behaviour has a negative impact on health, independent of physical activity levels (Tremblay et al., 2010a). *Sedentary behaviour* refers to activities in which the movement or postural control of large skeletal muscles is very limited, and involves energy expenditure between 1.0 and 1.5 METs (Mitchell et al., 2009; Pate et al., 2008). Examples of sedentary behaviour in children and adolescents include watching television, playing video games, and using a computer during discretionary time (Tremblay et al., 2011a). Guidelines for sedentary behaviour for children and adolescents recommend no more than two-hours per day of recreational screen-time and reduced passive transportation (e.g., using motor vehicles for transport) (Tremblay et al., 2011a). This excludes school-based and work-based sedentary activity. Independent of physical activity levels, children and adolescents who participate in less sedentary activities have better motor coordination, and a lower likelihood of being overweight and developing metabolic syndrome during adolescence (Lopes et al., 2012; Mark & Janssen, 2008; Tremblay & Willms, 2003). Current estimates suggest that 60% of youth spend more than two-hours per day participating in screen-time activities (Leatherdale & Ahmed, 2011). The negative health impacts of sedentary behaviours are twofold: 1) time spent participating in sedentary behaviour can displace time spent participating in physical activity, which limits the health benefits of regular physical activity, and; 2) sedentary behaviour and dietary behaviours tend to group together (Ebbeling et al., 2002). Epstein et al. (2002) found a significant increase in children's energy balance when sedentary behaviours were increased as a result of increased caloric intake and a decrease in physical activity.

Noteworthy, children and adolescents can be considered both sufficiently active (i.e., sixty-minutes of MVPA every day) and highly sedentary (i.e., more than two-hours of sedentary behaviour per day). In adults, sufficient physical activity combined with a highly sedentary lifestyles has been referred to as the "Active Couch Potato" phenomenon (Owen et al., 2010), and is negatively associated with three conditions that contribute to the metabolic syndrome

variables (i.e., waist circumference, systolic blood pressure, and two-hour plasma glucose (Healy et al., 2008)).

Combined, physical inactivity, sedentary behaviour, and unhealthy diet, are considered significant correlates of child and adolescent overweight and obesity (Ebbeling et al., 2002). The high rates of physical inactivity and sedentary behaviour in Canadian youth and the subsequent negative health outcomes are alarming, and further research into the determinants of these behaviours is warranted.

1.2 CONCEPTUAL FRAMEWORK

1.2.1 Social Network Theory

Network analysis is both a methodological tool (i.e., network analysis) and a theoretical paradigm (i.e., Network Theory (Granovetter, 1973, 1983)). Network analysis provides a unique approach of analyzing relational and structural aspects of health (Luke & Harris, 2007). It applies empirical data and mathematical modeling to examine social structure and social relationships among entities (e.g., individuals, organizations), and further analyzes how these relations affect individual and group behaviour (Hawe et al., 2004; Wasserman & Faust, 1994). Within the public health context, network analysis has focused on transmission networks (e.g., disease transmission), social networks (e.g., friendship support), and organizational networks (e.g., public health agencies). Specifically, social network analysis provides a means of examining connections between individuals and their attributes (e.g., behaviours), as well as examining social network positioning, network structure, and their association with individual behaviour (Luke & Harris, 2007). Individuals tend to associate and affiliate with others who are like themselves (Valente, 2010), and groups of individuals tend to share similar sociodemographic and behavioural characteristics, a feature known as homophily (McPherson et al., 2001). Homophily may be a result of an individual's propensity to choose friends with similar characteristics (i.e., *peer selection*), or a product of social influence where an individual's attitudes, beliefs, and behaviours tend to change to reflect their social networks' attitudes, beliefs, and behaviours (i.e., *peer influence*) (Valente, 2010). The latter process has been referred

to as ‘contagion’ whereby ideas and practices are spread through a network. While homophily is important in building network connectivity, it can limit external (i.e., outside of network) connections and resources, thereby impacting the information network members receive, the beliefs they develop, and the activities in which they participate in.

Social network analysis involves a variety of measures that can describe ego-level (i.e., individual) network positioning and connections, subgraph-level, and overall network-level structure (Wasserman & Faust, 1994). Within the adolescent health behaviour literature, common ego-level measures include *degree* (i.e., number of incoming connections to, and outgoing connections from, an individual), *popularity* (i.e., number of incoming connections to an individual), *reciprocity* (i.e., individual A indicating a connection to individual B, and individual B indicating a connection to individual A), *betweenness centrality* (i.e., the amount of times an individual lies on the shortest path between two other individuals), *degrees of separation* (i.e., number of individuals on the shortest path between two other individuals, ‘friend of a friend’), and *isolate* (i.e., no incoming nor outgoing connections) (Ennett & Bauman, 1993; Macdonald-Wallis et al., 2011; Seo & Huang, 2012; Strauss & Pollack, 2003; Wasserman & Faust, 1994) (*Figure 1.1*).

Subgraph-level measures involves a subset of a network and examine characteristics of a group of individuals (Luke & Harris, 2007; Wasserman & Faust, 1994). A common subgraph level measure in the adolescent health literature is *cliques* (i.e., a group of at least three individuals who are all connected) (Seo & Huang, 2012; Wasserman & Faust, 1994).

Ego-level and subgraph-level measures provide useful information on individual network positioning and connections to other individuals, which can be analyzed with regard to health behaviours. For example, degree centrality and betweenness centrality are critical as central people are often in important positions characteristic of high visibility, and may be highly influential in group ideals and behaviours (Valente, 2010). Degrees of separation also has important implications; as part of the Framingham Heart Study, Christakis and Fowler (2007) found a relationship between an individual’s obesity status and up to three degrees of separation.

Finally, reciprocated friendships can indicate a stronger bond between two individuals, and studies have shown that individuals are more likely to engage in risky behaviours (e.g., needle exchange) with close friends rather than distant ones, as there is likely a higher degree of trust (Valente & Vlahov, 2001).

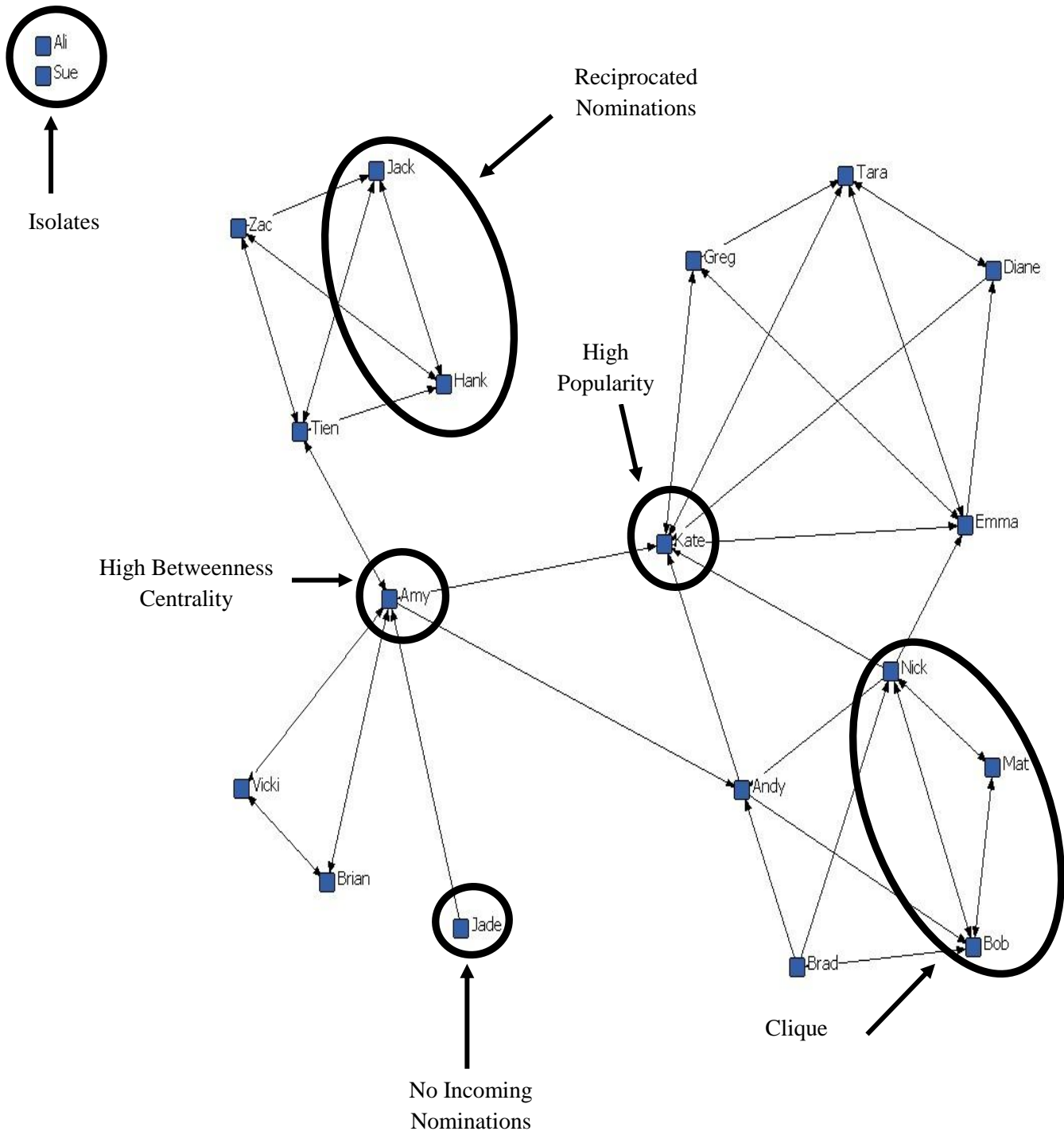


Figure 1.1. Example sociogram representing common social network-derived measures.

Network-level measures include *network density* (i.e., number of connections in a network as a percentage of the total possible connections), *network reciprocity* (i.e., proportion of reciprocated nominations in a network) and *centralization* (i.e., extent to which friendship ties are focused on one or a few individuals within a network) (Wasserman & Faust, 1994). Each of these measures provides unique information about the overall network composition. Density is a common measure, and is inversely related to the size of the network (i.e., number of individuals within a network) (Valente, 2010). There are practical limits to the number of individuals a person knows or is friends with, and it is also easier for many relationships to develop in a small group context (Valente, 2010). Dense networks allow individuals to have greater access to resources, both material (e.g., money, equipment) and immaterial (e.g., social support), and also have more pathways by which attitudes and behaviours can flow (Valente, 2010). Dense networks may, therefore, reflect a homogeneous group that can facilitate information exchange; however, too much density can limit the introduction of new ideas due to restricted outside connections.

There is evidence to suggest a link between network connections, network positioning, network-level structure, and an individual's health and health behaviours (Luke & Harris, 2007; Valente, 2010). Social network analysis provides a means of examining these relationships and positioning in order to analyze, predict, and potentially modify individual behaviour.

1.2.2 Social Cognitive Theory

While Social Network Theory focuses on structural and relational aspects of health, Social Cognitive Theory is a psychosocial theory that focuses on the psychological and behavioural outcomes of social position. Expanding upon Social Learning Theory (Bandura, 1977), Bandura (2004) developed Social Cognitive Theory to provide a comprehensive framework that could predict and explain health behaviours. Social Cognitive Theory uses aspects of both social learning theories, whereby behaviours are influenced by the social environment, and cognitive theories, where individuals have control over their participation in a behaviour (Bandura, 2004).

Social Cognitive Theory consists of the following three factors which interact and determine human behaviour: cognitive factors, environmental factors, and behavioural factors (Bandura,

2004). This interaction is referred to as reciprocal determinism, whereby behaviour initiation and maintenance results from the triadic interaction between an individual (i.e., cognitive factors and behavioural factors), and their environment. Within these three factors is a core set of determinants for health behaviours, which includes *perceived self-efficacy* of control over a behaviour, *health goals*, *knowledge* of health benefits and risks, *perceived facilitators and barriers*, and *outcome expectations* of the costs and benefits of a behaviour (Bandura, 2004). Each of these determinants plays a crucial role in predicting whether an individual will adopt and maintain a health behaviour.

Self-efficacy, or the belief in one's ability to perform a behaviour, is a central determinant of Social Cognitive Theory. Bandura (2005) stated that individuals are in control over their own behaviours, and lasting behavioural change is only possible if the individual perceives him or herself to have the ability to perform the behaviour. It is hypothesized that self-efficacy influences health behaviour through personal *health goals* and aspirations (i.e., the stronger the perceived self-efficacy, the higher the personal goals), barriers or facilitators, and outcome expectations.

In addition to self-efficacy, individuals need *knowledge* of how their current behaviours and prospective behaviours may impact their health before considering a change to their current lifestyle (Bandura, 2004). Perceived *facilitators and barriers* to a behaviour can be both cognitive and environmental in nature. For example, an environmental facilitator could be friendship support and encouragement to participate in extra-curricular activities. A potential barrier to behaviour adoption is poor personal time management.

Behaviours are also influenced by *health outcomes and expectancies*, which can take many forms. This can include physical outcomes, where individuals can receive either pleasure or displeasure from a particular health behaviour, or material losses or gains, such as winning a medal or achieving a high score on a video game (Baranowski et al., 2002). In addition to physical outcomes, behaviour adoption can be influenced by perceived social expectancies, or the social reaction a behaviour evokes. For example, an individual may witness a friend being

congratulated and praised after completing a race, and the individual may then be motivated to participate in that race to also receive that praise. Likewise, an individual may witness a friend become injured while playing sports and therefore may avoid this behaviour because of the physical pain it may produce. These social expectancies reflect the concept of observational learning whereby individuals have beliefs about behaviour based on observations of others who have performed the behaviour (Bandura, 1977).

1.2.3 Peer influence and peer selection mechanisms

The constructs underpinning Social Network Theory and Social Cognitive Theory provide a framework by which peer influence mechanisms can be understood. Several mechanisms have been proposed to help explain the social processes behind the similarities in attributes and behaviours among groups of friends (Prinstein & Dodge, 2008).

Peer pressure is an antagonistic behaviour where an individual is forced to perform a behaviour or conform to social norms, and is often coupled with teasing or belittlement (Prinstein & Dodge, 2008). Consequences to not conforming to this pressure may also be present. While peer pressure is often associated with high risk behaviours such as drug use (Brown, 2001), it can also occur within the context of physical activity and sedentary behaviour. For example, individuals may feel pressure to participate in organized sport or play video games if other friends are also participating in these behaviours, for possible fear of being excluded from social activities.

Co-participation is a supportive behaviour, which involves an individual participating in a behaviour with another individual (Prinstein & Dodge, 2008). There can be positive reinforcement from the friend to perform the behaviour or reinforcement from spending more time with friends. In their review, Macdonald-Wallis et al. (2012) noted that co-participation in physical activity increases the propensity for friendships to be developed and maintained through common sporting interests and local neighbourhood physical activities. Thus, a friend's physical activity level, or sedentary behaviour, may increase an individual's physical activity level, or sedentary behaviour, because individuals are able to enjoy spending more time with friends.

Similar to co-participation, an individual may witness a friend *model* a behaviour, and may subsequently be encouraged, or discouraged, to imitate that behaviour. Research has shown peer modeling as an effective tool to promote fruit and vegetable intake (Hendy & Raudenbush, 2000; Lowe et al., 2004). Witnessing a friend performing a behaviour can increase an individual's level of self-efficacy, which is a key factor in behaviour adoption and maintenance (Bandura, 2004). In terms of physical activity and sedentary behaviour, witnessing a friend participate in an activity, such as playing hockey, can increase an individual's belief in his or her ability to also participate in that activity. In addition to increased perceptions of self-efficacy, modeling can also be associated with positive outcome expectations. For example, witnessing a peer win a gold medal and receive praise after a sports competition could result in the individual associating sports competition with a positive outcome. Noteworthy, evidence suggests that a behaviour is more likely to be imitated if the observer perceives to have similar abilities as the modeler (Schunk, 1987) or if the modeler is admired by the observer (Bandura, 1977), which is important in terms of developing interventions as certain individuals may be more effective modelers compared with others.

Social norms are another mechanism by which behaviours can be 'transferred' or 'shared' among friends. There are two common types of social norms: 'descriptive' norms refer to an individual's perception of the amount the behaviour is performed by others, whereas 'injunctive' norms refer to an individual's perception of approval of a behaviour (Cialdini et al., 1990). Friendship networks during childhood and adolescence tend to share similar characteristics, based on underlying beliefs, values, attitudes and behaviours (Ryan, 2001). As certain behaviours become more popular within a group of friends, such as playing video games after school, the group consensus of these acceptable behaviours could be passed on to each individual. This can be related to peer pressure and forces to conform to these norms. Therefore, having more sedentary friends could encourage an individual to be more sedentary, either consciously as a result of peer pressure, or subconsciously, as a result of an increased exposure to perceived normative behaviours. Gender differences in the value of being physically active may reflect differences in the amount of influence from friends. Jago et al. (2009) found that boys perceived physical activity as a positive attribute and linked to social status, whereas some girls

stated that low physical activity ability could be perceived as desirable. These findings reflect the impact of injunctive norms and values on physical activity participation as a potential mechanism explaining differences in the impact of friendship influence between boys and girls.

Noteworthy is that not all peer influence mechanisms are overt, and often the adoption or maintenance of behaviours may be a result of *perceived support* for physical activity. Social support for physical activity and sedentary behaviour can come from a variety of facets, including instrumental or financial support (e.g., transportation), motivational support (e.g., verbal encouragement) and observational support (e.g., modeling) (Springer et al., 2006). Several studies have found that perceptions of support for physical activity is an important component of overall friendship influence and is associated with more physical activity (Duncan et al., 2005; Robbins et al., 2008; Springer et al., 2006). General measures of perceived social support have also been examined within the health literature (Li et al., 2013; Mummery et al., 2004; Patterson et al., 1998). Types of global support measures include emotional support and caring, help and guidance, and ability to share concerns with individuals of important social relations (e.g., friends, family, neighbors, important adults) (Smith et al., 1990; Zimet et al., 1988). Patterson et al. (1998) found that general perceived social support modified the relationship between negative life events and ballet injuries; among those who reported high levels of social support, negative life events were not related to injury, while negative life events accounted for 50% of the variance of injuries for those with low levels of social support. As an association between friend's physical activity and individual physical activity have been identified (Macdonald-Wallis et al., 2012), and general perceived support has been noted as a buffer in adolescent behaviours (Patterson et al., 1998; Rothon et al., 2011), it is possible that general perceived support from friends may modify the relationship between friend's physical activity or sedentary behaviour and individual's physical activity or sedentary behaviour. General perceived levels of social support from friends may therefore have an important modifying effect on the association between social network variables and levels of physical activity and sedentary behaviour among youth.

The above mechanisms provide a framework to explain homogeneity in behaviours among groups of friends. Another potential mechanism that may explain these similarities is *peer selection* where youth may seek out friends with similar behaviours and attributes. Here, friends are chosen based on pre-established attitudes and behaviours (Valente, 2010). In the smoking literature, several studies have attempted to disentangle peer influence from peer selection, and have found that both of these processes have an impact on behavioural similarities among groups; however, peer selection may provide a better explanation (Seo & Huang, 2012). Within the context of physical activity and sedentary behaviour, it is possible that individuals select friends based on pre-existing behaviours, such as being on the same hockey team or enjoying the same video games. Conversely, individuals may also become friends based on other important factors (e.g., social class, physical proximity of neighbourhoods) thereby allowing for the process of peer influence to guide behaviour adoption and maintenance. Overall, there are mechanisms to suggest that friends' behaviour and support may be important correlates of youth physical activity and sedentary behaviour.

1.3 DETERMINANTS OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR

There are many factors that influence youth physical activity and sedentary behaviour, including biological factors (e.g., gender, age), psychological factors (e.g., exercise knowledge, self-efficacy), the built environment (e.g., access to facilities, neighbourhood walkability), and the social environment (e.g., best friends' sports participation, parent's television viewing) (Biddle et al., 2004; Denault & Poulin, 2009; Ding et al., 2011; Giles-Corti et al., 2009; Norman et al., 2005; Sallis et al., 2000; Uijtdewilligen et al., 2011). While biological factors and their influence are fixed, the built and social environmental factors are modifiable, and therefore provide a practical basis for potential intervention opportunities with the overall aim of assessing and adjusting physical and social factors to increase physical activity and reduce time spent participating in sedentary behaviour.

1.3.1 Social environment across childhood and adolescence

The social environment is particularly important for children and adolescents, as social relationships and reinforcements help to define adolescent attitudes and behaviours. The *social*

environment refers to social relationships, physical structures (e.g., environments built upon existing social relations such as built infrastructure and natural resources), and cultural and societal norms (Barnett & Casper, 2001). The social environment influences behaviour by “shaping norms, enforcing patterns of social control, providing or not providing environmental opportunities to engage in particular behaviours, reducing or producing stress, and placing constraints on individual choice” (Institute of Medicine, 2003, p. 60).

During childhood, parents and important adults provide the main source of support for, and influence on, a child’s attitudes and behaviours (Markward et al., 2003). Parent’s physical activity is positively associated with children’s (age three to twelve years) physical activity (Sallis et al., 2000). During the transition from childhood to adolescence, children decrease the amount of time spent with parents, and increase the amount of time spent alone and with friends (Larson & Richards, 1991). Children and adolescents spend a large portion of their day interacting with friends during school and extra-curricular activities. While parental influence does not completely disappear, the inclusion of peer relations broadens an adolescent’s social environment. The balance between parent and peer influence varies depending on the specific behaviour and the quality of relationships (Kandel & Andrews, 1987). Nevertheless, adolescent’s autonomy from parents and desire to integrate with friendship networks increases the time spent with friends which, in turn, can increase the opportunity for friendship influence on individual behaviour.

With an increase in independence, adolescents also become more mature (e.g., able to meet restrictions placed on graphic video games and movies) and also more mobile (e.g., cycling greater distances, learning to operate motor vehicles). Particularly, after-school trips away from home are most used commonly for recreational or social purposes (Clifton, 2003). This provides more opportunity for social interactions among friends, along with opportunities to socialize with a greater variety of friends (e.g., adolescents in different neighbourhoods). Mobility has implication for both physical activity and sedentary behaviours. Prezza et al. (2001) found a correlation between children who had freedom of movement in urban areas (i.e., more autonomous and able to move without adult accompaniment) and playing with peers.

Alternatively, more reliance on motor vehicles for transportation can reduce active transport, which can result in reduced total daily physical activity. Overall, increased autonomy and independent mobility allows for more friend interactions which can influence adolescent physical activity and sedentary behaviour.

Childhood development coincides with a transition from mainly family support to friend support through an increase in autonomy and independence combined with more mobility and a search for satisfying friendships. Together, this leads to an increase in opportunities for friendship influence on an individual's behaviour.

1.3.2 Friendship networks

A *social network* refers to the web of connections between a defined set of individuals (Tichy et al., 1979). Specifically, *friendship networks* refer to the connections that individuals have with his or her friends. Research into the effects of peer pressure and forces of group conformity in youth have found that friendship networks can be very influential in terms of promoting or suppressing health behaviours (Alexander et al., 2001; Prinstein & Dodge, 2008). Numerous studies identified peer influence as an important predictor of adolescent drug and cigarette use (Bauman & Ennett, 1996; Seo & Huang, 2012). Patterns of drug use tend to conform to the values and behavioural structure of his or her peer group (Bauman & Ennett, 1996). This relationship has also been examined in the physical activity literature, and, to a lesser extent, the sedentary behaviour literature (Macdonald-Wallis et al., 2012). These results have identified an association between best friend, or a friendship groups', physical activity and an individual's physical activity (Macdonald-Wallis et al., 2012). These associations have been shown to be gender-specific, whereby friends' physical activity is associated with boys' physical activity to a greater extent than girls (De la Haye et al., 2010; Denault & Poulin, 2009; Jago et al., 2011; Macdonald-Wallis et al., 2011).

Research into child and adolescent behaviours, namely smoking, drug use, and delinquency, have utilized social network analysis and identified associations between aspects of social networks and health behaviours. For example, examining the proportion of delinquent and non-

delinquent individuals within cliques can provide insight into the impact of group norms on individual behaviours in that clique. Haynie (2002) found that the proportion of delinquent friends in an individual's friendship network is significantly associated with an individual's subsequent delinquency. Another example of the benefits of social network analysis is the investigation into health behaviours with regard to individual network positioning, such as clique members and isolates. Isolated individuals may be at a higher risk for participation in unhealthy behaviours; significantly higher rates of smoking are noted among isolate adolescents compared with clique members (Seo & Huang, 2012). In terms of physical activity, there is no opportunity for isolates to co-participate in these physical activities with friends, or to witness a friend model a behaviour. Isolates may therefore be at a greater risk of being insufficiently active due to their secluded position within a friendship network.

Social network analysis in the physical activity literature is beginning to emerge, and associations between friends' physical activity and individual's physical activity have been identified (Macdonald-Wallis et al., 2012). There are, however, gaps in this area that require further investigation. Findings from a recent systematic review on friendship networks and physical activity and sedentary behaviour (Macdonald-Wallis et al., 2012) showed that the amount of social network-derived measures within the physical activity and sedentary behaviour literature is small. In addition, there are a limited number of studies that have utilized a complete network which includes all individuals within a social setting, such as a school or class. Instead, several studies have used ego-based networks, which provide a measure of an individual's local friendship network. For example, the investigator may ask a respondent to provide the names of their closest friends then ask the respondent to state whether each of these friends engage in certain behaviours. Complete networks analysis is more powerful as it can provide a global view of the network structure and indicators for individual positioning (Valente et al., 2004). *Appendix A* provides an example of a friendship network using a complete network technique, and *Appendix B* shows an example of a friendship network using an ego-based technique.

There is also a lack of evidence examining differences in the association between aspects of friendship networks and physical activity and sedentary behaviour between boys and girls. As

differences in physical activity characteristics have been previously identified (e.g., participation rates (Colley et al., 2011), perceived importance of physical activity (Jago et al., 2009)), it is possible that certain aspects of friendship networks may have different associations on physical activity and sedentary behaviour between boys and girls. It is therefore important to examine these gender differences as future interventions may need to tailor to these differences in order to provide more effective programming. Finally, sedentary behaviour was highlighted as an under-investigated area in the *Global Recommendations on Physical Activity for Health* by the World Health Organization (2010), and emerging evidence has shown that levels of sedentary behaviour can have a negative impact on health outcomes, independent of physical activity levels (Tremblay & Willms, 2003). Further inquiry into aspects of friendship networks as a potential determinant of sedentary behaviour may provide valuable knowledge towards reducing sedentary behaviour among youth.

1.4 THESIS OUTLINE

1.4.1 Aim

The aim of this thesis was to examine the associations between aspects of friendship networks and physical activity and sedentary behaviour among youth through a synthesis and assessment of current peer-reviewed evidence and through an analysis of social network and behavioural survey data.

1.4.2 Research questions

- 1) What is the current peer-reviewed evidence on the associations between aspects of friendship networks and physical activity and sedentary behaviour among youth?
- 2) Is there an association between aspects of within grade friendship networks (i.e., grade friendship network density, proportion of active close friends, proportion of sedentary close friends, betweenness centrality, popularity, clique membership, receiving no friendship nominations) and both physical activity and sedentary behaviour among adolescents?

- 3) Is there effect modification of general perceived social support from friends on the association between aspects of friendship networks and physical activity and sedentary behaviour among adolescents?
- 4) Do the associations between aspects of friendship networks and physical activity and sedentary behaviour differ by gender?

1.4.3 Significance

Despite the known benefits of participating in regular amounts of physical activity and limiting sedentary behaviour, only a small proportion of Canadian youth are achieving the recommended guidelines of sixty-minutes of MVPA every day, and limiting recreational screen time to no more than two-hours per day (Tremblay et al., 2011a; Tremblay et al., 2011b). As such, the factors that influence each of these two behaviours demand further investigation. Friendships are a key aspect of childhood development, and an increased understanding of the processes by which friends influence individual behaviour would be valuable. By examining the association between aspects of friendship networks and both physical activity and sedentary behaviour, this thesis will contribute to the field of social determinants of youth physical activity and sedentary behaviour. The conclusions drawn from this study could be used to inform future researchers, teachers, parents, school board affiliates, and students, of the impact of friends and aspects of friendship networks. As friendship networks are a potentially modifiable determinant of physical activity and sedentary behaviour, there is also opportunity to inform future interventions that modify friendship network structure, positioning, and connections to harness the influence of friends to increase adolescent physical activity and decrease time spent participating in sedentary behaviour.

1.4.3 Thesis structure

This thesis contains four chapters. Chapter One provided background information on youth physical activity and sedentary behaviour, along with information on Social Network Theory and Social Cognitive Theory. Chapter One also identified the current gaps in knowledge in the area of social network analysis and physical activity and sedentary behaviour. This lead into the thesis aim and research questions. Chapter Two contains a systematized review of current literature on

aspects of friendship networks and physical activity and sedentary behaviour. In a follow-up to this review, Chapter Three contains a quantitative analysis of survey data that measures aspects of friendship networks and their association with both physical activity and sedentary behaviour. Chapter Four incorporates the results from the systematized review and quantitative data analysis and provides a summary of evidence. It concludes with recommendations for interventions and future research directions.

1.4.4 Systematized review rationale

The current high rate of child and adolescent physical inactivity and sedentary behaviour is an important concern. Further investigation into potential determinants of physical activity and sedentary behaviour, namely friendship networks, would provide insight into the mechanisms by which friends influence child and adolescent behaviour. The purpose of the systematized review was to address the *first and fourth thesis research question* by gathering and summarizing current evidence on the relationship between aspects of friendship networks and both physical activity and sedentary behaviour among youth. This systematized review built upon a recent review (Macdonald-Wallis et al., 2012). By updating the literature search, expanding upon gender differences, and examining theoretical frameworks, this review provided an additional level of knowledge and understanding on friendship networks and physical activity and sedentary behaviour. Results from this review informed the social network variables used in Chapter Three.

1.4.5 Analytical study rationale

The purpose of this chapter was to answer the *second, third, and fourth thesis research questions* and to contribute to the current Canadian literature on friendship networks and physical activity and sedentary behaviour through a cross-sectional analysis of a sample of adolescents (age eleven to fifteen years) from six Catholic schools in Calgary (Alberta, Canada). This chapter responded to the findings of the systematized review, and aimed to include a wider range of social network-derived measures that have been used to date within the physical activity and sedentary behaviour literature. Using a complete friendship network data, this analysis examined the associations between aspects of friendship networks (i.e., grade friendship network density,

proportion of active close friends, proportion of sedentary close friends, betweenness centrality, popularity, clique membership, receiving no friendship nominations) and adolescents' physical activity and sedentary behaviour. Furthermore, this chapter provided a unique contribution to this area of literature by examining general perceived social support from friends as a potential effect modifier for the association between social network-derived variables and adolescents' physical activity and sedentary behaviour.

1.5 ETHICS APPROVAL

The Conjoint Health Research Ethics Board at the University of Calgary's Faculty of Medicine approved this project in July 2010 (ID 16771). An amendment to the original ethics application was also approved, which allowed the candidate access to the survey data (March, 2012).

CHAPTER TWO

2.0 FRIENDSHIP NETWORKS AND PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR AMONG YOUTH: A SYSTEMATIZED REVIEW¹

Sawka K.J., McCormack G.R., Nettel-Aguirre A., Hawe P., Doyle-Baker P.K. (2013). Friendship networks and physical activity and sedentary behavior among youth: A systematized review. *International Journal of Behavioral Nutrition and Physical Activity*, 10, doi: 10.1186/1479-5868-10-13024289113.

Formatted for the manuscript-based thesis.

2.1 ABSTRACT

Background. Low levels of physical activity and increased participation in sedentary leisure-time activities are two important obesity-risk behaviours that impact the health of today's youth. Friend's health behaviours have been shown to influence individual health behaviours; however, current evidence on the specific role of friendship networks in relation to levels of physical activity and sedentary behaviour is limited. The purpose of this review was to summarize evidence on friendship networks and both physical activity and sedentary behaviour among children and adolescents.

Method. After a search of seven scientific databases and reference scans, a total of thirteen articles were eligible for inclusion. All assessed the association between friendship networks and physical activity, while three also assessed sedentary behaviour.

¹ Candidate contribution: The candidate helped conceive of the study, and lead the database search, article selection, synthesis, and drafting of the manuscript. The candidate also contributed to the interpretations of findings, and made the final approval before submission. The candidate is responsible for 100% of the work presented in this chapter. GRM/ANA helped conceive of the study. GRM/ANA assisted in article selection and synthesis. All authors contributed to the interpretation of findings and writing of the manuscript.

Results. Overall, higher levels of physical activity among friends are associated with higher levels of physical activity of the individual. Longitudinal studies show that an individual's level of physical activity changes to reflect his/her friends' higher level of physical activity. Boys tend to be influenced by their friendship network to a greater extent than girls. There is mixed evidence on a friend's sedentary behaviour and individual sedentary behaviour.

Conclusion. Friends' physical activity level appears to have a significant influence on individual's physical activity level. Evidence on 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.

2.2 BACKGROUND

Physical activity plays a vital role in the health of children and adolescents (Tremblay et al., 2011b). Along with a high caloric diet, low levels of physical activity and increased participation in sedentary leisure-time activity are two important lifestyle behaviours that have contributed to the increased prevalence of overweight and obesity among youth and adults (Ebbeling et al., 2002; Wang & Lobstein, 2006). In children and adolescents, overweight and obesity are associated with an increased risk of high blood pressure, dyslipidemia, impaired glucose tolerance, cardiovascular disease, and type II diabetes (Lau et al., 2006; Styne, 2001). Furthermore, overweight children are highly likely to become overweight adults, which may reflect the tracking of obesity-risk behaviours (i.e., physical activity and diet) from childhood into adulthood (Field et al., 2005; Styne, 2001).

The social environment comprises the physical surroundings, social relationships and cultural milieu within which people function and interact (Barnett & Casper, 2001). It has been shown to influence obesity-risk behaviours in adults (Lawrence et al., 2011; Trost et al., 2002); those reporting low social support from family and friends are more likely to be insufficiently active for health benefits compared with those with high levels of social support (Trost et al., 2002). The social environment also plays an important role in relation to children's physical activity and sedentary behaviour. The social environment of children includes the influence of parents, siblings, friends, neighbours, teachers, and coaches (Markward et al., 2003; Osterling & Hines,

2006). While parents are the most important source of influence in early-life, parental influence on their child's day-to-day behaviour becomes less evident as the child matures (Duncan et al., 1994; Ryan, 2001). Children and adolescents spend a significant portion of their time at school with friends and peers. Evidence suggests that the dietary behaviour of a friend or group of friends influences the dietary behaviour of the individual (Ali et al., 2011), with similar results observed for sports participation (Ali et al., 2011) and sedentary behaviour (De la Haye et al., 2010).

The pathways by which behaviours may be similar among groups of friends during childhood, however, are complex. Similar behaviour among friends likely reflect the processes of peer selection (i.e., an individual with certain behaviours seeking out others who also share similar behaviours) and peer influence or peer contagion (i.e., the influence of friends' behaviours causing changes in an individual's behaviour) (Valente, 2010). Several mechanisms may explain the processes of peer influence and contagion on physical activity and sedentary behaviour including: behavioural modeling (i.e., observing a peer perform a behaviour leading to increased motivation to perform a behaviour); peer pressure (i.e., direct attempts to impose a certain behaviour on a peer); group norms (i.e., the underlying attitudes and behaviours shared among a group of peers), and; co-participation (i.e., undertaking a behaviour with a peer potentially contributing to behavioural reinforcement) (Bandura, 2004; Prinstein & Dodge, 2008).

Social network analysis or sociometry (Wasserman & Faust, 1994) provides a means of studying the inter-relationships among friends themselves and does not rely on an individual recalling or reporting the behaviour of his/her friends or peers. Social network analysis is a quantitative method for assessing the structure and patterns of the ties or relationships among a set of entities (e.g., people or organizations) (Hawe et al., 2004). It can provide information about an individual's local relations (e.g., who he or she is friends with) and network position (e.g., whether he or she is centralized within a given network) as well as measures of the entire network itself (e.g., number of connections between people, and degrees of separation (Valente, 2010)). In child and adolescent health, social network analysis has been used extensively to investigate behaviours such as smoking, substance use, and delinquency in relation to individual-

level network measures (Christakis & Fowler, 2008; Ennett et al., 2006; Haynie, 2001; Pearson & Michell, 2000). For example, popularity, or being nominated as a friend by many others, is associated with higher odds of drinking alcohol among thirteen and fifteen year olds (Ennett et al., 2006), while substance use is associated with receiving fewer friendship nominations (McLeod & Uemura, 2012). Smoking (Ennett & Bauman, 1993), delinquency (Haynie, 2001), substance abuse (Ennett et al., 2006), and depression (Van Zalk et al., 2010) studies that have used social network analyses suggest that the attitudes and behaviours of adolescents influence the attitudes and behaviours of others in their friendship networks (i.e., peer contagion). Moreover, the influence of peer contagion might also be gender-specific. Mercken et al. (2010) found that teenage girls, but not boys, were influenced by their peer group to initiate smoking, while delinquent behaviour in friends may be more influential in boys than girls (Piquero et al., 2005).

Regarding physical activity, some evidence derived from social network analysis suggests that higher physical activity levels within friendship groups could be associated with higher levels of participation among individual group members (Macdonald-Wallis et al., 2012). Much of this evidence is based on individual-level or ego-network measures (i.e., a direct link between individuals) rather than an individual's position in the network of a class or school or the characteristics of the networks themselves. Furthermore, similar to other behaviours, there is preliminary support for gender-specific relationships between individual measures of friendship networks and physical activity. Jago et al. (2011) found that moderate-to-vigorous physical activity of boys' best friends, but not girls' best friends, was positively associated with an individual's moderate-to-vigorous physical activity.

Little is known about how specific network ties (i.e., local relations) and specific network roles (i.e., positions within the network) might influence physical activity and sedentary behaviours among children and adolescents. For example, a non-reciprocated friendship nomination (i.e., person 'A' says 'B' is my friend, but person 'B' does not say 'A' is my friend) may have a different influence on behaviour compared with a reciprocated nomination. The concept of reciprocation in a friendship network can indicate the presence of strong ties (reciprocated

nomination) and weak ties (non-reciprocated nomination) between individuals. Strength of ties may also be related to degree of friendship separation (i.e., friend of a friend) (Christakis & Fowler, 2007), or intimacy of friendship (i.e., first nominated friend, second nominated friend) (Fujimoto & Valente, 2012). Specific roles within a network may also influence behaviour, such as being an isolate (i.e., no ties to other individuals) or liaison (i.e., providing ties between groups within a network) (Ennett & Bauman, 1993). While studies have identified a relationship between specific network roles (e.g., isolates) and smoking (Ennett et al., 2006), as well as network characteristics (e.g., density) and delinquency (Haynie, 2001), this relationship in the physical activity and sedentary behaviour literature is still poorly understood. Knowledge of the dynamics of friendship networks in relation to physical activity and sedentary behaviour could be useful for informing health promotion interventions within social settings (i.e., schools).

A recent systematic review found strong similarities between a child or adolescent's level of physical activity and that of his/her close friends and wider peer group, but limited evidence on the role of social networks in influencing sedentary behaviour (Macdonald-Wallis et al., 2012). These authors, along with others (Valente et al., 2005), suggest that better interventions may come from better understanding of friendship networks and behaviour. To do so, however, requires a deeper understanding of the psychology and sociology of networks, such as who should be recruited to interventions and how experiences and messages can be amplified (or diluted) across the group (Valente et al., 2003). School-based, peer-group interventions in drug use lacked this sophistication, with consequent modest or negligible effects (Cho et al., 2005).

The purpose of this review was to expand and reassess the conclusions of a previous synthesis (Macdonald-Wallis et al., 2012) by undertaking a systematized literature review of studies examining the association between friendship networks and both physical activity and sedentary behaviour. A systematized review encompasses several, but not all aspects of a full systematic review (Grant & Booth, 2009). The objectives of this review were to: 1) examine the association between a friend's level of physical activity and sedentary behaviour and an individual's levels of physical activity and sedentary behaviour; 2) determine if the number of friends a child or adolescent has influences his/her own physical activity or sedentary behaviour, and; 3) identify

and differentiate the effects of different types of social network measures, for example, network ties and positions, that are potentially associated with physical activity and sedentary behaviour, especially as they operate at gender-specific levels.

2.3 METHOD

2.3.1 Database search and study inclusion

To identify studies for possible inclusion in our review, seven scientific online databases covering the medical, (MEDLINE, PubMed, CINAHL), kinesiology (SPORTDiscus), education (ERIC), sociology (SocINDEX), and psychology (PsycINFO) fields were searched. Search terms and phrases were combined and reflected the population of interest (i.e., child, preteen, adolescent, student, teen, boy, or girl), the exposure (i.e., social network, friend, peer, or social group), and the outcomes (i.e., physical activity, play, sport, exercise, sedentary, inactivity, or leisure) (*Appendix C*). Searches within each database were restricted to the English language, peer-reviewed, and primary studies. No restrictions were placed on year of publication. Databases were searched in June, 2012. Our broad search strategy resulted in 21,354 articles. KJS initially reviewed these titles and removed duplicates, non-journal articles and irrelevant titles. The remaining abstracts (n=1,676) were reviewed in detail by KJS and a random subsample (n=300) were reviewed by GRM to ensure scientific rigor (88.3% overall agreement).

Seventy-one articles were identified to undergo a full paper review and were read in detail by KJS and GRM. Studies eligible for this review must have included: children or adolescents aged six to eighteen years of age; a measure of a participant's friendship network through either friendship nominations (i.e., participant nominating friends from a class list) or friendship rating (i.e., participant indicating whom they prefer to play with most), and; a measure of physical activity or sedentary leisure-time activity (i.e., direct observation, motion monitors, direct or indirect calorimetry, doubly-labeled water, parent proxy, or self-report) for both the participant and the participant's nominated friends. Studies that utilized a general social support measure (i.e., how often does your best friend encourage you to exercise?) were excluded. We also excluded studies that used participant's proxy measure of friend's physical activity or sedentary behaviour. This was to ensure that each participant identified his or her friends (whom also

participated in the study), and that each participant recorded his or her own level of physical activity and sedentary behaviour. Final inclusion of each study was based on consensus of two authors (KJS and GRM). To broaden our search, reference lists from included studies were scanned to further identify potential studies.

2.3.2 Data extraction and analysis

From each included study, information regarding study design, sample size, participant characteristics, description of friendship network or friendship rating measure, physical activity and/or sedentary behaviour, confounders, and study findings were extracted and tabled. The most robust results from each study were included (e.g., findings based on adjusted estimates would be presented instead of findings based on unadjusted estimates if both were presented within a single study). Factors affecting study validity including sample design, sample size, response rate, control for confounders, and method of physical activity or sedentary behaviour measurement were appraised and synthesized, along with study results of the relationships between friendship networks and physical activity and sedentary behaviour. Information regarding the use of a theoretical framework or model, where reported, was also extracted from each article.

2.4 RESULTS

A total of thirteen studies were included in this review, four (Denault & Poulin, 2009; Gesell et al., 2012; Raudsepp & Viira, 2000; Yli-Piipari et al., 2011) of which were not included in the previous review (Macdonald-Wallis et al., 2012) (*Figure 2.1, Appendix D*).

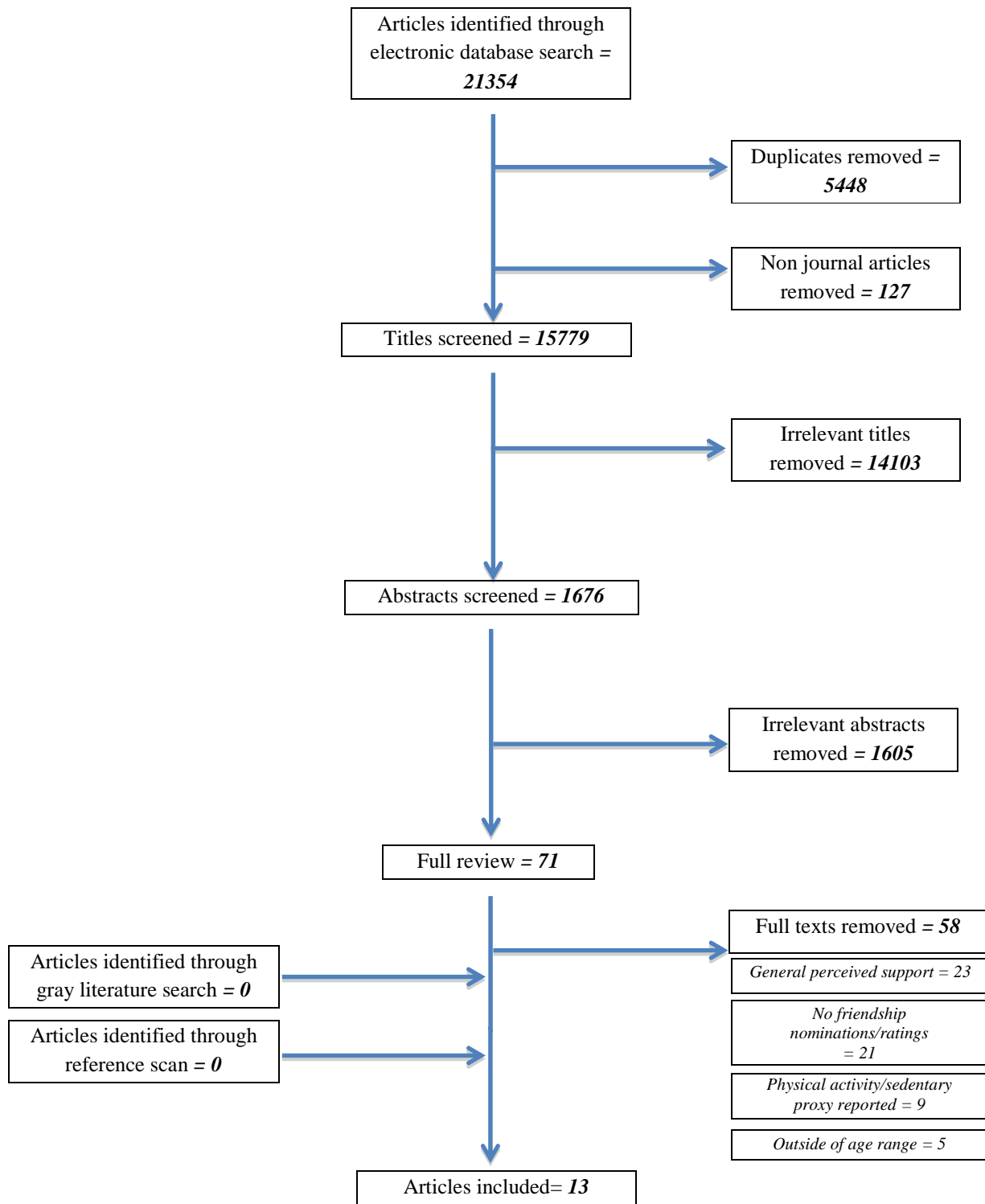


Figure 2.1 Flow diagram of article search and selection

2.4.1 Characteristics of studies reviewed

The reviewed studies included children and adolescents ranging from six to eighteen years of age (*Table 2.1, Appendix E*). One study (Schofield et al., 2007) included girls only, while the other studies had approximately equal proportions of boys and girls. Eleven studies reported response rates ranging from 58.6% to 93% (Ali et al., 2011; De la Haye et al., 2010, 2011; Denault & Poulin, 2009; Jago et al., 2011; Macdonald-Wallis et al., 2011; Ommundsen et al., 2010; Raudsepp & Viira, 2000; Schofield et al., 2007; Strauss & Pollack, 2003; Yli-Piipari et al., 2011). Of those, six had response rates of 80% or lower (Denault & Poulin, 2009; Jago et al., 2011; Livesey et al., 2011; Macdonald-Wallis et al., 2011; Ommundsen et al., 2010; Strauss & Pollack, 2003). The geographical location of studies included Australia (n=4), the United States (n=3), the United Kingdom (n=2), Canada (n=1), Estonia (n=1), Finland (n=1) and Norway (n=1). All of the studies occurred within a school or after-school setting.

Table 2.1 Characteristics of reviewed studies

Author(s)	Study Design (Country) and theoretical frameworks/model	Sample Size (Response Rate)	Sample Characteristics	Independent Variable	Dependent Variable	Confounding Variables	Findings
Ali et al. (2011)	Cross-sectional (United States) Theoretical framework/model: not stated	n= 3898 (88.6%)	16.26 ± 1.56 yrs of age; 51.30% girls	Researcher conducted in-home interview; a) Exercise, sports playing, TV watching of nominated close friends within school	Researcher conducted at home interview; a) Exercise (< 3 or ≥ 3 times/wk), b) Playing an active sport (Y/N), c) Television/video viewing (hrs/wk)	Demographics, weight status, sociodemographics, parental variables	Friend's exercise associated with individual's exercise (+); Friend's sports participation associated with individual's sports participation (+); Friend's TV/video viewing not associated with individual's TV/video viewing (n.s).
De la Haye et al. (2010)	Cross-sectional (Australia) Theoretical framework/model: not stated	n= 385 network 1: 164, network 2: 108, network 3: 113 (81% to 93%)	Year level 8 to 9 (12 to 15 yrs of age); 47.5% girls	Participant reported in school survey; a) Physical activity and screen-time behaviour of nominated close friends within year level (reciprocated and non-reciprocated), b) Number of received friendship nominations	Participant reported in school survey; a) Organized physical activity (hrs/wk & times/wk), b) Non-organized physical activity (hrs/wk & times/wk), c) TV/movie watching (hrs/day), d) Other screen-time [internet, gaming] (hrs/day)	Demographics, weight status	a) Boys' friend's organized physical activity associated with individual's organized physical activity in 2 networks (+)[other network (n.s)]; Girls' friend's organized physical activity associated with individual's organized physical activity in 2 network (+) [other network (n.s)], b) Boys' and girls' friend's unorganized physical activity not associated with individual's unorganized physical activity (n.s), c) Boys' and girls' friend's TV/movie watching not associated with individual's TV/movie watching (n.s), d) Boys' friend's other screen-time activities associated with individual's other screen-time activities in 1 network (+)[other

Author(s)	Study Design (Country) and theoretical frameworks/model	Sample Size (Response Rate)	Sample Characteristics	Independent Variable	Dependent Variable	Confounding Variables	Findings
							networks (n.s)]; Girls' friend's other screen-time activities associated with individual's screen-time activities in 3 networks (+), e) Boys' friendship nominations associated with organized physical activity in 2 networks (+) [other network (n.s)]; Girls' friendship nominations not associated with organized physical activity (n.s); Boys' and girls' friendship nominations not associated with unorganized physical activity (n.s); Boys' and girls' friendship nominations not associated with TV/movie watching (n.s); Boys' friendship nominations not associated with other screen-time activities; Girls' friendship nominations associated with other screen-time activities in 1 network (+) [other networks (n.s)].
De la Haye et al. (2011)	Longitudinal: 1 year follow-up (Australia) Theoretical framework/model: Theory of Planned Behaviour, Self Perception Theory	n= 378 group 1: 222, 92.9%; group 2:156, 90.2%	Group 1: 13.60 ± 0.40 yrs of age; 47.30% girls , Group 2: 13.7 ± 0.40 yrs of age; 44.90% girls	Participant reported in school survey; MVPA of nominated best friends and friends hang out with most within grade (reciprocated and non-reciprocated)	Participant reported in school survey; MVPA (hrs/wk)	Demographics, sociodemographics	Friendship selection influenced by similarities in friend's MVPA and individual's MVPA (+); Friend's MVPA associated with individual's MVPA over time (+).
Denault & Poulin (2009)	Longitudinal: 5 year follow-up (Canada)	n= 390 (75%)	12.4 ± 0.42 yrs of age; 55% girls	Participant reported in school survey (Time 1);	Participant reported in school survey (Time 1-5) and	Demographics, sociodemographics, parental variables, other	Boys' friend's sports participation associated with individual's sports participation (+); Girls'

Author(s)	Study Design (Country) and theoretical frameworks/model	Sample Size (Response Rate)	Sample Characteristics	Independent Variable	Dependent Variable	Confounding Variables	Findings
	Theoretical framework/model: not stated			Sports participation of nominated three best friends within classroom (reciprocated)	researcher conducted phone interview (Time 3-5); Sports participation (hrs/wk, mths/yr)		friend's sports participation not associated with individual's sports participation (n.s); Boys and girls friend's sports participation associated with individual's sports participation over time (+).
Gesell et al. (2012)	Longitudinal: 1.2 year follow-up (United States) Theoretical framework/model: not stated	n= 81 (n.r.)	7.96 ± 1.74 yrs of age; 65.40% girls	Researcher conducted face-to-face interview (Time 1,2,3); Physical activity of nominated friends within after-school program (reciprocated and non-reciprocated)	Accelerometer (Time 1-3); Physical activity (avg. daily count)	Demographics, weight status	Friendship selection and breakage not influenced by similarities in friend's physical activity level and individual's physical activity level (n.s); Friendship nomination and received friendship nomination not associated with physical activity level (n.s); Friend's physical activity level associated with change in individual's physical activity level (+).
Jago et al. (2011)	Cross-sectional (United Kingdom) Theoretical framework/model: not stated	n= 986 (58.6%)	10 to 11 yrs of age; 58.10% girls	Participant reported in school survey; Physical activity (counts per minute, MVPA) of nominated best friend of same gender within school (reciprocated and non-reciprocated)	Accelerometer; a) Physical activity (counts per minute), b) MVPA (counts per minute >2912)	Demographics, weight status, other	Boys' and girls' best friend's counts per minute not associated with individual's counts per minute (n.s); Boys' best friend's MVPA associated with individual's MVPA (+); Girls' best friend's MVPA not associated with individual's MVPA (n.s).
Livesey et al. (2011)	Cross-sectional (Australia) Theoretical framework/model: not stated	n= 192 (n.r.)	10.75± 0.95 yrs of age; 58.3% girls	Participant reported in school survey; Rating of friend status (like to play) for all participants within class	Participant reported in school survey; Physical activity (mean activity score)	Demographics, other	Boys' and girls' friendship rating in play not correlated with individual's physical activity level (n.s); Boys' and girls' friendship rating not associated with individual's physical activity (n.s).
Macdonald-Wallis et al. (2011)	Cross-sectional (United Kingdom) Theoretical framework/model: not stated	n= 986 (58.6%)	10 to 11 yrs of age; 55.8% girls	Participant reported in school survey; Physical activity (spatial correlation for counts per minute, MVPA) of nominated four closest friends within school (reciprocated)	Accelerometer; a) Physical activity (counts per minute), b) MVPA (counts per minute >2912)	Demographics, sociodemographics, other	Friendship network's counts per minute are similar to individual's counts per minute (+); Friendship network's MVPA are similar to individual's MVPA (+); Immediate through fifth degree friend's MVPA and counts per minute associated with individual's MVPA and counts per minute, respectively (+); Friendship network's MVPA associated with individual's MVPA (+); Friendship network's

Author(s)	Study Design (Country) and theoretical frameworks/model	Sample Size (Response Rate)	Sample Characteristics	Independent Variable	Dependent Variable	Confounding Variables	Findings
				and non-reciprocated)			counts per minute not associated with individual's counts per minute (n.s).
Ommundsen et al. (2010)	Longitudinal: 3 year follow-up (Norway) Theoretical framework/model: not stated	n= 80 (67.8%)	6 to 10 yrs of age (grades 1 to 4); 55% girls	Participant reported in school survey: Nomination of 3 friends prefer to work and play with most (Time 1 & 4)	Accelerometer; Physical activity (total counts) (Time 1)	Demographics, weight status, sociodemographic, other	Socio-metric status in grade 1 correlated with physical activity in grade 1 (-). Socio-metric status in grade 4 correlated with physical activity in grade 1 (+). For girls, socio-metric status in grade 4 associated with physical activity in grade 1 (+). For boys, socio-metric status in grade 4 associated with physical activity in grade 1 (-).
Raudsepp & Viira (2000)	Cross-sectional (Estonia) Theoretical framework/model: Social Learning Theory	n= 475 (81.30%)	14.2 yrs of age (13 to 15 yrs); 50.95% girls	Participant reported in school and at home survey; Physical activity of nominated best friend	Participant reported in school survey; Physical activity (hrs/wk)	Demographics, sociodemographics	Boys' best friend's moderate, hard, and very hard intensity physical activity associated with individual's higher activity level (+); Girls' best friend's MVPA not associated with individual's higher levels of physical activity (n.s); Girls' best friend's hard and very hard intensity physical activity associated with higher levels of physical activity for individual (+). Best friend's physical activity is a significant predictor of individual's physical activity (+).
Schofield et al. (2007)	Cross-sectional (Australia) Theoretical framework/model: not stated	n= 318 (92.10%)	16.0 ± 0.80 yrs of age; 100% girls	Participant reported in school survey; Physical activity of nominated three closest friends within school in descending order (reciprocated and non-reciprocated)	Pedometer; a) Physical activity (< 10,000 or ≥ 10,000 steps/day) and step counts	None	Girls' first through third nominated friend's step count associated with individual's step count (+)*; Girls with one, two, or three active friends significantly more active compared with girls with no active friends (+); First and second nominated reciprocated friend's step count associated with individual's step count (+)*; Third nominated reciprocated friend's step count not associated with individual's step count (n.s)*; First and third nominated non-reciprocated friend's step count not associated with individual's step count (n.s)*. Second nominated non-reciprocated friend's step count associated with individual's step count (+)*; First nominated friend's physical activity associated with individual's physical

Author(s)	Study Design (Country) and theoretical frameworks/model	Sample Size (Response Rate)	Sample Characteristics	Independent Variable	Dependent Variable	Confounding Variables	Findings
							activity (+)*. Second and third nominated friend's physical activity not associated with individual's physical activity (n.s)*.
Strauss & Pollack (2003)	Cross-sectional (United States) Theoretical framework/model: not stated	n= 17557 (79%)	Grade level 7 to 12 (12 to 18 yrs of age); 45 % girls	Researcher conducted in-home interview; Nomination of 5 best male and 5 best female friends within school	Participant reported in school survey; a) Sports participation (≤ 2 or > 2 times/wk), b) TV/video watching (hrs/wk)	Demographics, weight status, sociodemographics	Friendship nominations associated with sports participation (+); Friendship nominations associated with TV/video watching (-).
Yli-Piipari et al. (2011)	Cross-sectional (Finland) Theoretical framework/model: Expectancy-value model	n= 330 (80%)	12.2 \pm 0.22; 52.42% girls	Participant reported in school survey (Time 1); Physical activity of nominated three friends like to spend time within grade level (reciprocated and non-reciprocated)	Participant reported in school survey (Time 2); Physical activity (days/wk)	Demographics	For boys, within peer group showed homogeneity for physical activity (+)*. For girls, within peer group showed homogeneity for physical activity (+).

Associations between social network and physical activity/sedentary variables are considered statistically significant at $p < 0.05$ unless otherwise stated (i.e., * = $p < 0.10$ or "n.s" = not significant); (+) = a positive association between social network and physical activity/sedentary variables; (-) = a negative association social network and physical activity/sedentary variables; MVPA= moderate-to vigorous-intensity physical activity; n.r. = not reported; confounder categories: *Demographic* [age, gender, race]; *Weight Status* [height, weight, body mass index, weight status]; *Sociodemographics* [parent SES/income, education level, pocket money]; *Parental variables* [parent community involvement, parent beliefs about organized physical activity]; *Other* [pubertal status, behaviours, self-efficacy, movement assessment and motor skills, autonomy].

Nine studies were cross-sectional (Ali et al., 2011; De la Haye et al., 2010; Jago et al., 2011; Livesey et al., 2011; Macdonald-Wallis et al., 2011; Raudsepp & Viira, 2000; Schofield et al., 2007; Strauss & Pollack, 2003; Yli-Piipari et al., 2011), while the remaining four were longitudinal (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012; Ommundsen et al., 2010). Length of follow-up time for the longitudinal studies ranged from one to five years. Seven studies measured physical activity using self-administered questionnaire (De la Haye et al., 2010, 2011; Denault & Poulin, 2009; Livesey et al., 2011; Raudsepp & Viira, 2000; Strauss & Pollack, 2003; Yli-Piipari et al., 2011), four via accelerometer (Gesell et al., 2012; Jago et al., 2011; Macdonald-Wallis et al., 2011; Ommundsen et al., 2010), one via pedometer (Schofield et al., 2007), and one via face-to-face interview (Ali et al., 2011). Three studies (Ali et al., 2011; De

la Haye et al., 2010; Strauss & Pollack, 2003) also assessed the amount of sedentary leisure-time activities, which included hours per day of watching television and videos, playing video or computer games, or using the Internet. For the participant's friendship network measure, all but two studies (Livesey et al., 2011; Ommundsen et al., 2010) used participant nominated friends and best friends in their class, grade, school, or after school program. Livesey et al. (2011) asked children to rate how much they liked to interact during play with other children included in the sample, while Ommundsen et al. (2010) used children's preferences to play and work with other children in the study to create a socio-metric status score for each participant. Further, Strauss and Pollack (2003) measured participant's five best male and five best female friends, and determined the relationship between this measure of popularity and both sports participation per week and hours of television or video watching per day.

Twelve studies statistically controlled for at least one confounding variable, while Schofield et al. (2007) did not report controlling for confounders. Across these twelve studies, demographic variables were controlled for, including age and gender. Six studies adjusted for weight status (Ali et al., 2011; De la Haye et al., 2010; Gesell et al., 2012; Jago et al., 2011; Ommundsen et al., 2010; Strauss & Pollack, 2003). Several studies also adjusted for socioeconomic factors including parent socio-economic status, parent education level, and/or participant pocket money (Ali et al., 2011; De la Haye et al., 2010; Denault & Poulin, 2009; Macdonald-Wallis et al., 2011; Ommundsen et al., 2010; Raudsepp & Viira, 2000; Strauss & Pollack, 2003). Only three studies (De la Haye et al., 2011; Raudsepp & Viira, 2000; Yli-Piipari et al., 2011) explicitly stated the use or application of a theoretical framework or model with regard to their study design or interpretation of findings. De la Haye et al. (2011) used the Theory of Planned Behaviour, with particular focus on perceptions of peer (subjective) norms as a key mechanism of peer influence. These authors, however, noted that Self-Perception Theory (i.e., individual's internal states being guided own behaviours) might have provided a better explanation of their results. Raudsepp and Viira (2000) used Social Learning Theory, with particular focus on the concept of behavioural modeling to explain their significant findings whereby best friend's physical activity was positively associated with an individual's physical activity. Yli-Piipari et al. (2011) applied the expectancy-value model, which emphasizes personal values and

expectancies, as a means to help define socialization and friendship interactions and further explain similarities in physical activity behaviour among groups of friends.

In terms of friendship nominations, one study used only reciprocated nominations (Denault & Poulin, 2009), while others used both reciprocated and non-reciprocated nominations (De la Haye et al., 2010, 2011; Gesell et al., 2012; Jago et al., 2011; Macdonald-Wallis et al., 2011; Schofield et al., 2007; Yli-Piipari et al., 2011). Two studies (Ali et al., 2011; Raudsepp & Viira, 2000) did not indicate whether they used reciprocated, non-reciprocated nominations, or both. For studies that specifically examined popularity (e.g., the number of times a participant was nominated as a friend) or a socio-metric measure (e.g., preference to play with particular individual), reciprocation of a friendship nomination was not needed as this measure is based on how many times a participant was nominated (Livesey et al., 2011; Ommundsen et al., 2010; Strauss & Pollack, 2003).

2.4.2 Associations between friendship networks and physical activity

Of the ten studies (Ali et al., 2011; De la Haye et al., 2010, 2011; Denault & Poulin, 2009; Gesell et al., 2012; Jago et al., 2011; Macdonald-Wallis et al., 2011; Raudsepp & Viira, 2000; Schofield et al., 2007; Yli-Piipari et al., 2011) that measured close friends' or friendship groups' physical activity levels, all found some evidence that levels of physical activity among friends was associated with the level of physical activity of the individual (*Table 2.2*).

Table 2.2. Summary of the associations between friendship networks and physical activity and sedentary behaviour across reviewed studies.

		<u>Associations with physical activity</u>			<u>Associations with sedentary behaviour</u>		
		Positive	Null	Negative	Positive	Null	Negative
Boys	Close Friends	(De la Haye et al., 2010), (Denault & Poulin, 2009) ^{a, b} , (Jago et al., 2011), (Raudsepp & Viira, 2000)	(De la Haye et al., 2010), (Jago et al., 2011)		(De la Haye et al., 2010)	(De la Haye et al., 2010)	
	Friendship Group	(Yli-Piipari et al., 2011)*					
	Popularity	(De la Haye et al., 2010)	(De la Haye et al., 2010), (Livesey et al., 2011)	(Ommundsen et al., 2010) ^b		(De la Haye et al., 2010)	
	Friendship Selection						
Girls	Close Friends	(De la Haye et al., 2010), (Denault & Poulin, 2009) ^{a, b} , (Raudsepp & Viira, 2000), (Schofield et al., 2007)* ^a	(De la Haye et al., 2010), (Denault & Poulin, 2009) ^a , (Jago et al., 2011), (Raudsepp & Viira, 2000), (Schofield et al., 2007)*		(De la Haye et al., 2010)	(De la Haye et al., 2010)	
	Friendship Group	(Schofield et al., 2007), (Yli-Piipari et al., 2011)					
	Popularity	(Ommundsen et al., 2010) ^b	(De la Haye et al., 2010), (Livesey et al., 2011)		(De la Haye et al., 2010)	(De la Haye et al., 2010)	
	Friendship Selection						
Boys and girls	Close Friends	(De la Haye et al., 2011) ^b , (Gesell et al., 2012) ^b					
	Friendship Group	(Ali et al., 2011), (Macdonald-Wallis et al., 2011)	(Macdonald-Wallis et al., 2011)			(Ali et al., 2011)	
	Popularity	(Ommundsen et al., 2010) ^b , (Strauss & Pollack, 2003)	(Gesell et al., 2012)	(Ommundsen et al., 2010)			(Strauss & Pollack, 2003)
	Friendship Selection	(De la Haye et al., 2011) ^b	(Gesell et al., 2012) ^b				

Associations significant at $p < 0.05$ unless stated with * = $p < 0.10$; ^a = reciprocated nominations only; ^b = longitudinal analysis; *close friends*: physical activity or sedentary behaviour of nominated best friend or close friends, *friendship group*: average physical activity or sedentary behaviour of nominated friends, *popularity*: higher number of received friendship nominations or a higher measure of friendship rating/status (i.e., number of nominations received for preference to play with), *friendship selection*: individual choosing a friend based on similarities with his or her own physical activity or sedentary behaviour.

2.4.2.1 Popularity, socio-metric status, and physical activity

Five studies (De la Haye et al., 2010; Gesell et al., 2012; Livesey et al., 2011; Ommundsen et al., 2010; Strauss & Pollack, 2003) assessed popularity level or socio-metric status, and physical activity level of the individual and found differing results. Strauss and Pollack (2003) found that a higher count of friendship nominations was associated with higher sports participation. This supported De la Haye et al.'s (2010) finding that boys who played more organized physical activity tended also to be the most popular among school friends. In contrast, Gesell et al. (2012) and Livesey et al. (2011) did not find any significant association between popularity level and physical activity among boys and girls. Ommundsen et al. (2010) found that higher total accelerometer counts were correlated with lower socio-metric status in grade one children. Furthermore, in a longitudinal analysis, Ommundsen et al. (2010) found that, for girls, higher total accelerometer counts in grade one were associated with a higher socio-metric status in grade four, while for boys, higher total accelerometer counts in grade one were associated with a lower socio-metric status in grade four.

Three longitudinal studies (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012) assessed the change in participant's physical activity level over time, and all found that participants' level of physical activity significantly changed over time to emulate friends' higher levels of physical activity. Two longitudinal studies (De la Haye et al., 2011; Gesell et al., 2012) also examined whether participant's friendship selection was based on physical activity levels; De la Haye et al. (2011) found that friendship selection was significantly influenced by similarities in physical activity levels, whereas Gesell et al. (2012) did not.

2.4.2.2 Network position and physical activity

Schofield et al. (2007), although not adjusting for other factors, found that a higher pedometer step count for girls' first nominated *reciprocated* friends was moderately correlated with a high pedometer step count for the individual; however, first *non-reciprocated* friend's step count was not correlated with an individual's step count. Moreover, this study also found that the correlation between step count and nominated friends attenuated as friend's intimacy (i.e., second and third nominated friend) decreased regardless of whether or not the nomination was

reciprocated (Schofield et al., 2007). Macdonald-Wallis et al. (2011) measured degree of friendship separation, and found that the correlation of moderate-to-vigorous physical activity and counts per minute among friends was strongest with more immediate friendships (i.e., no separation via another person). Beyond nomination reciprocation and degrees of separation, studies did not include measures of local network roles (e.g., isolate, liaison), nor did they examine network-level measures (e.g., density, centrality).

2.4.2.3 Gender differences between friendship networks and physical activity

Six studies (De la Haye et al., 2010; Denault & Poulin, 2009; Jago et al., 2011; Ommundsen et al., 2010; Raudsepp & Viira, 2000; Yli-Piipari et al., 2011) reviewed found differences between the influence of friends on physical activity and sedentary behaviours of boys and girls. Boys tended to be more active, and were more likely to be influenced by the physical activity behaviours of their friends compared with girls. For example, Jago et al. (2011) and Raudsepp and Viira (2000) found that boys' friend's moderate-to-vigorous physical activity was associated with individual's moderate-to-vigorous physical activity, but this association was not statistically significant for girls. Denault and Poulin (2009) found that, for boys, a higher level of friend's sports participation was associated with a higher level of individual sports participation.

2.4.3 Associations between friendship networks and sedentary behaviour

Three studies (Ali et al., 2011; De la Haye et al., 2010; Strauss & Pollack, 2003) examined the association between friendship networks and sedentary behaviour and found contradicting results (*Table 2.2*). Ali et al. (2011) found no association between the weekly hours of television and video viewing of nominated close friends' and an individual's television and video viewing. In contrast, De la Haye et al. (2010) found significant positive associations between friends' video/computer gaming and Internet use and individual's (girls only) video/computer gaming and internet use in three separate age-based networks (school 1/grade 8; school 2/grade 8; school 2/grade 9). A positive association was also found for boys for the school 2/grade 8 network (De la Haye et al., 2010).

2.4.3.1 Popularity, socio-metric status, and sedentary behaviour

Strauss and Pollack (2003) found that as an adolescent's (boys and girls combined) popularity increased, they spent less time per day watching television.

2.4.3.2 Network position and sedentary behaviour

There were no studies that examined differences in reciprocated or non-reciprocated friendships, degree of separation, specific network positions or network characteristics.

2.4.3.3 Gender differences between friendship networks and sedentary behaviour

One study stratified their results by gender (De la Haye et al., 2010). De la Haye et al. (2010) found an association between higher levels of girls' friends' video/computer gaming and Internet use and higher levels of individual video/computer gaming and Internet use in all three networks examined. Boys associations were only present in one network (De la Haye et al., 2010). Contrary to Strauss and Pollack (2003), De la Haye et al. (2010) also identified a small but significant association between a girl's popularity (i.e., higher count of friendship nominations) and increased level of participation in video/computer gaming and Internet use.

2.5 DISCUSSION

Friendship networks are associated with physical activity among children and adolescents, with some, albeit less, evidence suggesting that friendship networks might also be associated with sedentary behaviour. This confirms previous evidence (Macdonald-Wallis et al., 2012) by showing that friendship networks have a greater influence on physical activity for boys compared with girls. This observation is strengthened by more longitudinal evidence, lending weight to the peer contagion models of physical activity (i.e., after becoming friends, behaviours become similar) as opposed to the peer selection model (i.e., adolescents choosing friends who have similar behaviour to themselves at the outset). The review identified a lack of explicit use of theoretical frameworks in studies to date.

The differential influence of friendship on physical activity for boys and girls may reflect differences in attitudes towards physical activity and differences in peer social norms (Fredricks

et al., 2005). Moreover, boys generally have higher levels of fitness and physical activity participation compared with girls (Colley et al., 2011; Tremblay et al., 2010b). Higher levels of physical activity in and of itself might provide more opportunities for co-participation and modeling (i.e., an individual witnessing another individual being active and may be therefore motivated to participate in the same activity). Another, albeit weaker, explanation could be that the faster rate of maturity among girls, on average, might result in girls developing a more concrete set of values sooner and therefore less likely to conform to group norms (Sumter et al., 2009). Gender differences have also been identified for diet, with boys' friends being more alike in their consumption of high caloric foods than girls' friends (De la Haye et al., 2010). This could suggest that gender-specific approaches to promoting healthy weight might be needed, especially if the primary vehicle for the intervention is the friendship network. However, more research is needed to identify which social mechanisms might be more influential in determining physical activity and sedentary behaviour for boys and girls.

Similarities in friendship network behaviours can be both the result of social influence, where children or adolescents adopt behaviours based on the attitudes and behaviours of friends within a network, or a result of friendship selection, whereby individuals select friends that share similar interests, attitudes, and behaviours (De la Haye et al., 2010). The processes of peer influence and peer selection are found to be associated in other health behaviours in the adolescent population including smoking (Myong-Hyon et al., 2010) and delinquency (Knecht et al., 2010). Disentangling these pathways is difficult based on cross-sectional study design, which includes the majority of studies reviewed here. While cross-sectional studies are able to tell us whether a relationship exists between a friendship network and an individual's behaviour, the direction of causality cannot be ascertained. The longitudinal studies in this review offer key information in terms of the influence of friendship networks on physical activity as they allow potential causal pathways to be extricated. Three of these studies (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012) found that an individual's physical activity level changed over time to become more similar to a friend's higher level of physical activity, while the fourth longitudinal study (Ommundsen et al., 2010) found a positive relationship for girls' socio-metric status in grade four and accelerometer counts in grade one. These results provide evidence to support a

causal pathway, where friends influence an individual's physical activity level (i.e., peer contagion). This friendship influence could be a result of social norms. Pressure from peers to conform to group norms is a strong motivator for behaviour adoption or maintenance, and is often combined with negative consequences, such as social isolation, if behaviours are not adopted (Bandura, 2004). Future research that assesses reasons for choosing friends will assist in understanding the factors (i.e., friendship selection versus friendship influence) that influence similarities in health behaviours across friendship networks.

Several studies included in this review used ego-based networks, where participants were asked to self identify and nominate their best or close friends; this compared with using complete friendship networks, where participants are given a full class or school list and asked to nominate their friends, thereby providing a global view of network structure. Previous research has recognized the importance of friendship network structure (e.g., density, centralization) in relation to health behaviours in youth (Ennett & Bauman, 1993; Ennett et al., 2006; Haynie, 2001). In addition, Seo and Huang (2012) found that isolates (i.e., no ties to other individuals (Wasserman & Faust, 1994)) were more likely to be smokers compared with clique members (i.e., members of a group of at least three individuals, where all three individuals are linked through friendship nominations (Wasserman & Faust, 1994)), and further identified that non-smoking adolescents were more likely to become smokers if they belong to a smoking clique. There were no studies that investigated the specific roles within a complete friendship network, such as liaisons (i.e., providing ties between groups within a network (Wasserman & Faust, 1994)) or isolates. Examining the relationship between isolates and physical activity and sedentary behaviour may have important health implications, as one study (Strauss & Pollack, 2003) found that decreased friendship nominations was associated with higher television and video viewing. Furthermore, liaisons are characterized as having a strong degree of interaction among several cliques, and therefore may be a useful mechanism to promote physical activity to a higher number of individuals.

Studies included in this review did not measure the length of friendship, frequency of friend contact, or context in which friends normally interacted (e.g., playing at recess or after school).

The former measures can indicate the strength of bond between two individuals, while the latter measure may have a specific impact on a friend's influence on sedentary behaviour, as sedentary leisure-time activities generally occur outside of the school setting. As well, the level of influence friends have on one another's behaviour might depend on whether the context and activities are organized or non-organized (e.g., sports vs. unstructured play). Stronger bonds, as seen through reciprocated friendship nominations, have a greater impact on physical activity levels as compared with non-reciprocated friends (Schofield et al., 2007). Accounting for the quality or strength of friendship bonds in addition to friendship ties may provide greater insight into the mechanisms explaining peer influences on physical activity and sedentary behaviour.

As with any review, the issue of publication bias should be considered when interpreting our findings. This review did not objectively-assess the scientific quality of each included study nor weigh findings based on their validity (i.e., using a validity assessment). Noteworthy, was that only three studies explicitly mentioned the use of a specific theoretical framework or model. Integration of the mechanism of peer selection or contagion within existing social cognitive models of behaviour may provide greater understanding regarding peer influence on physical activity and sedentary behaviour. At a minimum, future studies should describe the theoretical frameworks informing their methodologies and interpretation of results.

Despite undertaking a broader search of literature to identify studies, we found only four additional studies not included in a review completed approximately two years ago (Macdonald-Wallis et al., 2012). Nevertheless, these additional studies contributed to current knowledge – for example, one study provided additional support for gender differences with regard to peer influence as well as the association between peer influence and physical activity intensity (Raudsepp & Viira, 2000), and two studies provided longitudinal evidence that showed friends' physical activity behaviours tended to become similar over time, indicating a process of socialization (Denault & Poulin, 2009; Gesell et al., 2012). However, our review identified several gaps in current knowledge, not previously identified, including the lack of evidence regarding the association between specific social network ties, roles, positions, and characteristics and physical activity and sedentary behaviour, the dearth of studies incorporating

measures strength or quality of peer relationships, the lack of details regarding theoretical frameworks and models, and the need for more longitudinal study designs. Given that there are only thirteen published studies on this topic suggests that our understanding of the role of social networks on physical activity and sedentary behaviour among youth is in its early stages and that this topic demands more research attention.

Findings from this review provide support for a relationship between friend's physical activity and an individual's physical activity in children and adolescents, but findings for sedentary behaviour are mixed. Harnessing the influence of friendship to increase physical activity levels and decrease sedentary leisure-time activity would have a beneficial impact on reducing the current prevalence of overweight and obese youth through an increase in energy expenditure. More research examining sedentary behaviour among children is needed, including investigation of virtual peer networks that result from on-line gaming, as well as the influence of networks outside of the school setting (e.g., family, sports teams, camps, social clubs) on obesity-risk behaviours.

CHAPTER THREE

3.0 ASSOCIATIONS BETWEEN ASPECTS OF FRIENDSHIP NETWORKS AND PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOURS AMONG ADOLESCENTS²

3.1 ABSTRACT

Background. Patterns of participation in physical activity and sedentary behaviour are associated with health outcomes in adolescents. The social environment is considered an important correlate of physical activity, yet little is known about network positioning, connections, global network structure, and their association with adolescent physical activity and sedentary behaviour. This study examined the associations between aspects of friendship networks, general perceived social support from friends, and physical activity and sedentary behaviour among adolescents aged 11-15 years.

Method. A sample of adolescents from six Catholic schools (n=1061, response rate=80.5%) completed internet-based surveys capturing weekly physical activity, daily sedentary behaviour, ‘close friend’ nominations, and sociodemographic characteristics. Binary logistic regression odds ratios (OR) and 95% confidence intervals (95%CI) estimated cross-sectional associations between social network derived variables (friendship network density for each grade; proportion of active close friends; proportion of sedentary close friends; betweenness centrality; popularity, and; clique membership), general perceived social support from friends, and achieving at least sixty-minutes per day of moderate-to-vigorous physical activity (MVPA) every day, as well as participating in more than two-hours per day of sedentary behaviour. Regression models were gender-stratified and adjusted for sociodemographic characteristics. A Mann-Whitney U test was used to compare differences in both the mean number of days achieving at least sixty-minutes of MVPA, as well as more than two-hours per day of sedentary behaviour, between those who received no friendship nominations and those receiving at least one nomination.

² Candidate contribution: The candidate conceived of this study and identified variables for inclusion. The candidate led the statistical analyses, and interpreted the findings. Drafting of the manuscript was also performed by the candidate. The candidate is responsible for 100% of the work presented in this chapter.

Results. For boys and girls, an increase in ten percentual points of active close friends was associated with a significantly ($p < 0.05$) increased likelihood of achieving recommended physical activity levels (OR 1.11; 95% CI 1.02-1.21, and OR 1.14; 95% CI 1.02-1.27, respectively). For boys, higher general perceived social support from friends was associated with lower odds of achieving recommended physical activity levels (OR 0.63; 95% CI 0.42-0.96). Compared with boys in low density friendship networks, boys in higher density friendship networks were significantly more likely to participate in more than two-hours per day of sedentary behaviour (OR 2.93; 95% CI 1.32-6.49). General perceived social support from friends significantly modified the effect between social network variables and odds of being sufficiently active and highly sedentary. Adolescents who did not receive a friendship nomination reported participating in at least sixty-minutes MVPA on significantly fewer days per week compared with those who received at least one friendship nomination (mean=3.28 days/wk, SD=1.76 days/wk vs. 4.33 days/wk, SD=1.81 days/wk, respectively); however, no differences in sedentary behaviour were found.

Conclusion. Several aspects of friendship networks are associated with both boys' and girls' physical activity and sedentary behaviour. Associations between friendship networks and sedentary behaviour appear to be gender specific. Public health interventions focused on modifying both friendship network structure and behaviours of adolescents within a network may help adolescents achieve recommended levels of physical activity and sedentary behaviour.

3.2 BACKGROUND

Participating in more physical activity and less sedentary activity can provide many health benefits (Tremblay et al., 2011a; Tremblay et al., 2011b). For adolescents, the health benefits of increased physical activity include higher bone mineral density and cardio-respiratory fitness, reduced depressive symptoms, improved academic performance, and improved weight status (Biddle & Asare, 2011; Fox et al., 2010; Tremblay et al., 2011b). Moreover, independent of their physical activity levels, children and adolescents who are less sedentary (e.g., watch television, play video games, and use computers) have a lower likelihood of being overweight and developing the metabolic syndrome during adolescence (Mark & Janssen, 2008; Tremblay & Willms, 2003). To accrue optimal health benefits, current Canadian physical activity guidelines

recommend that adolescents accumulate at least sixty-minutes of moderate-to-vigorous intensity physical activity (MVPA) each day (Tremblay et al., 2011b), and limit their sedentary behaviour to no more than two-hours per day (Tremblay et al., 2011a). Despite both adolescents and parents being aware of the health benefits of physical activity (Yi Pan et al., 2009), only 4% of girls and 9% of boys in Canada accumulate sixty-minutes of MVPA on at least six days a week (Colley et al., 2011), while up to 60% of youth spend more than two-hours per day participating in screen-based activities (Leatherdale & Ahmed, 2011).

The social environment is one of the multiple determinants of adolescent health. It is comprised of physical surroundings, social relationships, and cultural norms (Barnett & Casper, 2001). Specifically, adolescents' social environment include social relationships with parents, neighbours, friends, peers, teachers and coaches (Markward et al., 2003). These relationships can assist in the transfer, encouragement, and discouragement of adolescent attitudes and behaviours. Friends have a particular influence on adolescent health, as a significant portion of time is spent at school and participating in extra-curricular activities. Mechanisms by which friends can influence individual behaviour include co-participation (i.e., participating in the same behaviour as a friend, offering positive support for that behaviour), modeling (i.e., witnessing a friend or peer performing a behaviour), and social norms (i.e., perception of the amount the behaviour is performed by others or perception of approval of a behaviour) (Bandura, 2004; Cialdini et al., 1990; Prinstein & Dodge, 2008). In addition, perceptions of social support, including the quality and amount of friend support for a particular behaviour, can facilitate an individual's health behaviours (Bandura, 2004; Mummery et al., 2004). General measures of perceived social support have also been used within the health literature (Li et al., 2013; Mummery et al., 2004; Patterson et al., 1998) and have been shown to modify the relationship between intrafamilial stress and children's television viewing (Li et al., 2013).

Social network analysis provides a means of quantifying relationships and attributes among entities, such as individuals or organizations and estimating patterns of association (Wasserman & Faust, 1994). Friendship nominations amongst a group of individuals can be aggregated to form quantitative estimates of an individual's friendship network. Analysis of friendship

networks has been used to examine and explain adolescent health behaviour such as smoking (Seo & Huang, 2012), diet (Fletcher et al., 2011), and more recently physical activity and sedentary behaviour (Macdonald-Wallis et al., 2012; Sawka et al., 2013). There is evidence to suggest associations between popularity, friend behaviours, and friendship reciprocity with regard to an individual's physical activity level; however, there are still mixed results on the association between aspects of friendship networks and sedentary behaviour (Macdonald-Wallis et al., 2012; Sawka et al., 2013). Gender differences have also been identified; several studies found that friends' physical activity was associated with boys' physical activity, but not girls' physical activity (Denault & Poulin, 2009; Jago et al., 2011; Raudsepp & Viira, 2000). Gender differences in other health behaviours, such as smoking (Liao et al., 2013; Mercken et al., 2010) and alcohol use (Hong et al., 2013; Mrug & McCay, 2013) have also been identified.

Within social network analysis there are a variety of measures that examine individual positioning and relationships which have yet to be explored within the context of physical activity and sedentary behaviour. These measures include ego-level (i.e., individual) variables such as network positioning and roles (e.g., clique member, isolate), betweenness centrality (i.e., an individual's tendency to link other network members) as well as network-level variables such as network density (i.e., number of connections in a network as a percentage of the total possible connections) (Wasserman & Faust, 1994). These network measures could provide an additional layer of understanding and greater insight into the overall influence of friends on individual behaviour. For example, high network density reflects a high level of connectivity among individuals, thereby increasing exposure to normative attitudes and behaviours. This measure has been examined in the adolescent substance abuse literature (Ennett et al., 2006; Hussong, 2002), and its applicability to physical activity and sedentary behaviour is worth investigating. Furthermore, while the association between popularity and physical activity and sedentary behaviour have been examined (De la Haye et al., 2010; Gesell et al., 2012; Livesey et al., 2011; Ommundsen et al., 2010; Strauss & Pollack, 2003), there has been less focus on segregated adolescents, such as those who receive no friendship nominations. These adolescents may be at a higher risk of being insufficiently active as they likely have limited or no opportunities to co-participate in activities with friends nor opportunities for friendship

modeling. Examining the physical activity and sedentary behaviour levels of adolescents who receive no friendship nominations will provide useful knowledge towards understanding the importance of friendship influence.

The aim of this study was to examine the associations between aspects of within-grade friendship networks (i.e., friendship network density, friend behaviours, popularity, network positioning), general perceived social support from friends, and achieving recommended levels of physical activity and sedentary behaviour. Moreover, this study examined whether associations between aspects of friendship networks and physical activity and sedentary behaviour differ by gender. Based on two previous syntheses on aspects of friendship networks and physical activity and sedentary behaviour (Macdonald-Wallis et al., 2012; Sawka et al., 2013), we hypothesize that a higher proportion of active friends will be associated with a greater likelihood of being sufficiently active for boys, but not for girls. As higher levels perceived social support for physical activity from family and friends has shown to be associated with an increase in physical activity levels, (Duncan et al., 2005; Robbins et al., 2008; Springer et al., 2006), we predict that higher levels general perceived social support from friends will be associated with an increased likelihood of being sufficiently active for both boys and girls. Moreover, we predict that general perceived social support from friends will modify the relationship between proportion of active friends and likelihood of being sufficiently active for boys such that a higher level of general perceived social support from friends combined with a higher proportion of active close friends will result in an increased likelihood of being sufficiently active.

3.3 METHOD

3.3.1 Data source

A sample of six Catholic schools in Calgary (Alberta, Canada) that did not offer specialized programming (e.g., performing arts, hockey) was invited to participate in this study. These six schools came from six separate neighbourhood communities within the city of Calgary.

Within these six communities, most recent estimates (2005) show total median income ranging from \$72,170 (School C) to \$92,453 (School D) (City of Calgary, 2014). The Calgary median total income in 2005 was \$67,238 (City of Calgary, 2014).

In each of the six schools, all adolescents in grades seven through nine were invited to participate, and a study information package was sent to homes seeking parental consent for their adolescent's participation. In-school surveys were administered in November and December 2010, and measures of physical activity, sedentary behaviour, sociodemographics, level of general perceived social support from friends were gathered (*Appendix F*), along with each adolescent's within-grade 'close' friend network (*Appendix G*). The University of Calgary Conjoint Research Ethics Board granted approval for this project (ID# 16771).

3.3.2 Study variables

Physical Activity

Two survey items captured the number of days adolescents achieved at least sixty-minutes of MVPA outside of school hours, during: 1) the past seven-days, and; 2) in a usual week (Prochaska et al., 2001). Acceptable two-week test-retest reliability for a composite score of these two questions has been previously reported (intraclass correlation=0.79) (Prochaska et al., 2001). The responses to these questions were averaged and then dichotomized into: 1) achieving sixty-minutes of MVPA on less than seven-days per week (i.e., *insufficiently active*), and; 2) achieving sixty-minutes of MVPA on seven-days per week (i.e., *sufficiently active*), reflecting the current Canadian youth physical activity guidelines (Tremblay et al., 2011b).

Sedentary Behaviour

Two survey questions captured the amount of time adolescents spent watching television or videos, using a computer, playing video games or using a handheld device, outside of school, on a typical: 1) weekday, and; 2) weekend day (Utter et al., 2003). The average hours spent per day sedentary was estimated ($[\text{five} \times \text{weekday hours} + \text{two} \times \text{weekend hours}] / \text{seven-days per week}$) and dichotomized into: 1) more than two-hours per day (i.e., *high sedentary*), and; 2) two- hours or less per day (i.e., *low sedentary*), reflecting the current Canadian adolescent sedentary behaviour guidelines (Tremblay et al., 2011a). Acceptable two-week test-retest reliability for weekday and weekend sedentary behaviour questions has been previously reported (weekday

television/video ($r=0.80$), weekend television/video ($r=0.69$), weekday computer ($r=0.66$), weekend computer ($r=0.71$)) (Utter et al., 2003)).

General Perceived Social Support from Friends

As an accompaniment to the social network analysis-derived measures, general perceived social support from friends was measured through a social support scale consisting of four items. These items asked adolescents to report on how often they had friends who: tried to help them, they could count on when things go wrong, they could share happy and sad times, and they could talk to about problems (i.e., never=1, sometimes=2, most of the time=3, or all the time=4) (Zimet et al., 1988). These four items were averaged, with higher scores reflecting higher levels of support. Internal consistency for this scale was acceptable (Cronbach's $\alpha=0.82$).

Sociodemographic Characteristics

Socioeconomic status was measured using the Family Affluence Scale (FAS) (Currie et al., 2009) which included four items asking adolescents to report: the number of cars, vans, or trucks their family owned (i.e., 0, 1, or ≥ 2 vehicles); if they had their own bedroom (i.e., no=0 or yes=1); the number of times their family travelled away on holiday (i.e., 0, 1, 2, or ≥ 2 times in past 12 months) and; the number of computers/laptops their family owned (i.e., 0, 1, 2, or ≥ 2). The responses to FAS items were summed and tertiled into low (FAS score <6), medium (FAS score 6 to <8), and high family affluence (FAS score ≥ 8). Adolescents reported their gender, age (i.e., ≤ 12 years, 13 years, and ≥ 14 years old), and how long they have lived in Canada (i.e., ≤ 5 years or >5 years). The number of times the adolescent moved homes in the last year was dichotomized (i.e., did not move or moved at least once) and which of the six schools the adolescent attended was also recorded (i.e., school A through F). School attended may provide a proxy for community situatedness and affluence.

Social Network Variables

To gather a complete social network, adolescents were presented with a list of all individuals enrolled in their grade and were asked to indicate their 'closest friends'. Using social network analysis software UCINET (Borgatti et al., 2002), seven network variables were estimated based

on the received ('incoming') friendship nominations from close friends. The variables included: 1) friendship network density (*density*); 2) proportion of received nominations from adolescents who achieved recommended levels of physical activity (*proportion of active close friends*); 3) proportion of received nominations from adolescents who participated in more than the recommended amount of sedentary behaviour (*proportion of sedentary close friends*); 4) amount of times an individual lies on the shortest path between two other individuals (*betweenness centrality*), 5) total number of nominations an adolescent received from other adolescents (*popularity*); 6) whether an adolescent has connections with at least two other adolescents and all three adolescents are connected through friendship nominations (*clique member*), and; 7) if the adolescent received no friendship nominations. All variables were normalized using the number of adolescents in each grade. *Density* was dichotomized at the median density (i.e., 12%) of the eighteen networks (three grades x six schools). Density distributions for boys and girls are presented in *Appendix H and I*. High density reflects a higher amount of connectivity between individuals within each grade. *Clique member* was also dichotomized based on whether or not the adolescent was a clique member. All other social network variables were taken as numerical or continuous.

3.3.3 Statistical analysis

Gender-stratified descriptive statistics including mean and standard deviations (SD) for numerical variables (i.e., general perceived social support from friends, proportion of active close friends, proportion of sedentary close friends, betweenness centrality, and popularity) were estimated. Frequencies for categorical variables (i.e., age, FAS, school, time living in Canada, and residential relocation in the last 12 months, friendship network density, clique member, receiving no friendship nominations) were also estimated. Independent samples t-tests, Pearson's chi-square tests and subsequent z-tests for pair-wise comparisons of proportions were undertaken to compare differences in all numerical and categorical variables, respectively. These tests were undertaken separately for boys and girls. To identify initial bivariate associations, Spearman's rank correlations (ρ) were estimated between continuous physical activity and sedentary behaviour variables, social network variables, and general perceived social support from friends. An alpha significance level of 0.05 was used for all statistical analyses. Of note, descriptive

statistics do not include adolescents who received no incoming nominations. Separate descriptive statistics for these adolescents are provided in results section 3.4.2.

Unadjusted binary logistic regression models estimated the independent odds ratios (OR) and 95% confidence intervals (95%CI) between each sociodemographic variable (age, FAS, school, time living in Canada, and residential relocation), social network variables (friendship network density, proportion of active close friends, proportion of sedentary close friends, betweenness centrality, popularity, clique member), general perceived support from friends and being 1) sufficiently active versus insufficiently active, and 2) high sedentary versus low sedentary. Adjusted binary logistic regression models estimated the OR and 95%CI for the association between sociodemographic characteristics, social network variables, and general perceived social support from friends and being 1) sufficiently active versus insufficiently active, and 2) high sedentary versus low sedentary. Unadjusted and adjusted regression analyses were undertaken to assess whether or not unadjusted variables remained significant after control for other relevant co-variables. Using an exploratory approach, we also conducted a backward stepwise likelihood ratio test using SPSS (IBM Corporation, 2011) to attain the final model with significant ($p < 0.05$) interaction terms between general perceived social support from friends and each of the social network variables (friendship network density, proportion of active closest friends, proportion of sedentary closest friends, betweenness centrality, popularity, clique member). To aid in interpretation of the regression results, the *proportion of active close friends* and *proportion of sedentary close friends* were converted to percentages and rescaled so that a one-unit change was equal to a ten percentual point change in these variables. Adolescents who did not receive a friendship nomination were excluded from the regression models because at least one incoming nomination was required for the calculation of the proportion of active close friends and proportion of sedentary close friends. Instead, Mann-Whitney U Tests were used to compare the amount of weekly physical activity and daily sedentary behaviour undertaken between those who did not receive a friendship nomination and those who received at least one friendship nomination.

3.4 RESULTS

From the six schools, all adolescents (1,393) in grades seven through nine were invited to participate, of which 1,112 provided active consent (response rate = 80.5%). A total of 1,061 (76.2%) adolescents provided complete data.

3.4.1 Descriptive statistics

The sample included 535 girls (50.4%), and 526 boys (49.6%) (*Tables 3.1,3.2*). Adolescents' age ranged from 11 years to 15 years, and were distributed as follows: 12 years and younger (boys= 40.9%, girls= 40.0%), 13 years (boys= 31.0%, girls= 33.3%), and 14 years and older (boys= 28.1%, girls= 26.7%). Similar percentages of boys and girls had high family affluence (boys= 37.5%, girls= 38.7%), middle family affluence (boys= 43.0%, girls=44.5%), and low family affluence (boys=19.6%, girls=16.8%). A higher percentage of boys achieved recommended levels of physical activity per week compared with girls (boys=16.0% and girls=7%), while participation in at least two-hours of sedentary activity per day was similar between boys and girls (boys=79.8% and girls=78.7%).

Table 3.1 Descriptive statistics for the sociodemographic characteristics, general perceived social support from friends, physical activity, and sedentary behaviour for boys ($n=526$).

	Physical Activity		Sedentary Behaviour	
	Sufficiently active (≥ 60 -min of MVPA every day)	Insufficiently active (≥ 60 -min of MVPA on < 7 days/week)	High sedentary (> 2 hrs/day of sedentary behaviour)	Low sedentary (≤ 2 hrs/day of sedentary behaviour)
Sociodemographic Characteristics				
<i>Age [n (%)]</i>				
12 years and younger	37 (17.2)	178 (82.8)	157 (73.0)	58 (27.0) ^b
13 years	31 (19.0)	132 (81.0)	132 (81.0)	31 (19.0)
14 years and older	16 (10.8)	132 (89.2)	132 (89.2)	16 (10.8) ^b
<i>Family affluence [n (%)]</i>				
Low	11 (10.7)	92 (89.3) ^a	80 (77.7)	23 (22.3)
Medium	32 (14.2)	194 (85.8)	177 (78.3)	49 (21.7)
High	41 (20.8)	156 (79.2) ^a	164 (83.2)	33 (16.8)
<i>Length of time in Canada [n (%)]</i>				
More than 5 years	6 (9.0)	61 (91.0)	56 (83.6)	11 (16.4)
5 years or less	78 (17.0)	381 (83.0)	365 (79.5)	94 (20.5)
<i>Number of times moved last year [n (%)]</i>				
Did not move	74 (17.2)	356 (82.8)	340 (79.1)	90 (20.9)
Moved at least once	10 (10.4)	86 (89.6)	81 (84.4)	15 (15.6)
Social Network Characteristics				
<i>Incoming close friend nominations [n (%)]</i>				
Received ≥ 1 nomination	87(16.1)	453 (83.9)	432 (80.0)	108 (20.0)
Received no nominations	0 (0.0)	9 (100.0)	5 (55.6)	4 (44.4)
Proportion active close friends [mean (SD)]	0.40 (0.4) ¹	0.30 (0.3) ¹	0.30 (0.3) ²	0.38 (0.3) ²
Proportion sedentary close friends [mean (SD)]	0.67 (0.3)	0.72 (0.3)	0.72 (0.3)	0.68 (0.3)
Betweenness Centrality [mean (SD)]	3.63 (4.2)	3.07 (4.2)	3.14 (4.3)	3.26 (3.9)
Popularity(incoming nominations) [mean (SD)]	7.08 (3.6)	6.98 (3.8)	6.89 (3.7)	7.40 (4.0)
<i>Clique Member [n (%)]</i>				
Not a member	35 (18.0)	155 (82.0)	156 (82.1)	34 (17.9)
Member	49 (14.6)	287 (85.4)	265 (78.9)	71 (21.1)
Perceived support from friends [mean (SD)] ^a	3.15 (0.7)	3.28 (0.6)	3.27 (0.6)	3.20 (0.6)
Total boys [n (%)]	84 (16.0)	442 (84.0)	421 (80.0)	105 (20.0)

Cells with same superscript *letter* signifies significant ($p < 0.05$) chi-square and Bonferroni-adjusted pair-wise comparison (z-test), cells with same superscript *number* signifies significant ($p < 0.05$) difference in means (Mann-Whitney U-test), ^a= average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous intensity physical activity, SD= standard deviation.

Table 3.2 Descriptive statistics for the sociodemographic characteristics, general perceived social support from friends, physical activity, and sedentary behaviour for girls ($n=535$).

	Physical Activity		Sedentary Behaviour	
	Sufficiently active (≥ 60 -min of MVPA every day)	Insufficiently active (≥ 60 -min of MVPA on < 7 days/week)	High sedentary (> 2 hrs/day of sedentary behaviour)	Low sedentary (≤ 2 hrs/day of sedentary behaviour)
Sociodemographic Characteristics				
<i>Age [n (%)]</i>				
12 years and younger	22 (10.3)	192 (89.7)	156 (72.9)	58 (27.1) ^a
13 years	11 (6.2)	167 (93.8)	140 (78.7)	38 (21.3)
14 years and older	6 (4.2)	137 (95.8)	122 (85.3)	21 (14.7) ^a
<i>Family affluence [n (%)]</i>				
Low	6 (6.7)	84 (93.3)	70 (77.8)	20 (22.2)
Medium	14 (5.9)	224 (94.1)	186 (78.2)	52 (21.8)
High	19 (9.2)	188 (90.8)	162 (78.3)	45 (21.7)
<i>Length of time in Canada [n (%)]</i>				
More than 5 years	3 (5.3)	54 (94.7)	43 (75.4)	14 (24.6)
5 years or less	36 (7.5)	442 (92.5)	375 (78.5)	103 (21.5)
<i>Number of times moved last year [n (%)]</i>				
Did not move	28 (6.6)	397 (93.4)	336 (79.1)	89 (20.9)
Moved at least once	11 (10.0)	99 (90.0)	82 (74.5)	28 (25.5)
Social Network Characteristics				
<i>Incoming close friend nominations [n (%)]</i>				
Received ≥ 1 nomination	39 (7.2)	503 (92.8)	425 (78.4)	117 (21.6)
Received no nominations	0 (0.0)	12 (100.0)	11 (91.7)	1 (8.3)
Proportion active close friends [mean (SD)]	0.43 (0.4) ¹	0.25 (0.4) ¹	0.24 (0.3) ²	0.34 (0.4) ²
Proportion sedentary close friends [mean (SD)]	0.75 (0.3)	0.74 (0.3)	0.76 (0.3)	0.70 (0.3)
Betweenness Centrality [mean (SD)]	2.68 (3.0)	3.16 (4.0)	3.26 (4.0)	2.66 (3.5)
Popularity(incoming nominations) [mean (SD)]	6.36 (3.1)	6.53 (3.5)	6.67 (3.6) ³	5.97 (2.7) ³
<i>Clique Member [n (%)]</i>				
Not a member	9 (6.1)	138 (93.9)	115 (78.2)	32 (21.8)
Member	30 (7.7)	358 (92.3)	303 (78.1)	85 (21.9)
Perceived support from friends [mean (SD)] ^a	3.54 (0.6)	3.53 (0.5)	3.53 (0.5)	3.53 (0.5)
Total girls [n (%)]	39 (7.3)	496 (92.7)	418 (78.1)	117 (21.9)

Cells with same superscript *letter* signifies significant ($p < 0.05$) chi-square and Bonferroni-adjusted pair-wise comparison (z-test), cells with same superscript *number* signifies significant ($p < 0.05$) difference in means (Mann-Whitney U-test), ^a= average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous intensity physical activity, SD= standard deviation.

Bonferonni adjusted z-test comparisons showed that the proportion of active boys was significantly ($p < 0.05$) higher among those with high family affluence compared with low family affluence. As well, for both boys and girls, the proportion of sedentary adolescents was significantly higher among those 14 years and older compared with those 12 years and younger. Furthermore, the mean proportion of sufficiently active friends was significantly different between sufficiently active boys and insufficiently active boys. For girls, only the mean proportion of active friends was significantly different between those sufficiently and insufficiently active. For both boys and girls, the mean proportion of active friends was also significantly different for those who were highly sedentary compared with low sedentary. The mean number of incoming nominations (i.e., popularity) was significantly different between high sedentary and low sedentary girls.

The majority of boys and girls were both insufficiently active and highly sedentary (boys=68.6%, girls=73.1%) followed by insufficiently active and low sedentary (boys=15.4%, girls=19.6%), sufficiently active and highly sedentary (boys=11.4%, girls=5.1%), and sufficiently active and low sedentary (boys=4.6%, girls=2.2%) (*Tables 3.3, 3.4*). For boys, there was an association between physical activity levels and sedentary behaviour, such that a lower proportion of sufficiently active boys participated in high sedentary behaviour compared with insufficiently active adolescents. Network densities for close friendships across the schools and grades ranged from 7.0% to 14.0%. The mean number of incoming closest friend nominations for boys was 6.99 (SD= 3.79) and 6.52 (SD=3.45) for girls. Nine boys (1.1%) and twelve girls (2.2%) received no friendship nominations. *Appendix J* provides a graphical example of the physical activity levels of adolescents in school D, grade 7. *Appendix K* provides a graphical example of the sedentary behaviour of adolescents in school D, grade 7.

Table 3.3 Proportion of sufficiently active, insufficiently active, high sedentary, and low sedentary boys.

Boys n= 526			
	Sufficiently Active* (≥60-min of MVPA every day)	Insufficiently Active (≥60-min of MVPA on <7 days/week)	Total
Low Sedentary (≤2 hrs/day of sedentary behaviour)	24 (28.6%)	81 (18.3%)	105 (20.0%)
High Sedentary (>2 hrs/day of sedentary behaviour)	60 (71.4%)	361 (81.7%)	421 (80.0%)
Total	84 (16.0%)	442 (84.0%)	

* = significant (p<0.05) association between physical activity and sedentary behaviour for boys.

Table 3.4 Proportion of sufficiently active, insufficiently active, high sedentary, and low sedentary girls.

Girls n= 535			
	Sufficiently Active (≥60-min of MVPA every day)	Insufficiently Active (≥60-min of MVPA on <7 days/week)	Total
Low Sedentary (≤2 hrs/day of sedentary behaviour)	12 (30.8%)	105 (21.2%)	117 (21.9%)
High Sedentary (>2 hrs/day of sedentary behaviour)	27 (69.2%)	391 (78.8%)	418 (78.1%)
Total	39 (7.3%)	496 (92.7%)	

No significant association between physical activity and sedentary behaviour for girls.

For boys, spearman rank correlations between social network variables ranged from -0.09 to 0.42 (Table 3.5). The continuous physical activity level score (days per week of achieving sixty-minutes of MVPA) was significantly (p<0.05) associated with sedentary behaviour (hours per day spent watching television or videos, using a computer, playing video games or using a handheld devices) (rho=-0.24). General perceived social support from friends was significantly (p<0.05) correlated with network density (rho=0.10) and popularity (rho=0.29).

Table 3.5. Spearman correlation matrix for physical activity, sedentary behaviour, social network variables, and general perceived social support from friends for boys ($n=526$).

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Physical activity level(a) ^a							
Sedentary behaviour(b) ^b	-0.24*						
Network Density(c)	-0.01	0.81*					
Proportion active close friends(d)	0.18*	-0.08*	-0.02				
Proportion sedentary close friends(e)	-0.10*	0.16*	0.40*	-0.09*			
Betweenness Centrality(f)	0.11*	-0.04	0.08	-0.02	-0.07		
Popularity(g)	0.15*	-0.01	0.37*	0.09*	0.03	0.42*	
Perceived support from friends(h)	0.01	0.02	0.10*	0.08	-0.01	0.07	0.28*

*= $p < 0.05$, a = days per week participant achieved sixty-minutes of moderate-to-vigorous physical activity, b= hours per day of sedentary behaviour.

For girls, spearman rank correlations between social network variables ranged from -0.08 to 0.38 (Table 3.6). Similar to boys, the physical activity level score was significantly ($p < 0.05$) associated with sedentary behaviour ($\rho = -0.15$). General perceived social support from friends was correlated with betweenness centrality ($\rho = 0.14$), and popularity ($\rho = 0.16$).

Table 3.6. Spearman correlation matrix for physical activity, sedentary behaviour, social network variables, and general perceived social support from friends for girls ($n=535$).

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Physical activity level(a) ^a							
Sedentary behaviour(b) ^b	-0.15*						
Network Density(c)	0.01	0.11*					
Proportion active close friends(d)	0.12*	-0.10*	-0.01				
Proportion sedentary close friends(e)	-0.04	0.17*	0.18*	-0.06			
Betweenness Centrality(f)	0.09*	0.06	0.01	0.00	-0.06		
Popularity(g)	0.05	0.12*	0.33*	0.20*	0.08	0.38*	
Perceived support from friends(h)	0.09*	-0.03	0.06	0.06	-0.08	0.14*	0.16*

*= $p < 0.05$, a = days per week participant achieved sixty-minutes of moderate-to-vigorous physical activity, b= hours per day of sedentary behaviour.

3.4.2 Physical activity and sedentary behaviour among those who received no incoming friendship nominations

There were twenty-one adolescents (9 boys, 12 girls) who did not receive any friendship nominations. Of these adolescents, there were seven (33.3%) who were twelve years and younger, eight (38.1%) who were thirteen years old, and six (28.6%) who were fourteen years

and older. Similarly, seven adolescents (33.3%) had low family affluence, eight (38.1%) had middle family affluence, and six (28.6%) had high family affluence.

Adolescents who received no incoming nominations participated in significantly fewer days per week of at least sixty-minutes of MVPA compared with those who received at least one friendship nomination (mean=3.28 days/wk, SD=1.76 days/wk vs. 4.33 days/wk, SD=1.81 days/wk, respectively). No difference in hours per day of sedentary behaviour was found between adolescents who received no friendship nominations, and those who received at least one nomination.

3.4.3 Associations between social network-derived variables and physical activity and sedentary behaviour for boys

In the unadjusted analysis, among boys, the likelihood of being active was significantly ($p < 0.05$) higher for those with high family affluence compared with low family affluence (OR 2.20; 95% CI 1.08-4.49) (*Table 3.7*). Boys in school E were significantly less likely to be sufficiently active compared with boys in school A (OR 0.38; 95% CI 0.16-0.90). Furthermore, proportion of active close friends was significantly associated with being sufficiently active (OR 1.09; 95% CI 1.02-1.16). In the adjusted analysis, an increase in ten percentage points of active close friends was significantly associated with an increased likelihood of being sufficiently active (OR 1.11; 95% CI 1.02-1.21). Boys from school E were significantly less likely to be active compared with school A (OR 0.26; 95% CI 0.08-0.84). Boys with a higher amount of general perceived social support from friends were significantly less likely to be active (OR 0.63; 95% CI 0.42-0.96). There were no significant interactions between social network variables and general perceived social support from friends (*Appendix L*). It is important to note that in this model, only 84 boys (16%) were sufficiently active. For completeness and comparability, we included all covariates; however, this model may not have had enough power to detect statistically significant associations with only a small proportion of boys who were sufficiently active.

In the unadjusted analysis, boys who were 14 years and older were significantly ($p < 0.05$) more likely to be highly sedentary compared with boys who were 12 years and younger (OR 3.05;

95%CI 1.67-5.55) (*Table 3.7*). Two social network variables were significantly associated with being sedentary; boys in networks with higher density had a higher likelihood (OR 2.44; 95%CI 1.56-3.84) of being highly sedentary compared with boys in networks with lower density, and those with higher proportion of active close friends (OR 0.93; 95%CI 0.87-0.99) were less likely to be highly sedentary. In the adjusted analysis, the likelihood of being highly sedentary remained significantly higher for boys 14 years and older compared with those 12 years and younger (OR 2.23; 95%CI 1.04-4.77). Noteworthy, proportion of active close friends did not remain significantly associated with a decreased likelihood of being highly sedentary, and therefore it is possible that other covariates accounted for this association. Boys in higher density networks were significantly more likely to be highly sedentary compared with boys in a low density network (OR 2.93; 95%CI 1.32-6.49). Boys in schools C (OR 2.92; 95%CI 1.04-8.21) and F (OR 4.24; 95%CI 1.30-13.77) were significantly more likely to be sedentary compared with boys in school A.

The second model (*Appendix M*) with interactions terms showed little difference in the main effects variables. There was a significant interaction between both proportion of active close friends (OR 1.12; 95%CI 1.00-1.26) and proportion of sedentary close friends (OR 1.16; 95%CI 1.01-1.32) and general perceived social support from friends and an increased likelihood of being highly sedentary. For a one unit change in the proportion of active close friends, given the interaction terms, the odds of being highly sedentary ranged from 0.74 when general perceived social support equals 1.0 (i.e., minimum value) to 1.04 when general perceived social support equals 4.0 (i.e., maximum value). For a one unit change in general perceived social support from friends, given the interaction term, the odds of being highly sedentary ranged from 0.77 when an individual had no active close friends (i.e., proportion of active close friends = 0), to 1.02 when an individual had all active close friends (i.e., proportion of active close friends=10).

For a one unit change in the proportion of sedentary close friends, given the interaction terms, the odds of being highly sedentary ranged from 0.66 when general perceived social support equals 1.0 (i.e., minimum value) to 1.02 when general perceived social support equals 4.0 (i.e., maximum value). For a one unit change in general perceived social support from friends, given

the interaction term, the odds of being highly sedentary ranged from 0.77 when an individual had no sedentary close friends (i.e., proportion of sedentary close friends = 0), to 1.10 when an individual had all sedentary close friends (i.e., proportion of sedentary close friends=10).

Table 3.7. Odds ratios (OR) and 95% confidence intervals (95%CI) for the association between sociodemographic characteristics, social network variables, general perceived social support from friends, physical activity, and sedentary behaviour for boys (n=526).

	Sufficiently active (≥60-min of MVPA every day)		High sedentary (>2hrs/day of sedentary behaviour)	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic Characteristics				
<i>School</i>				
A [#]	1.00	1.00	1.00	1.00
B	0.48 (0.22-1.03)	0.43 (1.77-1.06)	1.26 (0.57-2.69)	2.34 (0.95-5.74)
C	0.51 (0.22-1.15)	0.42 (0.15-1.15)	1.26 (0.54-2.91)	2.92 (1.04-8.21)*
D	1.09 (0.48-2.47)	0.67 (0.22-2.06)	0.59 (0.25-1.35)	1.54 (0.50-4.77)
E	0.38 (0.16-0.90)*	0.26 (0.08-0.84)*	0.65 (0.30-1.41)	1.95 (0.66-5.76)
F	0.49 (0.21-1.16)	0.51 (0.16-1.61)	1.54 (0.63-3.77)	4.24 (1.30-13.77)*
<i>Age</i>				
12 yrs and younger [#]	1.00	1.00	1.00	1.00
13 yrs	1.13 (0.67-1.91)	1.40 (0.71-2.75)	1.57 (0.96-2.58)	1.09 (0.58-2.08)
14 yrs and older	0.58 (0.31-1.09)	0.83 (0.35-1.95)	3.05 (1.67-5.55)*	2.23 (1.04-4.77)*
<i>Family Affluence</i>				
Low [#]	1.00	1.00	1.00	1.00
Middle	1.38 (0.67-2.86)	1.29 (0.60-2.77)	1.03 (0.59-1.82)	1.21 (0.66-2.23)
High	2.20 (1.08-4.49)*	2.00 (0.94-4.27)	1.43 (0.79-2.59)	1.55 (0.81-2.94)
<i>Length of time in Canada</i>				
More than 5 years [#]	1.00	1.00	1.00	1.00
5 years or less	0.48 (0.20-1.15)	0.48 (0.19-1.25)	1.31 (0.66-2.60)	1.23 (0.58-2.63)
<i>Number of times moved last year</i>				
Did not move [#]	1.00	1.00	1.00	1.00
Moved at least once	0.56 (0.28-1.19)	0.75 (0.35-1.61)	1.43 (0.79-2.60)	1.10 (0.58-2.10)
Social Network Characteristics				
<i>Density</i>				
Low (density <12%) [#]	1.00	1.00	1.00	1.00
High (density ≥12%)	0.86 (0.54-1.37)	0.56 (0.23-1.33)	2.44 (1.56-3.84)*	2.93 (1.32-6.49)*
Proportion of active close friends	1.09 (1.02-1.16)*	1.11 (1.02-1.21)*	0.93 (0.87-0.99)*	0.96 (0.89-1.03)
Proportion of sedentary close friends	0.95 (0.88-1.03)	1.02 (0.92-1.12)	1.04 (0.97-1.12)	0.91 (0.83-1.01)
Betweenness Centrality	1.03 (0.98-1.08)	1.02 (0.96-1.08)	0.99 (0.94-1.04)	1.00 (0.95-1.07)
Popularity	1.01 (0.97-1.05)	1.02 (0.97-1.07)	1.00 (0.96-1.03)	0.98 (0.93-1.03)
<i>Clique member</i>				
Member [#]	1.00	1.00	1.00	1.00
Not a member	1.32 (0.82-2.13)	1.21 (0.68-2.16)	1.23 (0.78-1.94)	1.32 (0.76-2.27)
General Perceived Social Support from Friends^a				
	0.71 (0.49-1.03)	0.63 (0.42-0.96)*	1.21 (0.85-1.71)	1.35 (0.92-1.98)

*= p<0.05, [#] = referent category, ^a =average general perceived social support index: 1= received support none of the time to 4=received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.

3.4.4 Associations between social network-derived variables and physical activity and sedentary behaviour for girls

In the unadjusted analysis, among girls, those 14 years and older were significantly ($p < 0.05$) less likely to be active compared with those 12 years and younger (OR 0.38; 95% CI 0.15-0.97) (Table 3.8). Proportion of active close friends was significantly associated with an increased likelihood of being sufficiently active (OR 1.13; 95% CI 1.04-1.23). After adjusting for all covariates, an increase in ten percentual points of active close friends was associated with an increased likelihood of being sufficiently (OR 1.14; 95% CI 1.02-1.27). It is important to note that in this model, only 39 girls (7.3%) were sufficiently active. This model may not have had enough power to detect statistically significant associations with only a small proportion of girls who were sufficiently active.

The second model (Appendix N) with interactions terms showed little difference in the main effects variables. There was an interaction between the proportion of sedentary close friends and general perceived support from friends, and a significantly increased likelihood of being sufficiently active (OR 1.31; 95% CI 1.04-1.67). For a one unit change in the proportion of sedentary close friends, given the interaction terms, the odds of being sufficiently active ranged from 0.53 when general perceived social support equals 1.0 (i.e., minimum value) to 1.20 when general perceived social support equals 4.0 (i.e., maximum value). For a one unit change in general perceived social support from friends, given the interaction term, the odds of being sufficiently active ranged from 0.62 when an individual had no sedentary close friends (i.e., proportion of sedentary close friends = 0), to 1.22 when an individual had all sedentary close friends (i.e., proportion of sedentary close friends=10).

Unadjusted results showed a significantly ($p < 0.05$) increase likelihood of being sedentary for girls 14 years and older compared with girls 12 years and younger (OR 2.16; 95% CI 1.24-3.75) (Table 3.8). Girls in school F were significantly more likely to be sedentary compared with girls from school A (OR 3.59; 95% CI 1.40-9.15). Moreover, girls with higher proportion of active close friends (OR 0.93; 95% CI 0.88-0.98) were significantly more likely to be sufficiently active, and increased popularity (OR 1.05; 95% CI 1.01-1.09) was associated with an increased

likelihood of being highly sedentary. After adjusting for covariates, girls in schools C (OR 2.89; 95% CI 1.22-6.83), E (OR 2.71; 95% CI 1.03-7.13), and F (OR 6.18; 95% CI 1.94-19.64) were significantly more likely to be sedentary compared with girls in school A. Noteworthy, popularity did not remain significantly associated with an increased likelihood of being highly sedentary.

The second model (*Appendix O*) with interactions terms showed little difference in the main effects variables. The only significant change in the main effects variable was clique membership, where girls who were not a clique member were significantly more likely to be highly sedentary compared with those who were clique members (OR 39.86; 95%CI 1.53-1034.20). There was a significant interaction between general perceived social support from friends and clique membership and a decreased likelihood of being highly sedentary (OR 0.38; 95% CI 0.15-0.96). For girls who are not clique members, for a one unit change in general perceived social support from friends, the odds of being highly sedentary is 1.17. For girls who are clique members, for a one unit change in general perceived social support from friends, the odds of being highly sedentary is 0.92. Girls who are clique members, given the interaction terms, are 15.20 times more likely to be highly sedentary when general perceived social support equals 1.0 (i.e., minimum value) and 0.84 times more likely to be highly sedentary when general perceived social support equals 4.0 (i.e., maximum value) compared with girls who are clique members.

Table 3.8. Odds ratios (OR) and 95% confidence intervals (95%CI) for the association between sociodemographic characteristics, social network variables, general perceived social support from friends, physical activity, and sedentary behaviour for girls (n=535).

	Sufficiently active (≥60-min of MVPA every day)		High sedentary (>2hrs/day of sedentary behaviour)	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic Characteristics				
<i>School</i>				
A [#]	1.00	1.00	1.00	1.00
B	0.23 (0.05-1.20)	0.17 (0.03-1.04)	1.08 (0.54-2.16)	1.73 (0.78-3.88)
C	1.26 (0.44-3.58)	0.86 (0.24-3.15)	1.66 (0.81-3.42)	2.89 (1.22-6.83)*
D	1.30 (0.44-3.85)	0.83 (0.16-4.24)	0.66 (0.33-1.31)	1.21 (0.46-3.18)
E	0.59 (0.17-2.02)	0.38 (0.07-2.01)	1.59 (0.77-3.31)	2.71 (1.03-7.13)*
F	0.93 (0.29-3.03)	0.96 (0.19-4.73)	3.59 (1.40-9.15)*	6.18 (1.94-19.64)*
<i>Age</i>				
12 yrs and younger [#]	1.00	1.00	1.00	1.00
13 yrs	0.58 (0.27-1.22)	0.68 (0.27-1.74)	1.37 (0.86-2.19)	1.19 (0.66-2.17)
14 yrs and older	0.38 (0.15-0.97)*	0.50 (0.14-1.80)	2.16 (1.24-3.75)*	1.61 (0.78-3.35)
<i>Family Affluence</i>				
Low [#]	1.00	1.00	1.00	1.00
Middle	0.88 (0.33-2.35)	0.88 (0.31-2.49)	1.02 (0.57-1.83)	1.11 (0.60-2.07)
High	1.42 (0.55-3.67)	1.46 (0.53-4.03)	1.03 (0.57-1.87)	1.15 (0.61-2.18)
<i>Length of time in Canada</i>				
More than 5 years [#]	1.00	1.00	1.00	1.00
5 years or less	0.68 (0.20-2.29)	0.54 (0.15-2.01)	0.84 (0.44-1.60)	0.76 (0.37-1.55)
<i>Number of times moved last year</i>				
Did not move [#]	1.00	1.00	1.00	1.00
Moved at least once	1.58 (0.76-3.27)	1.55 (0.70-3.42)	0.78 (0.48-1.26)	0.82 (0.48-1.40)
Social Network Characteristics				
<i>Density</i>				
Low (density <12%) [#]	1.00	1.00	1.00	1.00
High (density ≥12%)	0.82 (0.43-1.58)	1.05 (0.30-3.65)	1.44 (0.95-2.17)	1.43 (0.70-2.94)
Proportion of active close friends	1.13 (1.04-1.23)*	1.14 (1.02-1.27)*	0.93 (0.88-0.98)*	0.94 (0.88-1.01)
Proportion of sedentary close friends	1.01 (0.90-1.15)	1.02 (0.88-1.19)	1.07 (0.99-1.15)	0.96 (0.88-1.05)
Betweenness Centrality	0.96 (0.87-1.06)	0.96 (0.87-1.07)	1.05 (0.99-1.11)	1.04 (0.97-1.11)
Popularity	1.00 (0.95-1.07)	0.99 (0.91-1.07)	1.05 (1.01-1.09)*	1.03 (0.99-1.10)
<i>Clique member</i>				
Member [#]	1.00	1.00	1.00	1.00
Not a member	0.78 (0.36-1.68)	0.84 (0.34-2.04)	1.01 (0.64-1.60)	1.38 (0.80-2.41)
General Perceived Social Support from Friends^a				
	1.06 (0.57-1.97)	1.06 (0.55-2.04)	1.02 (0.70-1.50)	0.98 (0.65-1.48)

*= p<0.05, [#] = referent category, ^a = average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.

3.5 DISCUSSION

The overall low prevalence of adolescents achieving sixty-minutes of MVPA every day and high prevalence of adolescents participating in more than two-hours per day of sedentary behaviour was consistent with other Canadian estimates (Colley et al., 2013; Leatherdale & Ahmed, 2011). Our results suggest that for both boys and girls, a higher proportion of active close friends was associated with an increased likelihood of being sufficiently active. A unique finding of this study was that friendship network density was the only social network variable, of the variables tested in this thesis, associated with sedentary behaviour for boys; boys in higher density friendship networks were more likely to be highly sedentary compared with boys in lower density friendship networks. Moreover, boys with a higher proportion of active close friends and higher general perceived social support were more likely to be sedentary, and those with a higher proportion of sedentary close friends and higher perceived social support were also more likely to be sedentary. This study also contributed new findings relating to segregated adolescents; adolescents who received no friendship nominations spent significantly less days per week participating in sixty-minutes of MVPA compared with adolescents who received at least one friendship nomination. As with other adolescent health behaviours (e.g., smoking, drug use), these findings support the use of social network analysis as both a framework and methodological tool by which adolescent physical activity and sedentary behaviour can be examined.

3.5.1 Aspects of friendship networks and physical activity and sedentary behaviour

Friends' behaviour

The association between close friends' physical activity and an individual's physical activity was consistent with findings from two recent reviews (Macdonald-Wallis et al., 2012; Sawka et al., 2013); however, studies that separated their analysis by gender found an association for friends' physical activity and boy's, but not girl's, physical activity (Denault & Poulin, 2009; Jago et al., 2011; Raudsepp & Viira, 2000). Results from this analysis partially supported our hypothesis as *both* boys and girls with a higher proportion of active close friends were significantly more likely to be sufficiently active. This reflects recent findings from Sirard et al. (2013) who found that

friend's physical activity (i.e., hours per week of MVPA) was significantly associated with both boy's and girl's physical activity.

Friendship network density

Using a complete social network analysis, this study was able to contribute knowledge relating to network density and network positioning and physical activity and sedentary behaviour. Boys who were in a more connected friendship network (i.e., high density) were more likely to be sedentary compared with those in a less connected network (i.e., low density). As the majority of boys in this sample were sedentary (80.0%), a higher density network may have allowed for more exposure to normative attitudes, ideals, and behaviours among adolescents within the network, which could result in an increased likelihood of an individual being sedentary. Haynie (2001) found similar results for adolescent delinquency; the interaction between high density and delinquent peer networks resulted in higher delinquency involvement.

Adolescents who received no friendship nominations

While only a small number of adolescents did not receive any friendship nominations (n=21), this study found that adolescents who did not receive a friendship nomination participated in less weekly MVPA compared with those with at least one incoming friendship nominations. Adolescents who are not considered as a friend by other individuals may be less likely to receive positive support or encouragement and have limited opportunities to co-participate in physical activities with friends. In the smoking literature, isolate adolescents were significantly more likely to smoke compared with clique members and liaisons (i.e., individual who bridges communications between two or more groups) (Seo & Huang, 2012), and therefore may be at an increased risk of participating in unhealthy behaviours (e.g., smoking), as well as not participating in health enhancing behaviours (e.g., sufficient levels of physical activity).

General perceived social support from friends

Results from this study provide new insights into the associations between general perceived social support from friends and adolescent physical activity and sedentary behaviour. These results did not support our hypothesis; boys who had higher general perceived social support

from friends were less likely to be active. Therefore, it is possible that only higher perceived social support *for physical activity* would result in higher levels of physical activity, and general perceived social support provides support for other aspects of adolescents' health (e.g., mental health, academics).

Additionally, interaction effects were present; boys with higher general perceived social support from close friends and a higher proportion of *active* were more likely to be sedentary and boys with higher amounts of general perceived social support from friends and a higher proportion of *sedentary* close friends were more likely to be sedentary. These results were unexpected; we anticipated that higher general perceived support and a higher proportion of active close friends would result in an increased likelihood of boys being sufficiently active. The use of general perceived social support from friends as a potential modifying factor between social network variables and physical activity and sedentary behaviour has not previously been reported in the literature, thus our discussion of the reasons that underlie these findings is speculative. Potential explanations could involve: (1) current forms of social interaction for adolescents (e.g., Facebook, online gaming) may provide individuals with a virtual form of social support versus a physical form (e.g., sports teams, face-to-face games); or, (2) perceived social support may act as a protective factor for boys against low self-esteem, thus possibly diminishing their drive to participate in physical activity for physical health benefits. Physical health benefits has been cited as a reason for adolescent boys' participation in MVPA (Allison et al., 2005).

For girls, those with a higher number of sedentary close friends and higher perceived general social support from friends were more likely to be active. Moreover, girls who were members of a clique and also had higher perceived social support from friends were less likely to be highly sedentary. This may be a result of different functions of different social networks for girls such that they may seek social support from sedentary friends. For example, certain characteristics of sedentary friends may provide a more useful kind of support which translates to higher levels of activity. Girls may also have other friends with whom they are active, such as sports teams, or other mechanisms (e.g., co-participation with friends, family support) which prompt them to be active. This may differ from boys where social behaviours and relationships may be less defined

or centered on more similar activities (e.g., sports or online games). In addition, our analysis did not examine the gender distribution of individual's friendship networks. Girls may therefore receive social support from their girl friends, who also happen to be highly sedentary but also have friends who are boys, with whom they participate in physical activities with. It is important to note that the general perceived social support measure did not examine specific support for physical activity nor sedentary behaviour, but rather a broad measure of support. There may also be extenuating factors, such as family factors, which have been shown to influence adolescent physical activity (Sallis et al., 2000) and sedentary behaviour (Babey et al., 2013) that were not accounted for in this analysis.

3.5.2 Limitations

The low prevalence of sufficiently active boys (16%) and girls (7.3%) may have limited the statistical power necessary to detect some meaningful associations from the regression models.

While this study was able to identify significant associations between measures of friendship networks and physical activity, we were unable to draw any causal conclusions. Previous longitudinal analyses have shown that friends' physical activity tends to become similar over time (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013), indicating a process of friendship influence or socialization. However, several of these studies (De la Haye et al., 2011; Shoham et al., 2012; Simpkins et al., 2013) also found that adolescents tend to select their friends based on similarities in physical activity attributes. Overall, there appears to be both a socialization and selection effect that may explain similarities in physical activity behaviours among friends.

This study was also limited by the subjective measures of physical activity and sedentary behaviour and within grade 'closest friend' networks, as opposed to whole school, or out-of-school networks. As this survey was administered in the early Canadian winter months, the low levels of physical activity and high level of sedentary behaviour may be a result of weather conditions, and therefore future investigations in different seasons would further add to the evidence on friendship influence on different types of physical activity and sedentary behaviour

(e.g., winter activities versus summer activities). The physical activity questions asked in the Health Behaviour and Wellness survey corresponded to physical activity performed outside of the school setting only, while the Social Network survey captured only close friends within the grade level. Thus, we assumed that these close friendships would extend to activities outside of the school setting. Also, physical activity within the school setting (e.g., physical education class) was not included as part of total physical activity.

While our analysis included ‘school attended’ as a potential proxy for school situatedness, it is possible that other neighbourhood level variables (e.g., physical activity opportunities, access to out-of-school programs) may have a significant impact on the associations between aspects of friendship networks and physical activity and sedentary behaviour. Finally, the general perceived social support from friends measure did not specifically assess perceived social support for physical activity or sedentary behaviour, and therefore its applicability may be limited. Perceived support for specific behaviour has, however, been previously examined (Beets et al., 2006; Duncan et al., 2005; Prochaska et al., 2002) and has shown to be positively associated with adolescent physical activity.

3.5.3 Conclusion

Despite these limitations, this study contributed valuable knowledge to the Canadian literature on aspects of friendship networks and adolescent physical activity and sedentary behaviour.

Moreover, this study supported the use of Social Network Theory as a theoretical construct to assist in explaining similarities in physical activity and sedentary behaviours among adolescent friendship networks. Noteworthy, social network-derived variables associated with physical activity differ from those associated with sedentary behaviour; relationships between individual’s and their attributes (i.e., proportion of active close friends) appears to be associated with physical activity, while network structure (i.e., network density) appears to be associated with sedentary behaviour.

Results from this study could inform future public health interventions which utilize friendship influence to increase physical activity in the adolescent population. This can be achieved through

friendship network restructuring that focuses on exposing inactive individuals to active individuals, which can promote co-participation and active friend modeling. Increasing the proportion of active individuals within a friendship network, particularly those with a higher number of friends, may result in a snowball effect and increase the likelihood of other individuals becoming sufficiently active. Furthermore, our findings indicated that *both* boys and girls would benefit from these programs, as opposed to only boys. Finally, there is evidence to suggest that higher network density is associated with an increased likelihood of being sedentary among boys. Focusing on reversing group norms that discourage sedentary behaviour in higher density networks may encourage reductions in time spent participating in sedentary behaviours among adolescents within that network. Harnessing the benefits of positive friendship influence through network restructuring, which promotes modeling and co-participation, could help adolescents achieve the recommended Canadian physical activity guidelines and further accrue the health benefits of regular physical activity participation.

CHAPTER FOUR

4.0 THESIS CONCLUSION

4.1 DISCUSSION

The aim of this thesis was to examine the associations between aspects of friendship networks and physical activity and sedentary behaviour among youth through a synthesis and assessment of current evidence and through an analysis of social network and behavioural survey data, with the goal of informing future public health strategies aimed at increasing physical activity and decreasing sedentary behaviour among youth. This thesis first performed a systematized literature review to examine current evidence with respect to associations between aspects of friendship networks and physical activity and sedentary behaviour with a particular focus on gender differences (Chapter Two). The results of this literature review then informed the social network variables used in the analysis of survey data (Chapter Three), which focused on expanding the breadth of social network-derived variables to provide an additional level of understanding on the associations between aspects of friendship networks and physical activity and sedentary behaviour.

This thesis incorporated the use of Social Network Theory and Social Cognitive Theory as two frameworks to understand the processes by which friendship network positioning and relations, along with a friend's physical activity and sedentary behaviour, could be associated with an individual's level of physical activity and sedentary behaviour. The relevance of these frameworks was supported; collective evidence from the systematized review and survey data analysis suggested a relationship between several aspects of friendship networks and physical activity and sedentary behaviour among youth. These results showed that friendship network positioning and relations (i.e., Social Network Theory), as well as friendship support (i.e., a perceived facilitator from Social Cognitive Theory) are important factors in adolescent physical activity and sedentary behaviour.

4.1.1 Aspects of friendship networks and physical activity

Friends' physical activity

Consistent evidence from the studies reviewed in Chapter Two, along with results from Chapter Three, found significant associations between best friend or close friends' physical activity and an individual's physical activity. Newer evidence not included in the systematized review (Shoham et al., 2012; Simpkins et al., 2013; Sirard et al., 2013) also supported this finding. This association has also been identified in terms of other youth behaviours, including smoking (Ennett & Bauman, 1993; Seo & Huang, 2012; Valente et al., 2005), and delinquency (Haynie, 2001). Combined, this evidence lends itself to explaining similarities in physical activity behaviours among friendship groups, as well as supports the explanation of social processes that transfer behaviours from one friend to another.

Network Positioning

In addition to friends' behaviours, an individual's position within a network, specifically the number of incoming friendship nominations (i.e., popularity), was also associated with an individual's physical activity level. Evidence from three studies (De la Haye et al., 2010; Simpkins et al., 2013; Strauss & Pollack, 2003) found associations between higher levels of popularity, and higher levels of individual physical activity. Contrary, two studies (Gesell et al., 2012; Livesey et al., 2011) did not find associations. This may have been a result of sample size, where the smaller number of participants available to nominate others as friends limited the ability of investigators to find a significant association between popularity and an individual's physical activity. While the analysis in Chapter Three also did not find significant associations between popularity and physical activity, there was evidence to suggest that adolescents who received no friendship nominations participated in less weekly moderate-to-vigorous intensity physical activity (MVPA) compared with those with at least one friendship nomination, despite having only a small proportion of adolescents with no friendship nominations. These findings have two important implications. First, segregated adolescents may be at an increased risk of participating in fewer health promoting behaviours (e.g., physical activity) and more unhealthy behaviours. The latter has been shown in other adolescent literature, including higher suicide attempts (Hall-Lande et al., 2007) and smoking incidence (Seo & Huang, 2012) among isolates.

Second, popular students may play a key role in interventions focused on increasing levels of physical activity as they are more likely to participate in higher levels of physical activity and have a higher number of connections within a friendship network and therefore may be effective communicators.

Nature of friendships

The nature of relations among friends also had an impact on the associations between friend's physical activity and an individual's physical activity; more intimate friendships (i.e., reciprocated nominations, first nominated friend) had a greater impact on shared similarities in physical activity levels among friends compared with less intimate friendships. Higher nominated friends, as well as reciprocated friendships, likely indicate stronger bonds between individuals (Valente, 2010). This association has been supported in other health risk behaviours, including smoking, where the influence from reciprocated friendships was stronger on adolescent smoking compared with non-reciprocated friendships (Fujimoto & Valente, 2012).

General perceived social support from friends

Higher levels of perceived social support for physical activity from both family and friends have been associated with higher levels of physical activity among individuals (Gesell et al., 2008; Robbins et al., 2008; Springer et al., 2006). While the social support measure used in Chapter Three examined general perceived social support from friends as opposed to support for specific behaviours, it provided preliminary evidence to suggest that social norms may influence an individual's physical activity level (i.e., high general perceived social support from friends combined with overall low prevalence of physical activity among friends is associated with decreased likelihood of being sufficiently active for boys). Moreover, for girls, general perceived social support from friends modified the relationship between proportion of sedentary friends and an increased likelihood of being sufficiently active. While it was predicted that general perceived social support from friends would modify the relationship between the proportion of *active* friends and an increased likelihood of being active, these results may reflect differences in functions of friends for girls. Girls may seek to participate in physical activities with their active friends, as seen in the association between proportion of active close friends and increased

likelihood of being sufficiently active, while also seeking emotional support from other friends, who may be more sedentary, but offer the support needed to participate in sufficient levels of physical activity.

Overall, there is evidence to suggest an association between friends' behaviours (i.e., best and close friends' physical activity level), friendship network positioning (i.e., popularity and receiving no friendship nominations), friendship relations (i.e., friendship reciprocity, level of nomination) and an individual's physical activity level. This indicates that social processes could account for patterns in youth physical activity.

4.1.2 Aspects of friendship networks and sedentary behaviour

Friends' sedentary behaviour

There have been a total of six studies, including three identified in Chapter Two (Ali et al., 2011; De la Haye et al., 2010; Strauss & Pollack, 2003), the analysis in Chapter Three, and two recently published articles (Shoham et al., 2012; Sirard et al., 2013) that have examined the association between friend's sedentary behaviour and an individual's sedentary behaviour. While some evidence showed associations between a friend's sedentary behaviour and an individual's sedentary behaviour (Sirard et al., 2013), other investigations, including the analysis in Chapter Three, either found no associations (Ali et al., 2011), or associations within only a sub-sample of data (De la Haye et al., 2010; Shoham et al., 2012). These mixed results encourage future investigation to determine whether or not there is an association between friends' sedentary behaviour and an individual's sedentary behaviour. Evidence on the association between popularity and sedentary behaviour (De la Haye et al., 2010; Strauss & Pollack, 2003) was also inconclusive.

Characteristics of sedentary behaviour may partially explain this mixed evidence. Sedentary behaviour measures in this thesis included asking adolescents to respond to hours spent watching television or movies. While these activities may involve group participation, they can ultimately be done independently. Therefore, co-participation and support from friends is not necessarily needed, and an association between friends' sedentary behaviour and an individual's sedentary

behaviour may not be apparent. On the other hand, popular sedentary behaviours, such as using Facebook or texting, may not require face-to-face participation with friends, but are useful only if other individuals also participate in the behaviour (Valente, 2010). Thus, there is potential for friends' sedentary behaviour to be associated with an individual's sedentary behaviour.

Network structure

Chapter Three found associations between high density friendship networks and an increased likelihood of being sedentary for boys. Dense networks provide more pathways by which information can be circulated as well as more opportunities for resources to be spread (Valente, 2010). For instance, resources such as video games and movies may be more likely shared among individuals in these networks. In addition, the nature of the friendship network including the physical activity and sedentary behaviours of individuals within a network can also impact the behaviours of each individual, as these attitudes and behaviours can be more easily reinforced in higher density friendship networks. These results have important intervention implications. High density networks often have limited connections to external information and resources (Valente, 2010). The introduction of new ties that promotes less sedentary behaviour is therefore essential in ensuring that changes to individual behaviours are made.

General perceived social support from friends

Chapter Three also found that general perceived social support from friends modified the relationship between several social network variables (i.e., proportion of active friends, proportion of sedentary friends, clique membership) and the likelihood of being highly sedentary. These results may stem from contextual influences, such as a greater opportunity to provide and receive social support during sedentary behaviours (e.g., watching television), or through sedentary communications such as using Facebook, texting, or emailing. The significant associations between general perceived social support from friends and both physical activity and sedentary behaviour may have been a result of differences in friendship grouping (i.e., 'close friend' network and general perceived support from 'friends'), or a result of extraneous factors (e.g., family influence) that were not controlled for in the analysis. Nevertheless, these results support future investigation into general perceived social support as a potential modifier in the

relationship between aspects of friendship networks and both physical activity and sedentary behaviour.

4.1.3 Gender differences in the associations between aspects of friendship networks and physical activity and sedentary behaviour

Boys tend to participate in more weekly MVPA compared with girls (Colley et al., 2011). Despite these trends, the association between friend's physical activity and individual physical activity appeared to be significant for *both* boys and girls. While the majority of the studies from Chapter Two found significant associations between friend's physical activity for boys, but not girls, results from Chapter Three, along with newer evidence (Simpkins et al., 2013; Sirard et al., 2013) have shown that friend's physical activity is associated with girls' physical activity. Based on previous evidence on gender differences in other health behaviours (Hong et al., 2013; Liao et al., 2013; Mercken et al., 2010; Mrug & McCay, 2013), and the value of physical activity (Jago et al., 2009) these results were not anticipated. Nevertheless, there appears to be processes by which friends influence both boys' and girls' physical activity. These exact processes, however, may differ. For example, boys tend to participate in more physical activity compared with girls, and therefore co-participation may be a greater factor in the association between friends' behaviours and an individual's behaviours for boys, compared with girls (Colley et al., 2011). Gender differences in the social processes that account for similarities in friends' behaviours have yet to be examined within the context of physical activity.

In terms of other friendship network measures, there were differences in the associations with friendship network density between boys and girls; boys in higher density network were more likely to be sedentary compared with boys in low density networks, whereas this result was not significant for girls (Chapter Three). Moreover, girls who were members of a clique and also had higher levels of general perceived social support from friends were less likely to be highly sedentary. Thus, there appears to be differences in specific aspects of friendship networks and sedentary behaviour between boys and girls.

While not examined in this thesis, it is important to note that the gender distribution of friends may have a significant impact on the associations between aspects of friendship networks and an individual's physical activity and sedentary behaviour. A recent study by Sirard et al. (2013) found that a boy's physical activity was associated with girl friends' physical activity, while a girl's physical activity was associated with both boy and girl friends' physical activity. Therefore, the gender of friends may be an important factor in the associations between aspects of friendship networks and physical activity and sedentary behaviour.

There is evidence to suggest gender differences in the association between aspects of friendship networks and sedentary behaviour; however, the underlying mechanisms by which friends influence boys' behaviour and friends influence girls' behaviour is still unclear. Future research examining gender differences is critical as interventions may need to be uniquely tailored to girls and boys.

4.1.4 Peer influence and peer selection mechanisms

Social Network Theory and Social Cognitive Theory provide theoretical frameworks by which behaviour can be predicted and explained by the social environment. Evidence from this thesis has supported the use of these two theories as a means of explaining individual physical activity and sedentary behaviour. Friends' physical activity behaviour was consistently associated with an individual's physical activity behaviour. Moreover, the results of the longitudinal studies found that an individual's behaviours changed over time to emulate friends' behaviours, often working in a positive direction towards increased physical activity (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013). These results indicate a process of peer influence, or socialization, whereby the behaviours of individuals in a friendship network tend to assimilate over time. Key constructs of Social Cognitive Theory can help to explain these processes, through such factors as outcome expectations, perceived facilitators and perceived barriers. Specifically, several key peer influence mechanisms have been identified, including peer pressure, co-participation, modeling, social support, and descriptive and injunctive social norms (Prinstein & Dodge, 2008), and can each be applied to the results of this thesis.

Both *co-participation* and behavioural *modeling* have been commonly cited as mechanisms by which friends' physical activity can be associated with an individual's physical activity for both boys and girls (Jago et al., 2011; Macdonald-Wallis et al., 2012; Raudsepp & Viira, 2000). Co-participation in physical activities with friends provides a positive support mechanism by which friends' engagement motivates individual engagement. Jago et al. (2009) found that co-participation was a mechanism by which a sample of middle school students initiated physical activity, noting that individual's were encouraged to participate because "lots of my friends wanted to do it [activity]...". In addition, friends who model physical activity behaviours can also increase the likelihood of individual's participating in physical activity through several possible mechanisms. This can include positive outcome expectations such as observing the benefits of physical activity (e.g., improved fitness and weight status (Jimenez-Pavon et al., 2010; Meyer et al., 2006)). Modeling can also increase an individual's self-efficacy, where an individual observes a friend participating in an activity which can, in turn, increase an individual's perceived ability to perform that behaviour, and subsequently support future participation. Results from the longitudinal analyses supported the applicability of co-participation and modeling as a mechanism by which an individual's level of physical activity changes over time to become more similar to friends' physical activity.

Both 'descriptive' *social norms* (i.e., an individual's perception of the approval of a behaviour and the perception of the amount the behaviour is performed by others) and 'injunctive' social norms (i.e., perception of others' feelings towards a behaviour) have been shown to have a strong influence on adolescents' health behaviour, including food habits (Eisenburg et al., 2005), exercise (Rivis & Sheeran, 2003), and smoking and alcohol use (McMillan et al., 2005). These social norms may encourage either direct or indirect pressure from other group members to perform the normative behaviours. The influence of social norms on an individual's sedentary behaviour may be supported by this thesis. It is plausible that the associations between friendship network density and an increased likelihood of participating in sedentary behaviour are a reflection of descriptive and injunctive social norms, which promote sedentary behaviour as an accepted behaviour. Of note, clique membership was not associated with an increased likelihood

of being sufficiently active. Therefore, it is possible that social norms and peer pressure may play a lesser role in terms of associations between friends' physical activity compared with other mechanisms such as co-participation and modeling.

The physical activity level similarities among friendship networks may be a result of *peer selection*, rather than peer influence, whereby an individual chooses to be friends with another individual based on sociodemographic or behavioural similarities. Individuals often choose friends with similar attributes or behaviours (e.g., gender, age, ethnicity, smoking status) because people tend to feel more comfortable being around individuals that are similar to themselves, rather than people who are different (Valente, 2010). In terms of physical activity and sedentary behaviour, youth may choose to be friends with individual who participate in the same activities, such as sports teams or online gaming groups, because they are able to spend more time with these individuals during their discretionary time, and also able to discuss these common interests outside the activity context, thereby stimulating and reinforcing their friendship in other social settings (e.g., sitting together during lunch break).

Only two studies reviewed in this thesis examined both processes of peer influence and peer selection in their longitudinal analyses (De la Haye et al., 2011; Gesell et al., 2012), and each found conflicting results. Two recent studies (Shoham et al., 2012; Simpkins et al., 2013) used data from the same longitudinal study (i.e., National Longitudinal Study of Adolescent Health), and both found support for peer influence and peer selection processes. Overall, there is consistent evidence to suggest that peer influence, or socialization, accounts for similarities in friends' physical activity behaviour over time (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013), as well as some evidence showing peer selection as another important process (De la Haye et al., 2011; Shoham et al., 2012; Simpkins et al., 2013). There have been no studies that have compared these two processes, therefore we are unable to determine whether one process is more dominant than the other.

4.2 LIMITATIONS OF THESIS

There are potential biases that may limit the internal and external validity of this thesis, and their implications require acknowledgment.

4.2.1 Social Network Theory and Social Cognitive Theory as theoretical frameworks

This thesis applied Social Network Theory and Social Cognitive Theory as theoretical frameworks to explain the relationship between aspects of friendship networks and physical activity and sedentary behaviour among youth; however, there are several limitations to these theories. While Social Network Theory examines structural and relational aspects of health, it does not account for psychological aspects of behaviour adoption and change, such as individual motivation. In addition, Social Network Theory assumes that networks are closed, or at least bounded, and may then incorrectly classify an individual's network position (e.g., isolates in one network may have multiple connections in another network (Tichy et al., 1979)). Social Cognitive Theory focuses on behaviour change as a process of social learning, and therefore disregards emotional or biological factors that may influence individual behaviour. Furthermore, this theory consists of three interactive factors (i.e., environmental, cognitive, behavioural), but the extent to which one of these factors influences behaviour more than the other is unclear.

Other theories have been posited to explain the relationship between friend's physical activity and an individual's physical activity, including Theory of Planned Behavior (De la Haye et al., 2011), Self-Perception Theory (De la Haye et al., 2011), Social Learning Theory (Raudsepp & Viira, 2000), Expectancy-Value Model (Yli-Piipari et al., 2011) and Social Ecological Model (Langille & Rodgers, 2010). While the Social Cognitive Theory incorporates aspects of Social Learning Theory (i.e., social factors influence individual behaviour), Social Learning Theory may be particularly useful in explaining physical activity patterns. This theory posits that behaviours are learned through both direct experience and observational learning (i.e., modeling) (Bandura, 1977). This model can be applied to the results of this study as the physical activity of friends (i.e., models) was associated with an individual's physical activity. Furthermore, Theory of Planned Behavior (Ajzen, 1991) may better predict sedentary behaviour among boys. The Theory of Planned Behavior incorporates subjective norms and normative beliefs as important

constructs in intention to perform a behaviour. Valente (2010) noted that networks with many links (i.e., high density networks) are likely to have members who share common beliefs and values as they provide more pathways by which communication about ideas and behaviours can flow. Thus, Theory of Planned Behaviour may accurately describe the associations between high density networks and an increased likelihood of being highly sedentary among boys, as social norms may encourage highly sedentary behaviour, and higher density networks provide an effective means of exposing these norms among individuals within a network.

4.2.2 Reporting bias

Reporting bias occurs when participants either intentionally or unintentionally under report or over report exposures or outcomes (Oleckno, 2008). Seven of the thirteen studies reviewed in Chapter Two (De la Haye et al., 2010; Denault & Poulin, 2009; Livesey et al., 2011; Raudsepp & Viira, 2000; Strauss & Pollack, 2003; Yli-Piipari et al., 2011), as well as survey analysis in Chapter Three, utilized self-reported measures of physical activity. All of the studies that examined sedentary behaviour also utilized a self-report measure (Ali et al., 2011; De la Haye et al., 2010; Strauss & Pollack, 2003). Self-report measures possess several limitations in terms of validity and reliability, including ability to perform detailed recall, understanding of physical activity concepts, and issues with social desirability, the latter of which may lead to an over estimation of physical activity levels (Shephard, 2003; Trost et al., 2000). As a result of these limitations, misclassification can occur such that sufficiently active adolescents are classified as insufficiently active, and insufficiently active adolescents are classified as sufficiently active. Similar misclassification could occur for sedentary behaviour. This can result in an overall attenuation of the associations between aspects of friendship networks and both physical activity and sedentary behaviour. Direct measures of physical activity, such as accelerometers and doubly-labeled water, are able to assist in the removal of potential issues of recall and response bias (Sirard & Pate, 2001). In particular, accelerometers measure acceleration of movement and provide an objective and nonreactive tool for assessing physical activity and sedentary behaviour, and are able to provide data on amount and intensity of activity among youth (Sirard & Pate, 2001).

While self-report measures contain several limitations, Prochaska et al. (2001) assessed the test retest reliability and concurrent validity of the physical activity questions used in Chapter Three, and found the measure was reliable (intraclass correlation= 0.79) and correlated with accelerometer-assessed physical activity ($r=.40$, $p<0.001$). Acceptable test-retest reliability for the sedentary behaviour measures has also been reported (Utter et al., 2003). Moreover, the prevalence of sufficiently active adolescents in Chapter Three was consistent with other Canadian estimates (Colley et al., 2011; Leatherdale & Ahmed, 2011).

The definition of ‘friends’ or ‘close friends’ is also subjective. Individuals may consider friends to be only those who they socialize with on a regular basis, while others may consider anyone they interact with at school as a friend. While an adolescent’s perception of the definition of close friends is subjective, the mean number of incoming close friendship nominations in Chapter Three for both boys (6.99, SD= 3.79) and girls (6.52, SD=3.45) was similar to findings from another study. De la Haye et al. (2010) found, when provided with fifteen lines and asked to nominate his or her ‘close friends’ with the year (i.e., grade) level, boys’ mean incoming nominations in school 1/grade 8 was 5.2 (SD=2.9), school 2/grade 8 was 5.7 (SD=3.4) and school 2/grade 9 was 6.2 (SD=3.3), and girls mean incoming nominations in school 1/grade 8 was 5.1 (SD=2.8), school 2/grade 8 was 5.0 (SD=2.2) and school 2/grade 9 was 5.4 (SD=2.7). Furthermore, the mean number of incoming nominations for boys and girls was similar to the number of outgoing nominations for boys (7.05, SD=6.45) and girls (6.28, SD= 4.62) indicating the individuals chose, and were chosen by, approximately the same number of close friends.

Future studies examining friendships and physical activity and sedentary behaviour could use Global Positioning System (GPS) devices as a means of tracking adolescents’ interactions with friends. This would allow investigators to identify the individuals who often participate in physical activities or sedentary behaviours together. This could be used as a method of developing friendship network data that is directly related to physical activity and sedentary behaviour participation.

4.2.3 Confounding

Confounding is defined as a distortion of the true magnitude of effect between an exposure (i.e., aspects of friendship networks) and an outcome (i.e., physical activity or sedentary behaviour) (Oleckno, 2008). A confounder is an independent risk factor for the outcome of interest, must be associated with the exposure of interest, and must not lie on the causal pathway between the exposure and outcome (Oleckno, 2008). A potential confounding factor in the association between aspects of friendship networks and physical activity and sedentary behaviour is the built environment. For example, two adolescents may be friends because they live in the same neighbourhood. This neighbourhood may also have access to numerous recreational parks and fitness facilities. While it appears that the friends' physical activity is associated with an individual's physical activity, the association may actually be a result of their neighbourhood environment.

Only two studies (Ali et al., 2011; Strauss & Pollack, 2003) controlled for the built environment in their analysis, which included adjustments for school-wide clustering. The built environment is an important determinant of youth physical activity and sedentary behaviour (Dunton et al., 2003; Norman et al., 2005; Sallis et al., 2000). Lack of control for the built environment may therefore result in an overestimation (i.e., positive confounder) of the association between aspects of friendship networks and physical activity and sedentary behaviour. Therefore, associations between aspects of friendship networks and physical activity and sedentary behaviour identified in this thesis may not remain significant if neighbourhood built environment was controlled for. Despite these limitations, the analyses that adjusted for school-wide clustering also found significant associations between friends' physical activity and an individual's physical activity indicating that these associations may be present on top of unobserved characteristics common to each school (e.g., proximity to recreational parks).

4.2.4 Definition of friendship networks

Only within-school friendship networks were examined. While it is possible that the school-based measures captured an individual's entire friendship network, there are likely other important friend relationships outside of the school setting, such as friends on sports teams or

online gaming friends. Therefore, the results for individuals who received no friendship nominations from others within his or her grade level may not be accurate as these individuals may have a large support network outside of his or her grade (e.g., neighbourhood friends).

Identifying entire friendship networks delivers logistical challenges. Snowball sampling may address some of these issues through attempts to contact each of the initial respondent's friends, and then subsequent contact of their friends to develop a comprehensive friendship network (Valente, 2010). Furthermore, while it may not be necessary to identify an individual's entire friendship network, it is important to at least consider outside of school networks to increase the generalizability of the results.

4.2.5 Causal associations

Causal associations are those where a change in the frequency of the exposure produces a change in the frequency of the outcome (Oleckno, 2008). The majority of the results presented in this thesis are from cross-sectional examinations of aspects of friendship networks and physical activity and sedentary behaviour. In cross-sectional studies, it is impossible to establish a time sequence between exposure and outcome because they are measured at the same time (Oleckno, 2008). Thus, we are unable to determine whether friend's physical activity or sedentary behaviour influences an individual's physical activity or sedentary behaviour (i.e., peer influence), or whether an individual's physical activity or sedentary behaviour influences the friends he or she has (i.e., peer selection). Noteworthy, the associations identified in the longitudinal analyses (De la Haye et al., 2011; Denault & Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013) of this thesis reflect the results found in the cross-sectional studies. Future longitudinal studies and randomized control trials can attempt to establish causation. For example, to assess peer selection processes, a school-based intervention could measure existing within-school friendships, provide an intervention that increases levels of within-school physical activity, then measure the change in these friendships. To assess friendship influence processes, an intervention could restructure adolescent friendship networks and measure changes in physical activity levels among the participants.

4.2.6 External validity

External validity, or generalizability, represents the degree to which the results of one study are relevant to other populations (Oleckno, 2008). In Chapter Two, the associations between friends' physical activity and an individual's physical activity was identified for a wide age range of youth (i.e., six years to eighteen years), as well as for youth from a variety of countries (e.g., Australia, Canada, United Kingdom). These results may therefore be generalizable to other youth populations.

Chapter Three included data from six Calgary Catholic schools. The Calgary Catholic school board, similar to the Calgary Public school board, follows the curriculum requirements set out by Alberta's Department of Education, in addition to a religious education component (Calgary Schools and Education, 2014). The associations identified in the analysis in Chapter Three may therefore be applicable to adolescents in public schools. Furthermore, this study aimed to include *all* adolescents in grades seven through nine from these six schools, and the response rate was very good (80.5%). Noteworthy, there was only a small percentage of adolescents in the low family affluence (boys=19.6%, girls=16.8%). Overall, the results presented in this thesis may be generalized to other youth populations; however, as only within-school friendship networks were examined, we are unable to determine whether the associations identified would apply to other friendship networks, such as neighbourhood friends or sports teams. Furthermore, these results may not be generalizable to private schools or schools with specialized sports programming as students in these schools may have different affluence levels or may place particular focus on achieving high levels of physical activity.

4.3 IMPLICATIONS

Current estimates of low levels of physical activity and high amounts of sedentary behaviour among youth are concerning. This thesis was able to identify associations between several aspects of friendship networks and physical activity and sedentary behaviour. The evidence presented here could inform future public health interventions aimed at improving the physical activity and sedentary behaviours of Canadian youth.

Social network interventions in other health risk behaviours, including collegiate drinking and adolescent pro- and anti-social behavioural indicators (e.g., truancy, grade point average, drug use, and external mood states) have been implemented with poor results (Cho et al., 2005; Perry et al., 1998; Peterson Jr. et al., 2000). For example, attempts to alter injunctive social norms have changed collegiate students' perceptions of the amount their peers drink alcohol without actually changing the student's own behaviour (Clapp et al., 2003). Other interventions that focused solely on 'at-risk' youth have also suffered (Cho et al., 2005). Grouping 'at-risk' individuals together likely resulted in an exacerbation of negative behaviours through the promotion of unhealthy social norms, thus resulting in little or no change towards positive behaviours. Drawing from the results of these studies, effective intervention aimed at behaviour change, specifically increasing physical activity and decreasing sedentary behaviour, can be accomplished.

Using constructs from Social Network Theory, social network interventions can be defined by two primary tasks: 1) attempts to change the functional components of the network, such as changing an individual's function or position in the network, or 2) attempts to change the structure of the network through strengthening or relaxing friendship connections such that network restructuring can occur (Valente, 2010). With regard to the first task, it is important to recognize the behaviours of individuals within each friendship network. For inactive individuals within an inactive friendship network, the existing friendship network reinforces undesirable behaviours or identities (Gottlieb, 2000). This type of network condition welcomes the introduction of new ties, which can promote co-participation in physical activity with an active individual, as well as offer opportunities for positive role modeling. Providing opportunities for inactive individuals to interact with active individuals can increase exposure to physically active settings, and also support new friendship development. With respect to the second task, focus should then be placed on strengthening friendship ties with active adolescents (Macdonald-Wallis et al., 2011; Schofield et al., 2007). It is also important to acknowledge that key features of Social Cognitive Theory (i.e., self-efficacy, positive outcome expectations, and perceived facilitators), as well as friendship influence mechanisms (e.g., modeling, co-participation, and social norms), are critical in producing effective interventions (Hurd et al., 1981).

4.3.1 Recommendations for interventions

4.3.1.1 Increasing physical activity

This thesis identified several key aspects of friendship networks that are associated with physical activity, including a friend's level of physical activity, positioning within a social network (i.e., receiving no friendship nominations), number of friends (i.e., popularity), and nature of friendships (i.e., reciprocity, degrees of separation). While only a small number of adolescents in the Chapter Three survey data analysis were sufficiently active, these results support a trend for associations between friends' physical activity and an individual's physical activity that have been reported in two literature reviews (Macdonald-Wallis et al., 2012; Sawka et al., 2013). As the majority of both boys and girls are not meeting the recommended Canadian physical activity guidelines (Colley et al., 2011), interventions focused on improving the rates of physical activity, regardless of gender, would provide multiple health benefits to the youth population.

Two social processes, peer selection and peer influence, were identified to assist in explaining similarities in physical activity levels among friendship networks. Potential opportunities for intervention could reflect each of these processes; however, interventions focused on utilizing peer influence mechanisms may provide a better means of increasing physical activity levels among youth. For example, Denault and Poulin (2009) showed that best friends' participation was positively linked to an individual's sports participation over time, possibly as a result of co-participation. This provides support for potential peer influence processes that result in increased physical activity levels over time.

Friendship selection can have both a positive and a negative impact on an individual's physical activity level. When active individuals select friends who are also active, this behaviour is reinforced and supported and continued regular participation in physical activity is encouraged. Alternatively, inactive individuals selecting friends who are also inactive can have detrimental effects, such as limited exposure to physical activity and a reinforcement of social norms that promote inactivity. To combat these effects, efforts to increase physical activity levels may need to be implemented to encourage future friendship formation based on similarities in high levels of physical activity. Consequently, increases in physical activity levels may be accomplished

through peer influence mechanisms. While friendship selection processes are important for continued support and reinforcement of regular physical activity, the goal of modifying the current low levels of physical activity among Canadian youth may be better accomplished through a focus on peer influence mechanisms (e.g., co-participation, modeling, social norms) and friendship network restructuring.

4.3.1.1a Peer influence and friendship network restructuring

When planning health promotion and intervention strategies that focus on utilizing the effect of friendship influence to increase an individual's physical activity level, there are two important factors to consider. First, there is a considerable amount of social interaction with friends at school. Moreover, only within-school friendship networks were examined in this thesis. Second, physical activity within the school setting is semi-structured (e.g., teacher instructed physical education classes). Many of the studies reviewed in this thesis, including the analysis in Chapter Three, also reported on sports participation or physical activity that occurred outside of the school setting (Ali et al., 2011; De la Haye et al., 2010, 2011; Denault & Poulin, 2009; Livesey et al., 2011; Strauss & Pollack, 2003). Therefore, it is important to effectively employ within-school strategies that promote friendship formation and positive friendship influence on physical activity, but also ensure that these strategies are transferrable to outside of school physical activity. This will increase the likelihood of children and adolescents meeting the recommended guidelines for physical activity (i.e., sixty-minutes of MVPA, every day). The following are potential opportunities for interventions aimed at increasing physical activity levels among youth. Recommendation numbers one through three use within-school strategies that focus on exposure to physical activity settings and promote friendship formation. Recommendation number four focuses on friendship influence that promotes outside of school physical activity.

Potential Opportunities for Intervention

- 1) Create school policies that promote interaction between inactive and active youth. Providing opportunities for inactive individuals to participate in activities with active individuals may provide positive reinforcement to engage in physical activity and also provides opportunity for friendship formation. Witnessing other individuals model a physical activity related skill

(e.g., shooting a puck, kicking a soccer ball) could result in an increase in an individual's level of self-efficacy to perform that skill.

While the purpose of this recommendation is to promote positive support for physical activity, there are potential drawbacks. For example, an inactive individual may feel inadequate when participating in physical activity with an active individual, as a certain level of ability or skill in sport is often needed. This could then reduce this individual's level of self-efficacy and prevent any future participation in physical activity. To help to overcome this obstacle, focus should be placed on teamwork, rather than competition, during physical activity. There are also organized sports, such as curling, that require strategy on top of technique and skill. Another potential drawback is segregation, such that attempts to integrate youth could result in active individuals only playing with other active individuals, and inactive only playing with inactive. This can be overcome by having teachers, rather than students, pair adolescents during physical education classes to encourage interaction between inactive and active individuals.

Friendship influence is a reciprocal and transactional process (Prinstein & Dodge, 2008). Thus pairing an inactive individual with an active individual may decrease the activity level of the sufficiently active individual. These unanticipated negative consequences, referred to as boomerang effects, have been observed in other health behaviours (Dishion et al., 1999). Nevertheless, the mechanisms used to promote behaviour change would be the same, regardless of whether the outcomes are positive or negative. Results from this thesis do offer optimistic results; longitudinal evidence (De la Haye et al., 2010; Denault & Poulin, 2009; Gesell et al., 2012; Shoham et al., 2012; Simpkins et al., 2013) showed that physical activity of the individual tended to increase to match the physical activity of the friend. Thus, social network interventions that expose inactive individuals with active individuals may result in an overall increase in the physical activity levels of the friendship network.

2) Promote friendship formation.

This recommendation is specifically directed towards adolescents with little or no friends. While only a small number of adolescents in the Chapter Three survey data analysis did not receive any

friendship nominations, results showed that adolescents who received no friendship nominations participated in less weekly MVPA compared with those who received at least one friendship nomination. These adolescents may therefore be at a higher risk of not achieving recommended levels of physical activity. Moreover, those with fewer friendship nominations also participate in more screen-based activities compared with popular individuals (Strauss & Pollack, 2003). These adolescents may not be part of a friendship network at school and therefore have no opportunities to co-participate in within-school physical activities with friends. It is important to integrate these individuals within the physical activity context as well as provide opportunities to promote friendship formation.

There are three inter-related factors that impact friendship formation: 1) structural opportunities for contact (e.g., proximity), 2) individual characteristics (e.g., attractiveness between individuals), and 3) interaction outcomes (e.g., mutual benefits derived from friendships) (Fine, 1980; Haas et al., 2010). Structural opportunities provide the most viable means of friendship development, both inside and outside of the school setting. Teachers and parents play a vital role in increasing friendship opportunities, which can include school group projects with a variety of classmates, or encouraging adolescents to join extra-curricular activities.

A potential drawback to this strategy is that individuals may develop friendships with inactive individuals. Thus, the overall goal of increasing physical activity levels may not be reached. However, results from Chapter Three showed that having at least one close friendship nomination was associated with higher levels of MVPA compared with receiving no friendship nominations.

3) Identify opinion leaders.

A common approach to applying social network data to health promotion interventions is the identification of opinion leaders, and having these leaders act as change agents (Valente, 2010). Popular adolescents have a high number of incoming nominations and are also more likely to be physically active (De la Haye et al., 2010; Simpkins et al., 2013; Strauss & Pollack, 2003). These

socially integrated adolescents can act as role models and convey health messages while reaching to a higher number of individual within a network (Valente, 2010).

4) Encourage friends to be active together.

Co-participation is effective mainly because friends are able to spend more time with friends (Jago et al., 2009). While exposing inactive adolescents to physical activity settings is important, ensuring physical activity is enjoyable may also critical for continued behaviour that can be transferred to outside of the school setting. Therefore, keeping friends together may allow for a more positive physical activity experience. Parents can play an important role in this strategy by supporting adolescents to sign-up for organized sports with his or her friends.

One of the benefits of social network analysis is the identification of inactive cliques. Expanding upon the previous recommendation, focusing on modifying physical activity behaviours of smaller groups can help reinforce the new behaviour and also potentially produce a snowball effect of increased individual physical activity levels (Valente, 2010).

A potential drawback to this strategy is that keeping insufficiently active friends together could promote the establishment of social norms among these individuals that recognize inactivity as an accepted behaviour. To overcome this obstacle, a combination of the above recommendations may be needed. Including strategies that increase exposure between inactive and active individuals from different friendship networks may promote regular physical activity among the inactive individual. For example, exposing Sue, an insufficiently active adolescent, to Amy, a sufficiently active adolescent who is from a separate friendship network than Sue, may result in an increase in Sue's physical activity. Sue may then participate in more physical activity with individuals from her friendship network, thereby potentially leading to an increase in the physical activity levels of multiple adolescents.

4.3.1.2 Decreasing sedentary behaviour

Only a modest amount of literature has examined friend's sedentary behaviour and an individual's sedentary behaviours. While some associations between friend's sedentary

behaviour and individual behaviour were identified (De la Haye et al., 2010; Shoham et al., 2012; Sirard et al., 2013; Strauss & Pollack, 2003), there has not been consistent evidence to suggest the use of social network interventions as an effective means of decreasing sedentary behaviour. Results from Chapter Three, however, suggest a relationship between friendship network density and sedentary behaviour. Providing opportunities for new friendships to develop outside of the school setting may be an effective means of lowering an individual's sedentary behaviour as there is potential for new normative attitudes and behaviours to form which promote lower levels of sedentary behaviour.

There is also promise that the interventions recommendations aimed at increasing physical activity may also assist in decreasing sedentary behaviour, possibly through the displacement of sedentary behaviours due to increased physical activity participation. Overall, focus should be placed on after-school activities that promote social engagements where youth can be active together, such as sports participation.

4.3.2 Recommendations for future research

Our understanding of the processes by which aspects of friendship networks influence individual physical activity and sedentary behaviour is still in the early stages. Future research that builds upon the current gaps in knowledge presented here will lead to more informed public health intervention strategies.

- Sedentary behaviour.
 - Inconclusive evidence on the associations between friend's sedentary behaviour and an individual's sedentary behaviour requires further investigation. Vancampfort et al. (2014, p. 33) stated that “although sedentary behaviour may arguably be conceptualised as no more than the other side of the physical activity coin, we see it as a class of behaviours that can coexist with and also compete with physical activity.” Future research that examines sedentary behaviour as a negative health behaviour independent of levels of physical activity will assist in identifying important determinants of this behaviour.

- Outside of school friendship networks.
 - Friendship networks outside of the school setting have yet to be investigated. Outside of school networks may be particularly important for examining associations with sedentary behaviour as these types of activities generally occur outside of the school setting (e.g., watching movies, online gaming). The use of snowball sampling may help to address this issue.

- Differences in social influence mechanisms between boys and girls.
 - While modeling, co-participation, social support, social norms (subjective and injunctive), and peer pressure have been proposed as mechanisms by which friend's physical activity influences an individual's physical activity, it is unknown whether some mechanisms are more influential in boys than in girls. This would have important implications as intervention may need to be tailored differently for boys and girls.

- Type and intensity of physical activities and sedentary behaviours undertaken.
 - The structure of certain activities (i.e., team sports vs. individual sports vs. active transport) is a critical factor when examining physical activity and sedentary behaviour as friends' behaviours in certain types of activities may be more influential than in others.

- Gender distribution of friendship networks.
 - There is preliminary evidence (Sirard et al., 2013) to suggest a difference in the associations between the physical activity and sedentary behaviour of friends who are boys and friends who are girls on an individual's physical activity and sedentary behaviour; however, this requires further investigation.

- Longitudinal analyses examining friendship influences and friendship selection processes.
 - Additional longitudinal studies are needed to determine whether friendship influence, or friendship selection, has more of an impact on friendship network similarities as this may have important intervention implications (e.g., whether creating friendship with active friends, or adjusting existing physical activity levels among friends, would more effectively increase an individual's physical activity levels).

- Perceptions of friends' behaviours
 - Using qualitative techniques to accompany quantitative analyses would provide additional insight into descriptive and injunctive friendship group norms surrounding youth physical activity and sedentary behaviour.

- Use of Social Network Theory framework.
 - Within the physical activity and sedentary behaviour literature, there have been few studies that have utilized Social Network Theory as a framework to describe relationships between aspects of friendship networks and physical activity and sedentary behaviour, and instead utilized theories focused on social norms (i.e., Theory of Planned Behaviour) or behavioural modeling (i.e., Social Learning Theory). Applying Social Network Theory as a means of examining structural and relational aspects of adolescent physical activity and sedentary behaviour would broaden our understanding of social influence processes and provide a basis by which network interventions can be built.

4.4 CONCLUSION

Although the negative health outcomes of low levels of physical activity and high amounts of sedentary behaviour have been extensively researched, only a small proportion of Canadian youth are meeting the recommended guidelines for physical activity and sedentary behaviour. This thesis was able to provide a comprehensive examination of aspects of friendship networks

as one of many factors associated with youth physical activity and sedentary behaviour. The results are encouraging; best friend and close friend's physical activity is associated with individual physical activity for both boys and girls, and certain aspects of friendship networks (i.e., popularity, nature of friendships, general perceived social support from friends, friendship network density, receiving no friendship nominations) are associated with youth physical activity and sedentary behaviour. These results provide support for future research in this area, along with potential social network interventions that incorporate friendship network restructuring to promote co-participation and friend modeling. Regular physical activity and reduced time spent participating in sedentary behaviour is essential for people of all ages. By promoting active living in the youth population through targeted network restructuring, we can encourage important lifestyle behaviours that can continue throughout adulthood and improve the health and well-being of all Canadians.

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APPENDIX A: Example sociogram using a complete network (i.e., sociometric) technique

■ Ali
■ Sue

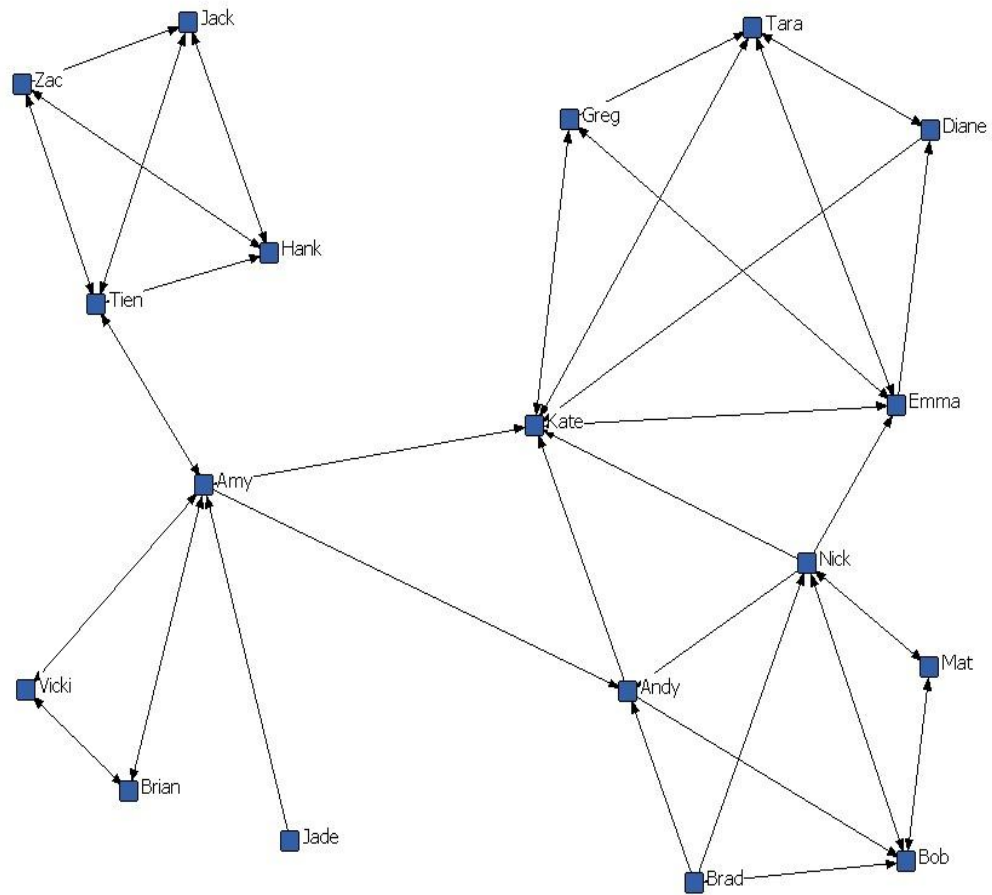


Figure 1.2. Example sociogram of a friendship network using a complete-network (i.e., sociometric) technique.

APPENDIX B: Example sociogram using an ego-network (i.e., egocentric) technique

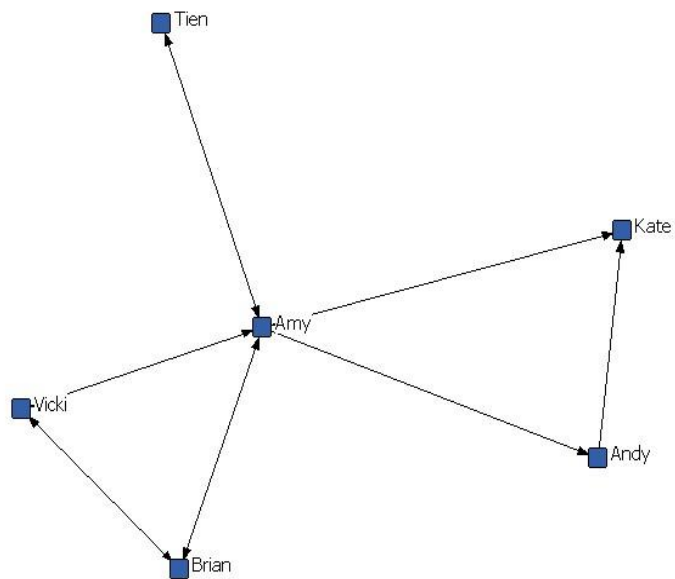


Figure 1.3. Example sociogram of Amy's friendship network using an ego-network (i.e., egocentric) technique. While we are able to identify the friendship nominations that Amy sent, we are unable to identify all the friends of Amy's friends and her position within the network as a whole. With the complete network technique (Appendix A), we can see that Amy has a high level of betweenness centrality as she connects several groups of friends.

APPENDIX C: Online database search terms

Table 2.3. Systematized review online database search terms (Chapter 2).

	<u>Population</u> Children & Adolescents	<u>Exposure</u> Friendship Network	<u>Outcome</u> Physical Activity Level/ Sedentary Behaviour
<i>Keywords/</i>	child*	social network*	physical* activ*
<i>Synonyms</i>	OR preteen*	OR peer*	OR exercise
	OR adolescen*	OR friend*	OR inactiv*
	OR teen*	OR social group*	OR sedentar*
	OR student*		OR transport*
	OR boy*		OR play
	OR girl*		OR sport
			OR leisure

APPENDIX D: Online database limitations and number of studies retrieved

Table 2.4. Systematized review online database limitations and number of studies retrieved (Chapter 2).

Database	Limitations	Studies Retrieved
MEDLINE July 23, 2012	- English - Human - Age groups Child (6-12 years) and Adolescent (13-18 years)	3445
PubMed July 23, 2012	- English - Humans - Child (0-18 years)	3025
SPORTDiscus July 23, 2012	-English	4103
CINAHL July 23, 2012	-Human -English -Children (6-12yrs) or adolescent (13-18yrs)	1730
SocIndex July 24, 2012	-Peer reviewed -English	2582
PsycInfo July 24, 2012	-Human -English - School age (6-12), Adolescence (13-17) and Young adult (18-29)	3065
ERIC July 15, 2012	- Peer reviewed - English	3404

APPENDIX E: Network data collection techniques for reviewed studies

Table 2.5. Network data collection technique for reviewed studies (Chapter 2). This is an addition to Table 2.1, page 29.

Author(s)	Network Data Collection Technique
Ali et al. (2011)	Ego Network
De la Haye et al. (2010)	Complete Network
De la Haye et al. (2011)	Complete Network
Denault & Poulin (2009)	Ego Network
Gesell et al. (2012)	Complete Network
Jago et al. (2011)	Ego Network
Livesey et al. (2011)	Complete Network
Macdonald-Wallis et al. (2011)	Ego Network
Ommundsen et al. (2010)	Complete Network
Raudsepp & Viira (2000)	Ego Network
Schofield et al. (2007)	Ego Network
Strauss & Pollack (2003)	Complete Network
Yli-Piipari et al. (2011)	Complete Network

APPENDIX F: Health Behaviour and Wellness Survey

Health Behaviour and Wellness Survey Questions (Chapter Three). Survey questions used in analysis are indicated with an arrow.

CORE Connections

Health, Behaviour, Wellness Survey (HBW) – Junior High Survey

Hi...

We are here today to ask you some questions that will help us learn more about what makes students like you healthy and happy.

Your answers are COMPLETELY CONFIDENTIAL.

This means that no one at the school will know your answers. So feel free to be completely honest. Please try to answer every question. There are no right or wrong answers.

Please raise your hand to get your survey code.

SURVEY CODE (*required response)

About You

Let's start with a little information about you.

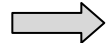


1. How old are you?
1. 11
 2. 12
 3. 13
 4. 14
 5. 15
 6. 16 years old



2. What grade are you in?
1. Grade 7
 2. Grade 8
 3. Grade 9

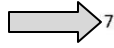
3. Were you born in Canada?
1. Yes
 2. No



4. How long have you lived in Canada?
1. Less than 2 years
 2. 2 – 5 years
 3. More than 5 years

5. What language do you usually speak at home?
1. English only → skip to question 7
 2. English and another language
 3. Another language only

6. What is the other language that you speak at home?

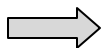


7. Last year, how many times did you move from one home to another?
1. I did not move
 2. 1 time
 3. 2 times
 4. 3 or more times
8. Who do you live with most of the time?
1. Both parents in the same house
 2. Both parents but at different times (such as mom during the week and dad on weekends)
 3. One parent
 4. One parent and a step-parent in the same house
 5. Other, Who? _____
9. In general, how happy do you feel about your life right now?
1. Quite happy
 2. Not very happy
 3. Not happy at all
10. How often do you feel confident in yourself?
1. Always
 2. Sometimes
 3. Hardly ever
 4. Never
11. How often do you feel helpless?
1. Always
 2. Often
 3. Sometimes
 4. Hardly ever
12. How often do you feel left out of things?
1. Always
 2. Often
 3. Sometimes
 4. Hardly ever
13. There is an important adult who is NOT my mom or dad...

	All the time	Most of the time	Not very often	Never
...who is around when I need help.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...who I can share happy and sad times with.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...who is a comfort to me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...who cares about my feelings.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

14. My Family

	All the time	Most of the time	Not very often	Never
My family really tries to help me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I get the emotional help and support I need from my family.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I can talk about my problems with my family.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My family is willing to help me make decisions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



15. My Friends

	All the time	Most of the time	Not very often	Never
My friends really try to help me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I can count on my friends when things go wrong.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I have friends I can share happy and sad times with.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I can talk about my problems with my friends.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16. How are you doing in school compared to other students in your class?

1. Better than average
2. Average
3. Below average

17. How much education do you want to have before you stop going to school?

1. Grade 10
2. Grade 11
3. Grade 12
4. College or University

18. Are you currently working at a paid job?

1. Yes
2. No → skip to question 20

19. On average, how many hours a week do you work?

1. Less than 5 hours a week
2. 5-14 hours a week
3. More than 14 hours a week

These next questions are being asked because you gave us saliva samples. Your answers will help us learn more about those samples.

20. What time did you go to sleep last night?

21. What time did you wake up this morning?

22. *When did you start this survey? (*response required)

1. First thing in the morning → skip to question 23
2. Halfway through the morning → skip to question 29
3. After lunch → skip to question 31

83. In the past month,

	Yes, most days	Yes, once a week	Yes, less than once a week	No, never
...has anyone teased you or called you bad names?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...has anyone spread rumours about you?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...have you been left out of things on purpose?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...have you been physically threatened or hurt by another student?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

84. In the past month, how often...

	Never	Sometimes	All of the time
...do you feel safe while in the school building?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...are you afraid that someone will hurt or bother you at school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...are you afraid that someone will hurt or bother you on the way to school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

You and Your Lifestyle

Physical activity means any activity where you get out of breath some of the time, like running, biking, skiing, sports and playing tag. (Don't include your gym class.)

- 85. In the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?
1. 0 days, I was not physically active at all in the last week
 2. 1 day
 3. 2 days
 4. 3 days
 5. 4 days
 6. 5 days
 7. 6 days
 8. 7 days, I was physically active every single day.

- 86. In a usual week, on how many days are you physically active for a total of at least 60 minutes per day?
1. 0 days
 2. 1 day
 3. 2 days
 4. 3 days
 5. 4 days
 6. 5 days
 7. 6 days
 8. 7 days

The next two questions are about watching television and computer use during your free time (don't include watching television or computer use at school).



87. In your free time on a typical weekday (Monday to Friday), how many hours do you spend doing the following: Watching TV, videos, DVDs, using a computer, playing video games or using a handheld device (PSP, Nintendo, phone) for playing games or watching shows or movies?
1. 0 hours per day
 2. 1
 3. 2
 4. 3
 5. 4
 6. 5
 7. More than 5 hours per day



88. In your free time on a typical weekend day (Saturday and Sunday), how many hours do you spend doing the following: Watching TV, videos, DVDs, using a computer, playing video games or using a handheld device (PSP, Nintendo, phone) for playing games or watching shows or movies?
1. 0 hours per day
 2. 1
 3. 2
 4. 3
 5. 4
 6. 5
 7. More than 5 hours per day

89. How do you think of your body?
1. Underweight
 2. About the right weight
 3. Overweight

90. Which of the following are you trying to do with regard to your weight?
1. I am not trying to do anything about my weight
 2. Trying to lose weight
 3. Trying to gain weight
 4. Trying to stay the same weight

Good job! You are almost done! Stretch your arms and finish the survey!

You, Your Family and Your Community

91. Please tell us about the neighbourhood where you live.

	All the time	Most of the time	Not very often	Never
People say hello and often stop to talk to each other in my neighbourhood.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
It is safe in my neighbourhood to play outside during the day.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
You can trust the people in my neighbourhood.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
There are good places to spend my free time in my neighbourhood (e.g. leisure centres, park, stores).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I could ask for help or a favour from neighbours.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- 92. Does your family own a car, van or truck?
1. No
 2. Yes, one
 3. Yes, two or more

- 93. Do you have your own bedroom?
1. No
 2. Yes

- 94. During the past 12 months, how many times did you travel away on holiday with your family?
1. Not at all
 2. Once
 3. Twice
 4. More than twice

- 95. How many computers or laptops does your family own?
1. None
 2. One
 3. Two
 4. More than two

96. Have you ever been in contact with a stranger on the internet who made you feel unsafe?
1. Yes
 2. No

97. Here is a list of things which some families do together. How often do you and your family usually do each of these things?

	Every day	Sometimes	Never
Watch TV or a movie together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play indoor games together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Eat a meal together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Go for a walk together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Go places together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Visit friends or relatives together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Play sports together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sit and talk about things together	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

APPENDIX G: Social Network Survey

Example Social Network Survey Question (Chapter Three).

1) Who are your closest friends? (check all that apply)

- | | | | |
|-------------------------------|--------------------------------|-------------------------------|--------------------------------|
| <input type="checkbox"/> Amy | <input type="checkbox"/> Brian | <input type="checkbox"/> Jack | <input type="checkbox"/> Sue |
| <input type="checkbox"/> Ali | <input type="checkbox"/> Diane | <input type="checkbox"/> Jade | <input type="checkbox"/> Tara |
| <input type="checkbox"/> Andy | <input type="checkbox"/> Emma | <input type="checkbox"/> Kate | <input type="checkbox"/> Tien |
| <input type="checkbox"/> Bob | <input type="checkbox"/> Greg | <input type="checkbox"/> Mat | <input type="checkbox"/> Vicki |
| <input type="checkbox"/> Brad | <input type="checkbox"/> Hank | <input type="checkbox"/> Nick | <input type="checkbox"/> Zac |

APPENDIX H: Bar graph of grade friendship network density for boys

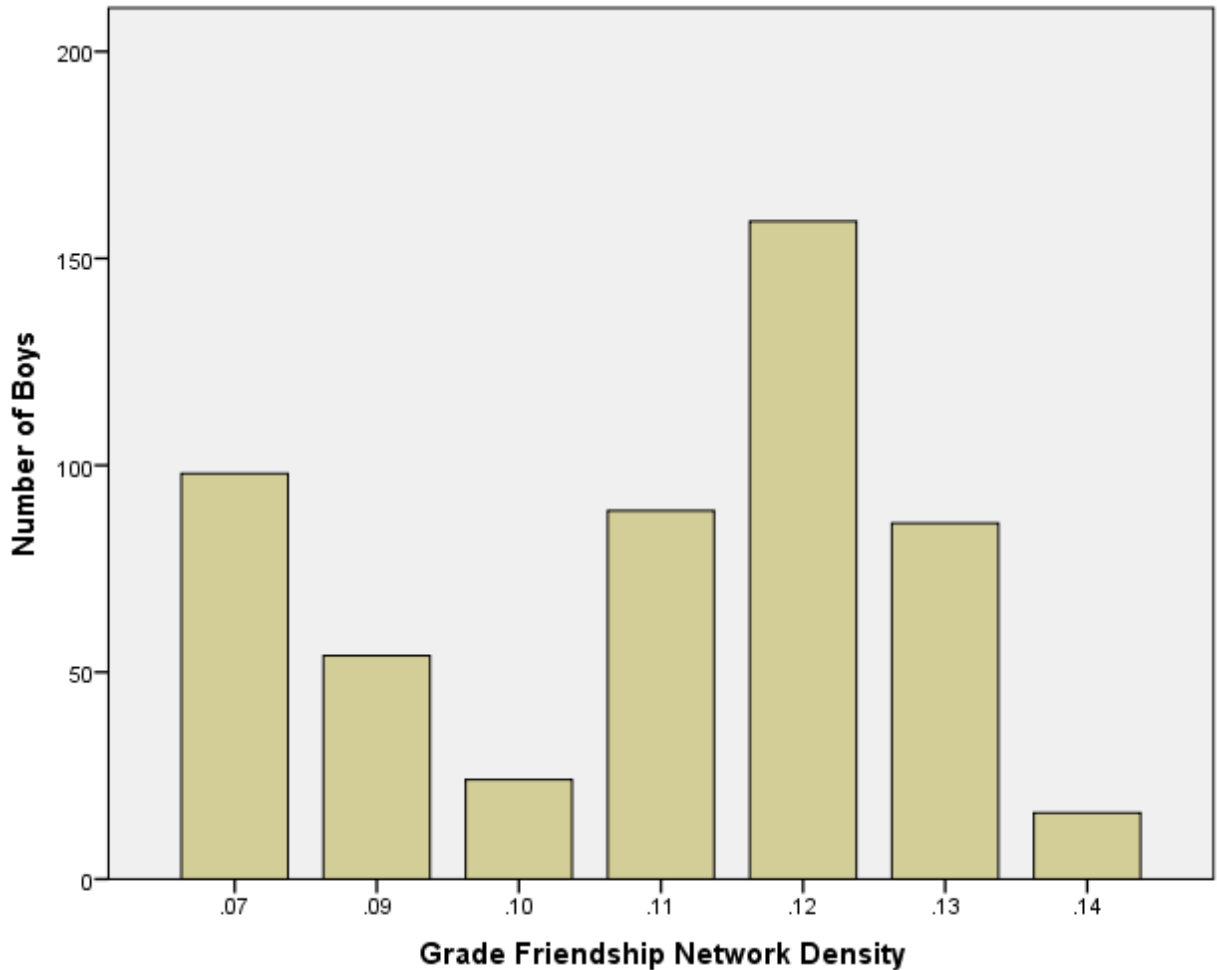


Figure 3.1. Bar graph of grade friendship network density for boys (n=526). Networks are by school and by grade.

This graph shows the number of boys that are within each grade friendship network density. Density is calculated by dividing the proportion of close friendship nominations received by the total possible number of nominations. There were a total of eighteen networks (three grades x six schools) and ranged in density from 7% (i.e., .07) to 14% (i.e., .14). The greatest number of boys (n=159) had a grade friendship network density of 12%.

APPENDIX I: Bar graph of grade friendship network density for girls

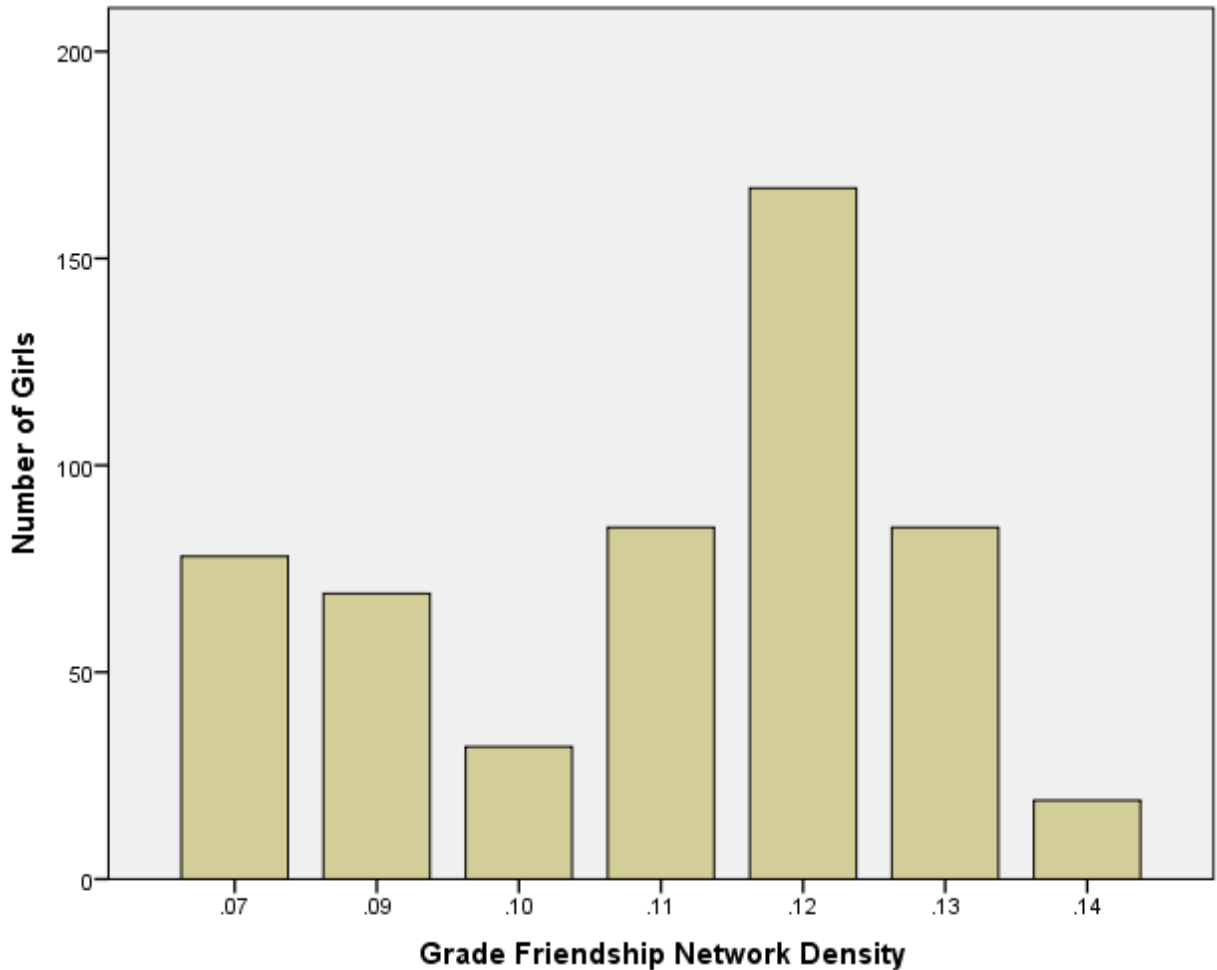


Figure 3.2. Bar graph of grade friendship network density for girls (n=535). Networks are by school and by grade.

This graph shows the number of girls that are within each grade friendship network density. Density is calculated by dividing the proportion of close friendship nominations received by the total possible number of nominations. There were a total of eighteen networks (three grades x six schools) and ranged in density from 7% (i.e., .07) to 14% (i.e., .14). The greatest number of girls (n=167) had a grade friendship network density of 12%.

APPENDIX J: Sociogram for school D, grade 7, including individual physical activity status

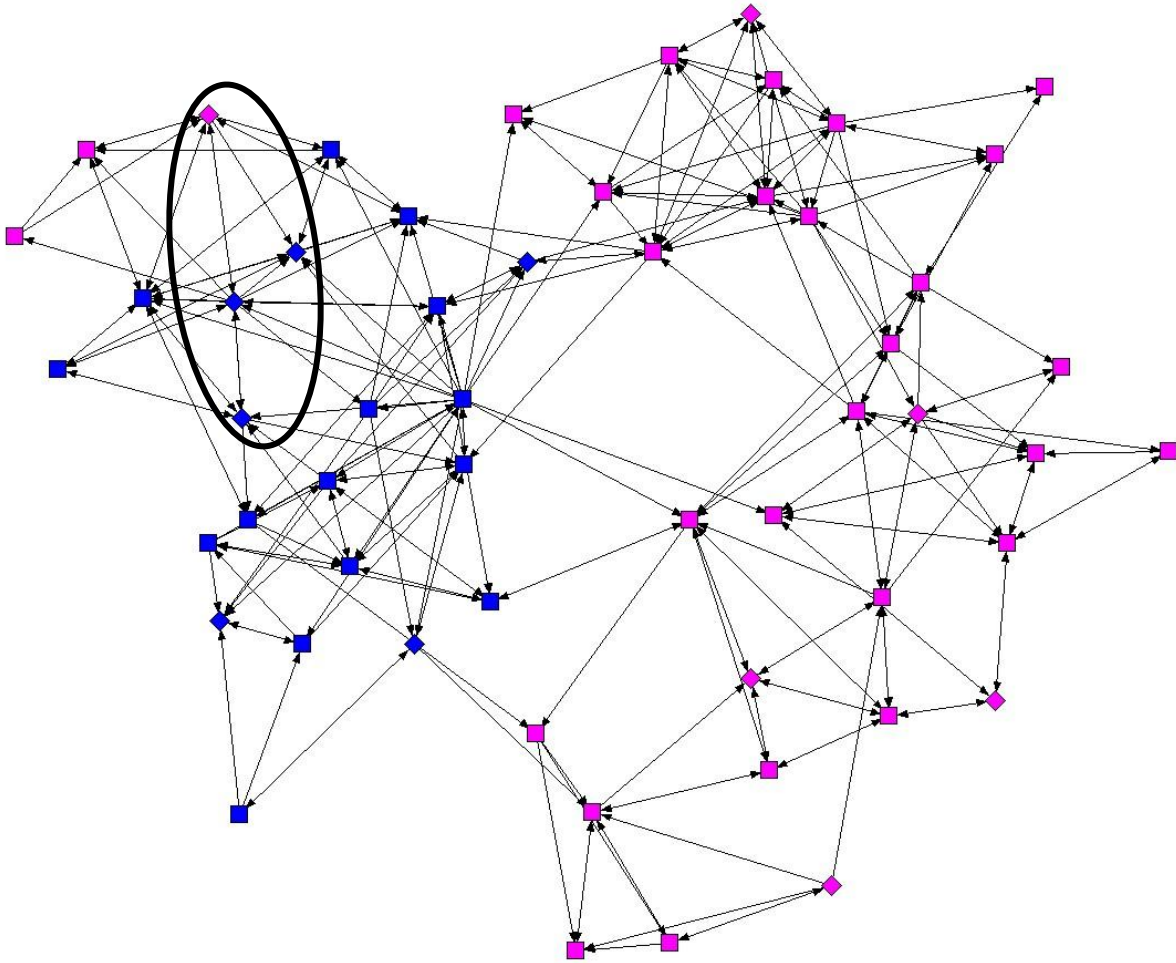


Figure 3.3. Sociogram for school D, grade 7, including individual physical activity status.

Blue color indicates boys, pink color indicates girls. Diamond indicates adolescents who were sufficiently active (≥ 60 -min MVPA every day), square indicates insufficiently active adolescents (≥ 60 -min of MVPA on < 7 days/week). The circle indicates a group of sufficiently active adolescents who are connected by 'close' friendship nominations.

APPENDIX K: Sociogram for school D, grade 7, including individual sedentary behaviour status

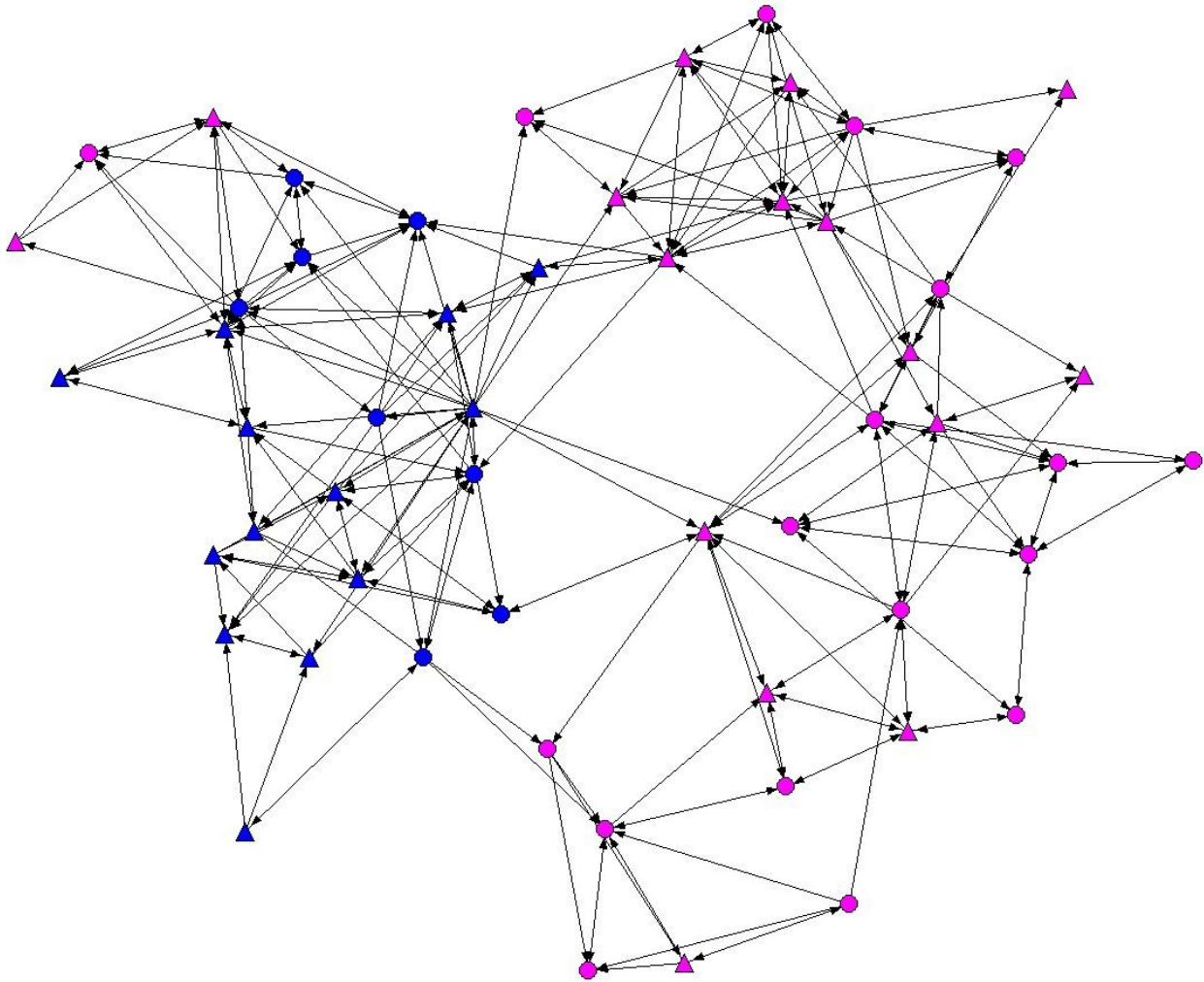


Figure 3.4. Sociogram for school D, grade 7, including individual sedentary behaviour status.

Blue color indicates boys, pink color indicates girls. Triangle indicates adolescents who were high sedentary (>2hrs/day sedentary behaviour), circle indicates low sedentary adolescents (\leq 2hrs/day sedentary behaviour).

APPENDIX L: Binary Logistic Regression Model with Interaction Terms: Boys, sufficiently active

Table 3.9. Odds ratios (OR) and 95% confidence intervals (95% CI) for the association between sociodemographic characteristics, social network characteristics, general perceived social support from friends, significant interaction terms between social network variables and general perceived social support from friends, and physical activity for boys (n= 526). This table includes the full model results related to Table 3.7: boys, sufficiently active model, page 62.

	Sufficiently active; n=84 (16.0%) (≥60-min of MVPA every day)
	Adjusted OR (95% CI)
Sociodemographic Characteristics	
<i>School</i>	
A [#]	1.00
B	0.43 (1.77-1.06)
C	0.42 (0.15-1.15)
D	0.67 (0.22-2.06)
E	0.26 (0.08-0.84)*
F	0.51 (0.16-1.61)
<i>Age</i>	
12 yrs and younger [#]	1.00
13 yrs	1.40 (0.71-2.75)
14 yrs and older	0.83 (0.35-1.95)
<i>Family Affluence</i>	
Low [#]	1.00
Middle	1.29 (0.60-2.77)
High	2.00 (0.94-4.27)
<i>Length of time in Canada</i>	
More than 5 years [#]	1.00
5 years or less	0.48 (0.19-1.25)
<i>Number of times moved last year</i>	
Did not move [#]	1.00
Moved at least once	0.75 (0.35-1.61)
Social Network Characteristics	
<i>Density</i>	
Low (density <12%) [#]	1.00
High (density ≥12%)	0.56 (0.23-1.33)
Proportion of active close friends	1.11 (1.02-1.21)*
Proportion of sedentary close friends	1.02 (0.92-1.12)

Betweenness centrality	1.02 (0.96-1.08)
Popularity	1.02 (0.97-1.07)
<i>Clique member</i>	
Member [#]	1.00
Not a member	1.21 (0.68-2.16)
General Perceived Social Support from Friends^a	0.63 (0.42-0.96)*

Interaction Terms

*= p<0.05, [#] = referent category, ^a = average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.

APPENDIX M: Binary Logistic Regression Model with Interaction Terms: Boys, high sedentary

Table 3.10. Odds ratios (OR) and 95% confidence intervals (95%CI) for the association between sociodemographic characteristics, social network characteristics, general perceived social support from friends, significant interaction terms between social network variables and general perceived social support from friends, and sedentary behaviour for boys (n= 526). This table includes the full model results related to Table 3.7: boys, highly sedentary model, page 62.

	High sedentary; n=421 (80.0%) (>2hrs/day of sedentary behaviour)
	Adjusted OR (95% CI)
Sociodemographic Characteristics	
<i>School</i>	
A [#]	1.00
B	2.42 (0.96-6.01)
C	2.94 (1.02-8.47)*
D	1.50 (0.48-4.74)
E	1.76 (0.58-5.32)
F	4.00 (1.20-6.69)*
<i>Age</i>	
12 yrs and younger [#]	1.00
13 yrs	1.16 (0.61-2.22)
14 yrs and older	2.39 (1.10-5.18)*
<i>Family Affluence</i>	
Low [#]	1.00
Middle	1.25 (0.68-2.31)
High	1.54 (0.80-2.94)
<i>Length of time in Canada</i>	
More than 5 years [#]	1.00
5 years or less	1.25 (0.58-2.70)
<i>Number of times moved last year</i>	
Did not move [#]	1.00
Moved at least once	1.01 (0.52-1.94)
Social Network Characteristics	
<i>Density</i>	
Low (density <12%) [#]	1.00
High (density ≥12%)	2.99 (1.34-6.69)*
Proportion of active close friends	0.96 (0.89-1.03)

Proportion of sedentary close friends	0.91 (0.83-1.01)
Betweenness centrality	1.01 (0.95-1.07)
Popularity	0.97 (0.93-1.02)
<i>Clique member</i>	
Member [#]	1.00
Not a member	1.31 (0.75-2.27)
General Perceived Social Support from Friends^a	0.34 (0.12-1.03)
Interaction Terms	
Proportion of active close friends * general perceived social support from friends	1.12 (1.00-1.26)*
Proportion of sedentary close friends * general perceived social support from friends	1.16 (1.01-1.32)*

*= p<0.05, [#] = referent category, ^a = average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.

APPENDIX N: Binary Logistic Regression Model with Interaction Terms: Girls, sufficiently active

Table 3.11 Odds ratios (OR) and 95% confidence intervals (95%CI) for the association between sociodemographic characteristics, social network characteristics, general perceived social support from friends, significant interaction terms between social network variables and general perceived social support from friends, and physical activity for girls (n= 535). This table includes the full model results related to Table 3.8: girls, sufficiently active model, page 65.

	Sufficiently active; n=39 (7.3%) (≥60-min of MVPA every day)
	Adjusted OR (95% CI)
Sociodemographic Characteristics	
<i>School</i>	
A [#]	1.00
B	0.16 (0.03-1.00)
C	0.81 (0.22-2.94)
D	0.90 (0.17-4.66)
E	0.38 (0.07-2.07)
F	0.99 (0.20-4.89)
<i>Age</i>	
12 yrs and younger [#]	1.00
13 yrs	0.69 (0.27-1.79)
14 yrs and older	0.48 (0.13-1.77)
<i>Family Affluence</i>	
Low [#]	1.00
Middle	0.79 (0.28-2.27)
High	1.41 (0.51-3.92)
<i>Length of time in Canada</i>	
More than 5 years [#]	1.00
5 years or less	0.61 (0.16-2.28)
<i>Number of times moved last year</i>	
Did not move [#]	1.00
Moved at least once	1.60 (0.72-3.54)
Social Network Characteristics	
<i>Density</i>	
Low (density <12%) [#]	1.00
High (density ≥12%)	1.07 (0.30-3.81)
Proportion of active close friends	1.14 (1.02-1.27)*
Proportion of sedentary close friends	1.02 (0.88-1.19)

Betweenness centrality	0.96 (0.86-1.06)
Popularity	0.98 (0.91-1.07)
<i>Clique member</i>	
Member [#]	1.00
Not a member	0.75 (0.30-1.86)
General Perceived Social Support from Friends^a	0.14 (0.02-0.88)*
Interaction Terms	
Proportion of sedentary close friends * general perceived social support from friends	1.31(1.04-1.67)*

*= p<0.05, [#] = referent category, ^a = average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.

APPENDIX O: Binary Logistic Regression Model with Interaction Terms: Girls, high sedentary

Table 3.12 Odds ratios (OR) and 95% confidence intervals (95%CI) for the association between sociodemographic characteristics, social network characteristics, general perceived social support from friends, significant interaction terms between social network variables and general perceived social support from friends, and sedentary behaviour for girls (n= 535). This table includes the full model results related to Table 3.8: girls, highly sedentary model, page 65.

	High sedentary; n=418 (78.1%) (>2hrs/day of sedentary behaviour)
	Adjusted OR (95% CI)
Sociodemographic Characteristics	
<i>School</i>	
A [#]	1.00
B	1.79 (0.80-4.03)
C	3.10 (1.30-7.38)*
D	1.20 (0.46-3.16)
E	2.85 (1.08-7.51)
F	6.87 (2.11-22.35)*
<i>Age</i>	
12 yrs and younger [#]	1.00
13 yrs	1.16 (0.64-2.12)
14 yrs and older	1.63 (0.78-3.41)
<i>Family Affluence</i>	
Low [#]	1.00
Middle	1.09 (0.58-2.04)
High	1.16 (0.61-2.21)
<i>Length of time in Canada</i>	
More than 5 years [#]	1.00
5 years or less	0.76 (0.37-1.56)
<i>Number of times moved last year</i>	
Did not move [#]	1.00
Moved at least once	0.91 (0.53-1.58)
Social Network Characteristics	
<i>Density</i>	
Low (density <12%) [#]	1.00
High (density ≥12%)	1.48 (0.72-3.04)
Proportion of active close friends	0.94 (0.88-1.01)

Proportion of sedentary close friends	0.96 (0.88-1.05)
Betweenness centrality	1.76 (0.96-3.22)
Popularity	1.03 (0.98-1.09)
<i>Clique member</i>	
Member [#]	1.00
Not a member	39.86 (1.53-1034.20)*
General Perceived Social Support from Friends^a	1.88 (0.99-3.55)
Interaction Terms	
Clique member * general perceived social support from friends	0.38 (0.15-0.96)*

*= p<0.05, [#] = referent category, ^a = average general perceived social support index: 1= received support none of the time to 4= received support all of the time in increments of 0.25, MVPA= moderate-to-vigorous physical activity, OR= odds ratio, CI= confidence interval.