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Friendship Selection Patterns Among Low Income Minority Girls/ Adolescents: Links to Obesity Risk

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FRIENDSHIP SELECTION PATTERNS AMONG LOW-INCOME MINORITY GIRLS/ADOLESCENTS: LINKS TO OBESITY RISK

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ABSTRACT

Research suggests interventions for pediatric obesity fail because they do not consider the broader social context in which adolescents spend their time: the adolescent friendship network. A critical step to address friendship network barriers to reducing child obesity is understanding contexts that promote friendship network patterns that promote healthy weight (i.e., social inclusion of overweight youth, friendship clusters that are diverse in weight status). This study sought to understand whether community-based summertime programming could facilitate healthier selection patterns for a demographic disproportionately at risk for obesity: low-income girls of color. Participants were 42 African American and Latina adolescent females (M =11.96 years, SD=1.12) enrolled in a community-based summer program for girls focused on healthy lifestyles. At two time points (before and at the end of programming), body mass index, dietary intake, and physical activity were assessed. At the end of the program, the friendship network that emerged during the program was measured. Social network analyses and traditional analyses were used to examine (1) selection patterns that emerged related to obesity and obesogenic behaviors, and (2) whether these selection patterns related to change in obesogenic behaviors over the course of the program. Results suggested that the program may foster social inclusion of overweight youth, but girls still tended to befriend others with similar weight statuses and dietary habits. No evidence was found for the relevance of selection patterns to girls' improvement in obesity risk during the program. That overweight youth were socially included in the context of organized PA suggests promising potential for similar community-

based summer programming to provide positive social experiences associated with PA for overweight youth. Future studies should examine complete social networks for longer duration to investigate the potential for community-based summer programming to capitalize on social factors that promote healthy weight among youth.

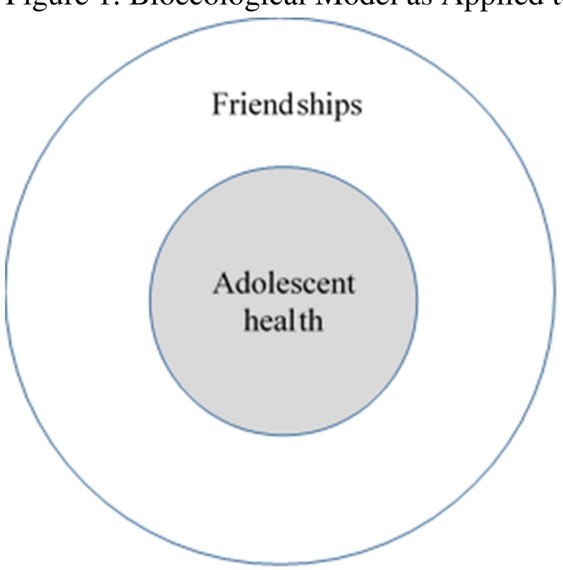
CHAPTER ONE

INTRODUCTION

Obesity rates among children and adolescents in the United States have remained alarmingly high despite extensive prevention and intervention efforts (Ogden, Carroll, Kit, & Flegal, 2014). Childhood obesity is a significant health burden that negatively impacts quality of life and leads to disability and mortality in adulthood (Finkelstein, Brown, Wrage, Allaire, & Hoerger, 2010). In youth, obesity can cause diffuse damage to the body's organs and severe chronic health conditions previously not seen in children, including pulmonary disorders, cardiovascular problems, fatty liver disease, high cholesterol, hypertension, and diabetes (Daniels, 2005; Han, Lawlor, & Kimm, 2010). Furthermore, obesity is fairly intractable once it develops, such that obese adolescents are likely to become obese adults (Owen et al., 2009). Obese adolescents are also at high risk for systemic diseases in adulthood and a significantly shorter life span (Bjorge, Engeland, Tverdal, & Smith, 2008). This large health burden carries with it an escalating economic burden in the form of $190 billion in annual U.S. healthcare costs for obesity-related problems and decreases in workforce participation (Finkelstein, DiBonaventura, Burgess, & Hale, 2010; Lehnert, Sonntag, Konnopka, Riedel-Heller, & König, 2013). Thus, novel approaches to obesity interventions in adolescence are more critical than ever to stemming long-term health and economic consequences of the obesity epidemic (Daniels, 2005).

One novel approach that has been largely overlooked is intervention with the *friendship networks* of adolescents with obesity risk. Recent research argues that traditional pediatric obesity interventions are unsuccessful because they intervene with adolescents at the individual level without considering adolescents' larger social context, particularly the friendship network (Ho et al., 2012). Indeed, friendship networks are a significant factor in adolescent health (see Williams, Holmbeck, & Greenley, 2002, for a review). Bioecological theory (Bronfenbrenner & Morris, 2006) asserts that adolescent development is driven by bidirectional processes of *selection* and *influence*: adolescents select microsettings, and those microsettings subsequently influence adolescents. Researchers have begun to apply this theory to adolescent health, arguing that adolescents select friends based in part upon these friends' attributes, including their health (e.g., weight status, health behaviors, etc.); in turn, adolescent health is influenced by the friends they have selected (Haas, Schaefer, & Kornienko, 2010; Simpkins, Schaefer, Price, & Vest, 2013) (see Figure 1).

Figure 1. Bioecological Model as Applied to Adolescent Health



Note. Adapted from Bronfenbrenner & Morris (2006) and Simpkins et al. (2013).

Studies suggest that adolescents' obesity and obesogenic (i.e., obesity-promoting) behaviors are especially related to those of their friendship networks (Kitzman-Ulrich et al., 2010). In particular, recent research has highlighted that who overweight youth befriend (i.e., selection patterns) plays a critical role in maintaining and promoting obesity among overweight youth (de la Haye, Robins, Mohr, & Wilson, 2011; Schaefer, Simpkins, & Vest, 2015). Unfortunately, research on friendship networks and adolescent obesity has largely overlooked how to address problematic selection patterns related to weight. Such efforts must be based upon an understanding of stigma against obesity, which drives these selection patterns.

Stigmatization of Overweight Youth

Stigma against overweight youth is a longstanding phenomenon. As early as the 1960s, a pair of seminal studies found that children consistently preferred pictures of a healthy peer or peers with one of four disabilities (holding crutches, sitting in a wheelchair, having a facial disfigurement, or having a missing hand) to pictures of overweight youth, rating the overweight child as significantly less likable and less desirable as a friend (Goodman, Dornbusch, Richardson, & Hastorf, 1963; Richardson, Goodman, Hastorf, & Dornbusch, 1961). A recent replication of this study among 458 fifth and sixth grade youth (Latner & Stunkard, 2003) found that not only were overweight youth still rated as the least likeable, but dislike for overweight youth had increased since 1961. Specifically, likability ratings for the overweight child were significantly lower in the 2003 study compared to the 1961 study, and the difference in likability between the healthy and overweight children was over 40% greater than in 1961 (Latner & Stunkard, 2003). Thus, despite the fact that childhood obesity rates have tripled in the last several decades and overweight is becoming a normative state (Ogden et al., 2014), stigmatization of obesity by children seems stronger than ever (Latner & Stunkard, 2003).

Stigma of overweight youth appears to begin in early childhood and strengthen throughout childhood and adolescence (Puhl & Latner, 2007). Furthermore, stigma towards overweight youth is prevalent regardless of the child's ethnicity or gender, occurring among African-American 5-10 year olds (Young-Hyman, Schlundt, Herman-Wenderoth, & Bozylinski, 2003), Latina adolescents (Neumark-Sztainer, Story, & Faibisch Ed.D, 1998), and Caucasian and Latino middle school youth (Greenleaf, Chambliss, Rhea, Martin, & Morrow, 2006). While this strong and pervasive stigma may have many detrimental consequences for overweight youth, one consequence that may increase their obesity risk is how stigma impacts whom youth befriend. In particular, there are two interrelated patterns resulting from stigma that characterize how overweight adolescents select friends and are selected as friends (i.e., selection patterns): *social marginalization of overweight youth* and *obesogenic friendship clusters*.

Social Marginalization of Overweight Youth

One pattern that results from child obesity stigma is that overweight adolescents are socially marginalized by their peers (Fisberg et al., 2004). For example, examination of a cross-sectional, nationally representative sample of 90,118 adolescents aged thirteen through eighteen participating in the National Longitudinal Study of Adolescent Health (hereafter referred to as Add Health) revealed that social exclusion of overweight adolescents occurs across multiple aspects of social connectedness (Strauss & Pollack, 2003). Specifically, although overweight adolescents selected the same number of friends as healthy weight youth, they were less likely to be selected as friends compared to healthy weight adolescents (Strauss & Pollock, 2003), a finding which has been replicated with other samples (Valente, Fujimoto, Chou, & Spruijt-Metz, 2009). In addition, the number of friendship nominations adolescents received was inversely related to body mass index (BMI), such that as an adolescent' BMI increased, the number of peers listing that adolescent as a friend decreased (Strauss & Pollack, 2003). Moreover, compared to healthy weight peers, overweight adolescents were significantly more likely to receive no friendship nominations (i.e., be socially isolated), and they were significantly less likely to be listed as a best friend by a peer in the network (Strauss & Pollack, 2003). Furthermore, overweight adolescents also occupied less central positions within the social network, as indicated by several measures: overweight adolescents were significantly less likely than healthy weight adolescents to be friends with highly nominated peers and less likely to play an "intermediary" role between well-connected adolescents (Strauss & Pollack, 2003). A recent longitudinal study of Australian ninth and tenth graders further demonstrates the degree to which overweight youth are socially marginalized (de la Haye et al., 2011). While overweight adolescents were not opposed to befriending youth of any weight status, healthy weight adolescents showed a strong aversion to befriending overweight peers (de la Haye et al., 2011).

Social Marginalization May Increase Obesity Risk

The multiple ways in which overweight adolescents are marginalized result in them being less socially connected to peers and spending more time alone than healthy weight adolescents (Falkner et al., 2001; Haas et al., 2010; Salvy, Roemmich, et al., 2008). Because physical activity (PA) in childhood and adolescence primarily involves social play with others (e.g., tag, soccer, kickball), youth without friends are unlikely to be physical active (Salvy & Bowker, 2013; Salvy, Bowker, Germeroth, & Barkley, 2012). The importance of friends to PA has been supported by several studies that used experience sampling method (ESM) to capture real-time relations between youth PA and with whom youth spend time. In one ESM study, urban youth were found to engage in more intense PA when in the presence of peers and friends compared to when alone or with parents (Salvy, Bowker, et al., 2008). Similarly, another ESM study using accelerometers found that youth were less likely to be sedentary and more likely to engage in PA when with their friends, but less likely to engage in PA when with their parents (Bohnert et al., 2013). Given that lack of PA is a key contributor to adolescent obesity (Spruijt-Metz, 2011), these findings suggest that overweight adolescents' limited connections to other youth within their friendship networks is concerning for their obesity risk.

Obesogenic Friendship Clusters

For youth who are socially marginalized, the only options for friendships are often other socially marginalized youth (Sijtsema, Lindenberg, & Veenstra, 2010). For overweight youth, who are excluded by healthy weight peers, their only friendship options are other overweight youth (Schaefer et al., 2015). As previously mentioned, overweight youth are open to friendships with youth of all weight statuses, but only other overweight youth reciprocate the friendship interest (de la Haye et al., 2011). Thus, as a result of overweight youth being socially marginalized, a second selection pattern tends to emerge that is also problematic for the obesity risk of overweight youth: the formation of *obesogenic friendship clusters,* i.e. small friendship groups characterized by similarity in overweight status and/or obesogenic behaviors. Indeed, numerous studies have found that adolescent friendship groups tend to share the same weight status (e.g., Fowler & Christakis, 2008; Halliday & Kwak, 2009; Renna, Grafova, & Thakur, 2008; Trogdon, Nonnemaker, & Pais, 2008; Valente et al., 2009).

Friendship groups with similar weight status may also share similar levels of obesogenic behaviors (e.g., lack of physical activity; high consumption of nutrient-poor, energy-dense foods). Preliminary research investigating this notion presents conflicting results. A study of Australian high schoolers found that same-sex friends were similar in frequency and quantity of participation in organized PA (de la Haye, Robins, Mohr, & Wilson, 2010). However, whether youth clustered based on similarity in other obesogenic activities depended upon gender. Among females only, friends were similar on hours spent in sedentary screen-based activities (de la Haye et al., 2010). Among males only, friends were similar on amount of nutrient poor, calorie-dense food consumed (de la Haye et al., 2010). Thus, although friendship selection based on similarity in weight status is well established, whether and in which ways adolescents select friends based on similarity in obesogenic behaviors requires clarification.

Obesogenic Friendship Clusters May Increase Obesity Risk

These selection patterns for similarity in weight status (and potentially obesogenic behaviors) are concerning because after selecting each other as friends, overweight friendship groups who engage in obesogenic behaviors may influence each other in ways that maintain and even promote their overweight status (Salvy & Bowker, 2013). A growing body of research supports the notion that friends influence each other's obesogenic behaviors (e.g., physical activity and dietary intake) and, subsequently, weight (e.g., Ali, Amialchuk, & Heiland, 2011; de la Haye, Robins, Mohr, & Wilson, 2013; Gesell, Tesdahl, & Ruchman, 2012; Jago et al., 2011; Simpkins, Schaefer, Price, & Vest, 2013; Trogdon et al., 2008). For instance, with regards to PA, longitudinal analysis of a large sample of adolescents from the Add Health study found that over time, adolescents were more likely to engage in regular exercise and pursue a sport if their friends did (Ali et al., 2011). Similarly, in a three-month study of youth in after-school programs, youth consistently made adjustments to their PA level of 10% or more to match the PA level of their immediate friends (Gesell, Tesdahl, et al., 2012). Research on friendship influence on dietary intake is less consistent. Several experimental studies found that overweight girls matched the eating style of their eating partners, consuming more when in the presence of overweight girls compared to when in the presence of healthy weight girls (Romero, Epstein, & Salvy, 2009; Salvy, Howard, Read, & Mele, 2009). Similarly, adolescents in the Add Health study were more likely to consume fast food if their friends did (Ali et al., 2011). In contrast, other dietary behaviors in the Add Health sample were not susceptible to friendship influence, including consumption of calorie-dense snacks, likelihood of consuming five servings of fruits and vegetables a day, and likelihood of eating breakfast (Ali et al., 2011). In sum, evidence suggests that over time, friends influence each other's PA levels and may also influence dietary intake, although evidence for dietary intake is mixed. Friendship influence on obesogenic behaviors renders homogeneous friendship clusters problematic, as clusters of overweight friends and/or friends who engage in high levels of obesogenic behaviors may maintain and even reinforce each other's overweight status and obesogenic behaviors (Salvy & Bowker, 2013).

Weight Status as a Moderator

It is possible that an adolescent's weight status affects their likelihood of forming obesogenic friendship clusters and the impact of such clusters on their own obesity risk. That is, adolescents who are obese (rather than overweight) may be especially likely to befriend other adolescents with similar weight status and obesogenic behaviors. Similarly, being part of a friendship group with homogeneous weight status and obesogenic behaviors may increase the obesity risk of obese youth more so than the obesity risk of overweight or healthy weight youth. Although several studies have controlled for weight status as a nuisance variable when examining the link between friends' similarity in weight status and obesogenic behaviors (e.g., Rancourt, Conway, Burk, & Prinstein, 2013; Rayner, Schniering, Rapee, Taylor, & Hutchinson, 2013), to date only one study has examined the relevance of weight status to whether adolescents befriend youth with similar obesity risk, and whether having such friends influenced obesity risk of the adolescent. Trogdon and colleagues (2008) tested the similarity of BMI among friends in a sample of 3,702 adolescents who participated in the Add Health stud, and found several ways in which the relation between adolescent BMI and friends' BMI differed depending on adolescent weight status. First, adolescent BMI was significantly positively related to the BMI of their friendship network, but this relation was stronger for adolescents with higher BMI (Trogdon et al., 2008). Specifically, an increase in average BMI of friends by 1 raw BMI unit predicted a 0.20 unit increase in BMI among adolescents at the 25th BMI percentile, a 0.39 unit increase in BMI among adolescents at the median BMI percentile, and a 0.66 unit increase in BMI among adolescents at the 75th BMI percentile (Trogdon et al., 2008). Thus, overweight youth were more likely than healthy weight youth to select friends with similar weight status. Furthermore, the magnitude of the effect of peer BMI on adolescent BMI over time (i.e., influence) depended upon adolescent weight status. Specifically, average peer BMI was almost twice as large for youth at the 75th BMI percentile compared to youth at the 25th BMI percentile (Trogdon et al., 2008). Although peers are distinct from friends, results from this study nonetheless suggest that the ways in which friendship network patterns relate to obesity risk may differ for youth of different weight statuses. For example, it is possible that similarity in weight status and obesogenic behaviors may only be problematic for the obesity risk of youth who are overweight or obese, not for healthy weight youth. A nuanced understanding of these relations for youth who are healthy weight versus overweight or obese is needed in order to tailor programming that would promote health for all youth.

Summertime, Friendship Networks, and Obesity

Given the evidence that typical selection patterns promote the obesity risk of overweight youth, research is needed on contexts that promote healthier selection patterns, i.e., friendship networks that are inclusive of traditionally stigmatized youth and allow for more heterogeneous friendships clusters. An ideal setting for developing a clearer understanding of how friendship patterns may be fostered (Fredericks & Simpkins, 2013), as well as links between such friendship patterns and obesity risk, is community-based summertime programming. Out-of-school time programming such as summer programs help youth develop and maintain friendships by facilitating sustained contact and relationship-building experiences among youth (Larson, 2000; Schaefer, Simpkins, Vest, & Price, 2011). Summertime programming in particular, however, offers the opportunity for adolescents to form friendships with new peers, outside of the school context and corresponding school friendship networks. Indeed, transitions from one context to another (such as from school to a summer program) present unique opportunities for youth to regroup into new friendship networks (Bohnert, Aikins, & Arola, 2013) with different selection patterns than they have previously experienced. In addition, summertime is a period of increased obesity risk for adolescents (e.g., Baranowski et al., 2014), and summer programming has been highlighted as a strategy to address obesity risk over the summer months (Bohnert, Ward, Burdette, Silton, & Dugas, 2014; Swinburn, 2009).

Furthermore, in addition to facilitating new friendship networks, summertime programming facilitates *atypical* selection patterns, that is, it facilitates relationships between adolescents who would not normally select each other as friends in the context of school (Dworkin, Larson, & Hansen, 2003; Fredricks & Simpkins, 2013). Specifically, co-participation in the same summer program may help socially marginalized adolescents overcome common barriers to friendship based on stigma (Dworkin et al., 2003; Moody, 2001), such as child obesity stigma. Although overweight youth are socially marginalized in school friendship networks, in the context of summertime programming focused on a particular activity (e.g., learning a sport), youth develop a sense of belongingness and loyalty to their co-participants which overrides previous stigma (Dworkin et al., 2003). This may foster friendship networks characterized by social inclusion and heterogeneous friendship clusters (Dworkin et al., 2003; Watkins, Larson, & Sullivan, 2007). Taken together, summertime programming may offer an ideal context in which to study how selection patterns may promote healthy weight.

Investigation of selection patterns and obesity within the context of community-based summertime programming may be the most needed among low-income girls of color. Latina and African-American girls and girls from low-income households are at disproportionately high risk for obesity and experience a particularly dramatic decline in PA over the course of adolescence (Grieser et al., 2006; Kimm et al., 2002; Ogden et al., 2014; Treuth et al., 2009). Additionally, friendship influences on obesity appear to be especially powerful among early adolescent girls (Feunekes, de Graaf, Meyboom, & van Staveren, 1998; Jago, Page, & Cooper, 2012; Trogdon et al., 2008; Urberg, 1992). Among girls but not boys, PA may differ according to the social norms of the friendship group (Jago et al., 2009). Girls also demonstrate stronger concerns than boys about peer evaluation related to dietary intake and PA (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002; Martin, Leary, & O'Brien, 2001). A recent study found that girls whose friends engage in less moderate-to-vigorous PA were more likely to have higher BMI themselves; this did not hold true for boys (Larson, Wall, Story, & Neumark-Sztainer, 2013). Furthermore, girls also may internalize negative peer evaluation regarding weight and obesogenic behaviors more than boys do and thus be particularly affected by it (Kunesh, Hasbrook, & Lewthwaite, 1992). Therefore, understanding how selection patterns could promote healthy weight and behaviors may be particularly important among girls of color.

An ideal summer program in which to study how selection patterns could promote healthy weight among girls of color may be the Girls in the Game (GIG) Sports and Leadership Camp. This community-based program recruits girls from across a large urban area and who are of diverse weight status. GIG exemplifies a context that may facilitate (1) social inclusion of overweight youth and (2) friendship clusters that are diverse in weight status, *specifically in the context of healthy weight behaviors.* That is, in addition to fostering these healthier friendship selection patterns for overweight youth in general (which may promote healthy weight), GIG may specifically foster these friendships through physical activity and healthy eating. First, the program creates an environment in which girls can learn and participate in PA without the presence of boys. Research indicates that girls prefer and are more likely to engage in PA when in same-sex environments due to finding it more enjoyable, worrying less about their body image, greater opportunity to develop PA skills and develop friendships with fellow participants, avoiding comparison to boys, and avoiding critical comments from boys related to their bodies or performance (Whitehead & Biddle, 2008; Taylor et al., 2000; Olafson, 2002; Hannon &

Ratliffe, 2005). Furthermore, the program is marketed as "getting all girls in the game," i.e. helping all girls connect with a fitness activity they enjoy, regardless of previous skill, athletic ability, or weight status. Indeed, the program is not marketed towards girls who self-identify as "athletes"; instead, the program assumes no exposure and provides hands-on workshops for a multitude of fitness activities. Systematic reviews of effective PA interventions for adolescent girls highlight that programs that increase choice and offer a wide-range of ways to be active make PA more enjoyable for girls (Camacho –Miñano, LaVoi, & Barr-Anderson, 2011). Additionally, the coaches who lead these workshops are largely former program participants; as a result, being physically active is modeled by older girls who closely reflect the demographic characteristics of the program participants (including having diverse weight status). Taken together, the design of the program may be particularly likely to foster social inclusion of overweight youth, and as such, may foster friendship groups that are diverse in weight status, dietary intake, and physical activity behaviors.

In turn, friendship selection patterns observed may have implications for change in participants' eating and physical activity. In addition to focusing on healthy lifestyles, the program also includes a goal of gaining leadership skills. This combination of participant-centered leadership and a large variety of physical activity options set the stage for long-term, lifestyle, behavioral change (Ramsing & Sibthorp, 2008). Beyond simply helping girls engage in more PA during the program, the program may foster psychological changes in participants that facilitate long-term behavior change. Specifically, GIG program's design may offer overweight girls a friendship context in which they feel included during these activities, and as such may foster feelings of competence and identification with such activities (Dworkin et al., 2003). In sum, in addition to observing alternative selection patterns in this program, these selection patterns may also promote increased healthy eating and physical activity.

The Present Study

This interdisciplinary study examined the friendship network that formed within the context of a summer program focused on healthy lifestyles for low-income girls of color, and how selection patterns within the network related to girls' weight and obesogenic behaviors. The summer program examined for this study, described above, is ideally structured to facilitate the formation of a friendship network that may be less susceptible to friendship network selection patterns driven by weight-based stigma. As such, the program may uniquely promote social inclusion of overweight youth and friendship groups that are diverse in obesogenic behaviors. An understanding of contexts that promote friendship network patterns that may promote healthy weight is a critical step towards addressing friendship network barriers to reducing child obesity. In particular, understanding whether a summer program could facilitate social inclusion of overweight youth as well as friendship clusters that are diverse in weight status would provide evidence for intentionally developing interventions with this goal in mind. Furthermore, examination of a community-based summer program focused on healthy lifestyles for low-income girls of color is an ideal first step given that low-income girls of color may particularly need and benefit from community-based programs that address friendship selection influences on obesity. Specifically, this study aimed to address the following research questions:

Specific Aims

Specific aim 1. *Examine obesity-related selection patterns that emerge in a community-based summer program for girls focused on healthy lifestyles.*

Aim 1a. Examine whether overweight youth are socially marginalized, i.e. whether higher body mass index (BMI) percentile is associated with fewer friendships and less central (more peripheral) positions within the network.

Research suggests that overweight youth tend to have fewer friends and occupy less central positions within the network (Strauss & Pollack, 2003). However, in this program, it is hypothesized that BMI percentile will not relate to number of friends formed in the program nor centrality of girls' positions in the friendship network.

Aim 1b. Examine whether the network that forms within the program is characterized by obesogenic friendship clusters, and whether likelihood of clustering depends on weight status. That is, are healthy weight, overweight, and obese girls equally likely to select friends with similar weight status?

Research suggests that adolescents tend to select friends with similar weight status, and that this clustering is particularly observed among obese youth (e.g., Schaefer et al., 2015, Trogdon et al., 2008). However, in this program, it is hypothesized that similarity in weight status will not increase likelihood of friendship formation, and that this will be equally true for healthy weight, overweight, and obese girls. Given consistent findings that adolescent friendships are characterized by similarity in PA but inconsistent findings related to similarity in diet (e.g., de la Haye, Robins, Mohr, & Wilson, 2010), it is predicted that similarity in physical activity (but not dietary intake) will increase likelihood of friendship formation.

Specific aim 2. *Examine whether the observed selection patterns within the program relate to change in obesogenic behaviors over the course of the program, and whether this depends upon weight status.*

Aim 2a. Examine whether girls who are more socially included demonstrate more improvement in obesogenic behaviors over the course of the program, and whether this depends upon weight status.

Given that social marginalization is associated with increased obesogenic behaviors among adolescents (Salvy et al., 2012), it is hypothesized that girls with more friends and more central network positions in the program will demonstrate increased improvement in obesogenic behaviors over the course of the program. It is hypothesized that the relation between social inclusion and improvement in obesogenic behaviors will not depend on weight status.

Aim 2b. Examine whether girls' change in obesogenic behaviors over the course of the program is related to the change in the obesogenic of their friends, and whether this depends upon weight status.

Given research suggesting the influence of adolescent friends on obesogenic behaviors (Salvy et al., 2012), it is hypothesized that change in physical activity and dietary intake over the course of the program will relate to change in friends' physical activity and dietary intake. It is predicted that the relation between girls' and friends' behavior change will not depend on weight status.

CHAPTER TWO

METHOD

Participants

Participants in this study included 42 girls aged 10-14 (M=11.96, SD=1.12) recruited from a community-based summer program as part of a multi-wave larger research study examining multiple years of the summer program. Participants for this study were recruited from the first wave of the study. Participants were recruited using two methods: (a) a Girls in the Game mailing to parents and guardians of all 10-14-year-old girls enrolled in the program (81 girls) and (b) announcements at the program informational meeting for families. As part of the mailing, parents received a cover letter explaining the study, as well as an informed consent document and an invitation to an informational camp meeting. During the informational meeting, parents received a brief overview, had the opportunity to ask any questions about the study, and filled out informed consent forms. Consent forms obtained during this initial meeting also served as part of the initial data collection, Time 1 (T1). Families who did not attend this meeting but had eligible daughters (girls aged 10–14) enrolled in the program were invited to participate in a second T1 data collection session held several days later. Of the 43 girls participating in the program, 1 participant dropped out of the program. The resulting sample of 42 girls represented 52% of the total camp network. The Institutional Review Board of Loyola University Chicago approved this study. Per parent report, participants identified as African American (57%) and Latina (43%).

Program

The Girls in the Game (GIG) Sports and Leadership Camp is a summer program for girls provided by a nonprofit organization in Chicago, IL. The program targets girls who reside in urban Chicago neighborhoods that have few resources and high numbers of low-income youth. Program participants are provided with six hours of programming at a city park Monday through Friday for three to four consecutive weeks. Programming consists of instruction and engagement in PA through both traditional (e.g., basketball, soccer, dance) and non-traditional (e.g., yoga, lacrosse, field hockey) sports and fitness activities. Participants also receive education in health, nutrition, and leadership skills. Each program day is composed of three 50-minute morning rotations (two sports lessons and one health and leadership lesson), a 40-minute lunch period, one hour of swimming, 45 minutes of team fitness, and a 10-minute snack time. Daily lunch and snacks consisting of healthy foods, such as vegetables, fruit, and milk, are provided. Program participants are provided with transportation to and from camp.

Procedure and Measures

Obesity and obesity-related health behaviors were measured at two time points: once several days before camp (Time 1) and once in the last week of camp (Time 2). Friendship networks formed during the camp were assessed once, during the last week of camp (Time 2).

Demographics

The youth survey included questions about birth date, age, and grade in school. Ethnicity information was obtained from the program demographic database completed by parents.

Weight Status

Height and weight measurements were obtained following the protocol used in the National Health and Nutrition Examination Survey (Centers for Disease Control and Prevention, 2007). Weight was measured, with participants wearing light clothing and no shoes, to the nearest 0.1 kilogram (kg) using a digital scale (Seca 770, Hamburg, Germany). Participants' height without shoes was measured to the nearest 0.1 centimeter using a Seca 214 mobile stadiometer while participants' heads were held in the Frankfort plane. These data were used to calculate BMI according to the following formula: BMI = $kg/meter^2$. BMI-for-age percentiles were calculated based on Centers for Disease Control and Prevention (CDC) growth charts using the Children's Hospital of Philadelphia online calculator. BMI-for-age weight status categories were created based on these BMI percentiles as outlined by the CDC: underweight (less than 5^{th} percentile), normal weight (5th percentile to less than the 85th percentile), overweight (85th to less than the 95th percentile), or obese (equal to or greater than the 95th percentile). At Time 1, 1% of participants were underweight, 43% were healthy weight, 24% were overweight, and 32% were obese.

Dietary Intake

Two 24-hour dietary recalls were administered at each time point during individual face-to-face interviews with research staff. Participants were asked to remember everything they ate and drank between the time they awoke the previous morning until the time they got up that current morning. Participants were asked to supply estimated portion sizes using food models and to describe cooking methods. Nutrient intake was calculated by multiplying portion sizes, converted to gram weights, by the nutrient content per gram of that food. Information from the

24-hour recalls was analyzed using the University of Minnesota Nutrition Data System (NDS) for Research. This software features a multiple-pass approach that prompts for complete food descriptions and preparation methods and include >16,000 foods and values for 117 nutrients and nutrient ratios. Recalls were averaged across the two recalls for each time point and analyzed for (1) average daily servings of fruits and vegetables (i.e., healthy snacks) and (2) average daily servings of high-density, nutrient-poor snacks (i.e., unhealthy snacks). The multiple pass, 24 hour dietary recall has been extensively used with adolescents and has been shown to be both reliable and valid (Greger & Etnyre, 1978). Healthy snacks and unhealthy snacks were originally intended as the constructs to be utilized as a measure of dietary intake in all study models. However, the exponential random graph models (ERGMs) did not converge and thus were unable to be estimated with the inclusion of these variables. Therefore, an alternative snacking construct, net snacking, was created by subtracting average daily servings of unhealthy snacks from average daily servings of healthy snacks. Higher net snacking scores reflected more servings of healthy snacks than unhealthy snacks on average.

Physical Activity

PA was measured using an accelerometer (Actigraph GT3X), worn at the waist just behind the right hip. The Actigraph captures daytime activity levels with no need to move or reattach the device (Kinder et al., 2012), rendering it an ideal choice for collecting PA data in a community-based youth sample. Participants wore accelerometers for a total of six days and nights including two weekend days. Participants were instructed to remove accelerometers when bathing and during the 60 minutes of pool time per day at camp. To infer PA, accelerometer data will be passed through a customized Visual Basic Excel macro (Trost et al., 2013) designed to infer non-wear time and to determine the amount of time spent in light, moderate, and vigorous PA. A valid day of PA monitoring was defined as having nine or more hours of wear time. Data were reported as total PA time and moderate-to-vigorous PA time in minutes.

Friendship Networks

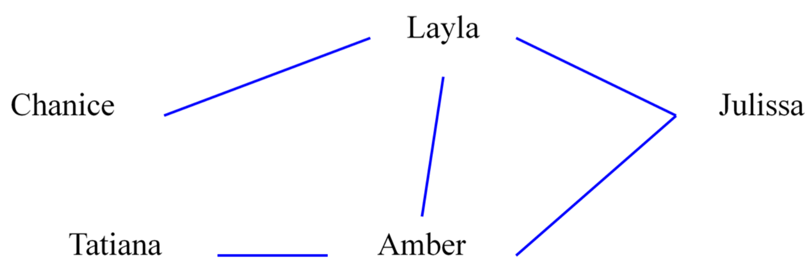
The friendship networks formed within the intervention program were assessed at Time 2 through friendship nominations via one-on-one interviews (e.g., Bondonio, 1998; Hlebec & Ferligoj, 2002; Marsden, 2005). Participants were asked, "Please tell me the names of the friends you hang out with and talk to and do things with the most here at Girls in the Game." Participants were not restricted as to how many friends they could nominate. Friendship ties were entered into analyses as directed, i.e. specifying the sender and the recipient of each friendship nomination.

Analytic Plan

All analyses will be conducted using R, a statistical computing and graphics language and open-source environment. Initially, network visualization and descriptive analyses will be run to characterize the network, including network size, number of friendship ties, and centralization (i.e., degree of cluster formation), and to guide creation of statistical models to address specific aims.

The first aims focused on examining obesity-related selection patterns that emerge in a community-based summer program for girls focused on healthy lifestyles. Initially, in order to partially address Aim 1a (examine whether overweight youth are socially marginalized), a correlation was run between BMI percentile and centrality scores in order to test how BMI related to the degree to which girls occupied central (rather than peripheral) positions within the network. Although centrality can be calculated in numerous ways (see Valente, Coronges, Lakon, & Costenbader, 2008), in this study centrality was operationalized using *betweenness centrality* scores. Betweenness centrality considers the most critical people in the network to be those who lie on the greatest proportion of shortest paths (relationships) between all other pairs of individuals in the network (Freeman, 1979; see Figure 2).

Figure 2. Betweenness Centrality Illustration



Note. Lines between girls in the network indicate friendship ties. Chanice and Tatiana each only lie on one shortest path between girls in the network. In contrast, Amber lies on the shortest path between Tatiana and Layla and the shortest path between Tatiana and Julissa. Similarly, Layla lies on the shortest path between Amber and Chanice and the shortest path between Chanice and Julissa. In this network, Amber and Layla would have higher betweenness centrality scores than Chanice and Tatiana.

In order to address the remaining aspects of Aim 1a as well as Aim 1b (examine whether the network that forms within the program is characterized by obesogenic friendship clusters, and whether likelihood of clustering depends upon weight status), Exponential Random Graph Modeling (ERGM) was used. The ERGM is a statistical model that can estimate the likelihood of friendship ties as a function of individual attributes and attributes of friendships (e.g., similarity or difference on a particular attribute) while accounting for the structure of the network (e.g., network size) and dependency that exists in relational data (Cranmer & Desmarais, 2011). ERGMs treat dyads, rather than individuals, as the unit of analysis. For each possible pair of participants in the network, the ERGM estimates the likelihood a friendship existing (Cranmer & Desmarais, 2011). The dyad in question is represented on both sides of the equation, which accounts for the complex interdependencies within social network data that render traditional statistical approaches inappropriate for social network questions. That is, within network data, a participant who is a predictor may also be an outcome. ERGMs can be represented by the following formula:

$$P(Y_{ij} = 1|n, Y^c_{ij}) = \text{logit}^{-1}\left(\sum_{k=1}^{K}\theta_k\delta(\Gamma_{yk})\right)$$

Where Y_{ij} is a given dyad, n is the number of nodes, Y^c_{ij} represents all dyads other than Y_{ij}, K is the number of network statistics in the model, $\delta(\Gamma_{yk})$ is the amount by which Γ_{yk} changes when $Y_{ij,}$ is toggled from 0 to 1, i.e. when a friendship tie between the dyad is absent (0) versus present (1). In this study, ERGM was used to test a model of the observed friendship network that estimated whether the likelihood of friendship could be predicted by a girl's weight status and by similarity in a dyad's weight status and obesogenic behaviors. Given the sample was relatively equally divided between two ethnicities, similarity in ethnicity was also be included as a predictor. Statistical significance of predictors of friendship ties was based on a *t* value calculated from the estimated population mean and variance. The ERGM estimated coefficients as odds ratios that indicate how a one-unit change in the value of a predictor affects the odds of a friendship tie existing.

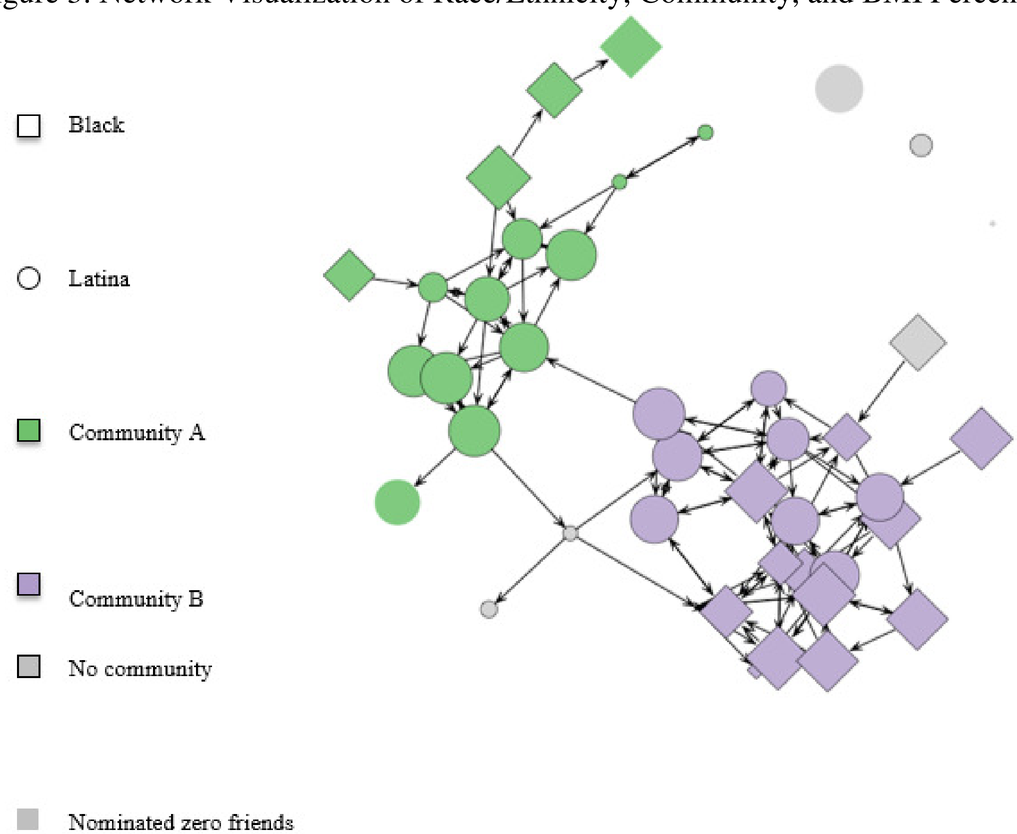
The second aims focused on examining whether the observed selection patterns within the program related to change in obesogenic behavior over the course of the program. In order to address Aim 2a (examine whether girls who are more socially included demonstrate more improvement in obesogenic behaviors over the course of the program), four separate hierarchical multiple regressions were used to examine improvement in physical activity (total physical activity, moderate-to-vigorous physical activity), healthy eating (fruit and vegetable servings), and unhealthy eating (unhealthy snack servings), respectively. In Step 1 of each regression, number of friends (degree) and centrality of network position (as measured by the betweenness centrality statistic) were entered as continuous independent variables. In Step 2 of each regression, BMI percentile and Time 1 level of the obesogenic behavior being examined (physical activity, healthy eating, or unhealthy eating) were entered as covariates. In Step 3, the two-way interaction terms of variables in Step 1 and 2 were entered. Time 2 level of the obesogenic behavior was entered as the continuous dependent variable. Recommendations from Baron and Kenny (1986) and Holmbeck (1997, 2002) were followed for interpretation.

In order to address Aim 2b (examine whether girls' change in obesogenic behaviors over the course of the program is related to change in obesogenic behavior of their friends, and whether this depended on weight status), network autocorrelation models were used. These statistical models estimate how individual attributes of friends relate to each other. Network autocorrelation models are a special case of OLS regression where the dependent variable is an individual attribute. Instead of predicting friendship ties, as ERGMs do, network autocorrelation models predict attributes of individuals in the network. However, because the data are being examined from a network perspective, these observations of individual attributes are not considered to be independent of one another. Thus, a network approach such as network autocorrelation is needed rather than traditional statistical approaches that require independence of observations. Network autocorrelation models can be represented by the following formula:

$$y = (I - \Theta W)^{-1} (X\beta + (I - \psi Z)^{-1} v)$$

where Θ and ψ represent influence processes by which individual attributes may be related to those of their friends (Leenders, 2002). In this study, separate models were run for change in PA and change in dietary intake. First, change scores were generated for each of these variables. Next, two separate network autocorrelation models were run, following the above formula, to estimate whether behavior change of individuals in the network were related among friends. The first model estimated whether improvement in minutes of PA was related among friends. The second model estimated whether improvement in dietary intake was related among friends. Weight status was included as a covariate of interest in each of the autocorrelation models.

Figure 3. Network Visualization of Race/Ethnicity, Community, and BMI Percentile



Note. Arrows Indicate the Direction of Friendship Ties. Size of Nodes Reflect BMI Percentile, with Larger Nodes Representing Higher BMI Percentile

Missing Data

Analytic plans for network data must address missing data given that friendship network data is often incomplete (Wasserman & Faust, 1994). Missing network data can take two forms: missing node data (i.e., data from a member of the network is missing) and missing edge data (i.e., data about a relationship that exists in the network is missing). Missing node data is particularly problematic, even more so when friendship ties are directed, as in this study (Kossinets, 2006). In these instances, missing data from a participant means missing both the friendship nominations sent and received by that participant. As it can be challenging to identify and separate the sources of missing data and to estimate the effects of missing data, pre-emptive measures should be taken against missing data effects (Kossinets, 2006).

One strategy that can be helpful is to select network measures for analysis that are robust even when data is missing at random and thus unable to be controlled for. Towards this end, measures of social inclusion in this study included number of friendship ties received (i.e., indegree centrality) in addition to betweenness centrality. Number of friendship ties is a fairly stable metric and can be used reliably to indicate network position even with a large percentage of data missing (e.g., 50% missing at random) (Valente & Davis, 1999). Furthermore, these centrality measures are suitable even when data is missing from small networks (Borgatti, Carley, & Krackhardt, 2005; Galaskiewicz 1991). Another strategy that was used in this study to address missing data is that friendship ties were considered to exist regardless of whether they are reciprocal. This accounts for missing friendship nominations from missing participant data (Stork and Richards, 1992) and allows participants with missing social network data to still be included in ERGM. In addition to making these measurement choices that can alleviate the effects of missing data, other recommended strategies that were employed include removing missing participants from network estimations and imputing missing data (Huisman, 2009; Kossinets, 2006).

Regardless of these strategies, missing data in this study may be a significant limitation, as it can cause underestimation of clustering and homophily (Kossinets, 2006). However, valuable information can still be learned despite these limitations. A high correlation exists between actual network properties and those measured from random samples of networks (i.e., from incomplete pictures of the network) when using the network measures selected for this study and described above (Costenbader & Valente, 2003). Thus, using these strategic selection of measures, inferences can still be made regarding properties of the network as well as how the network may serve as an intervention (Costenbader & Valente, 2003).

CHAPTER THREE

RESULTS

Descriptive Statistics

Baseline demographic characteristics of participants are listed in Table 1. The 42 participants sent 186 directed friendship ties in total, but 65 ties were sent to girls not participating in this study. When ties to non-participants were removed, 121 directed friendship ties were observed among study participants. Of the 42 study participants, four were missing network data, resulting in 164 possible friendship ties missing from the network (i.e., ties that may have existed if data was available).

Table 1. Baseline Demographic Characteristics of Participants

Characteristic	%	M	SD
Race/Ethnicity	57% Black		
Age		11.95	1.12
Weight status			
Healthy weight	40.5%		
Overweight	21.5%		
Obese	38%		
Daily Total PA minutes		308.48	
Daily MVPA minutes		13.20	
Daily fruit and vegetable servings		5.10	3.25
Daily unhealthy snack servings		0.98	1.89

Note. PA = Physical activity, MVPA = moderate-to-vigorous physical activity.

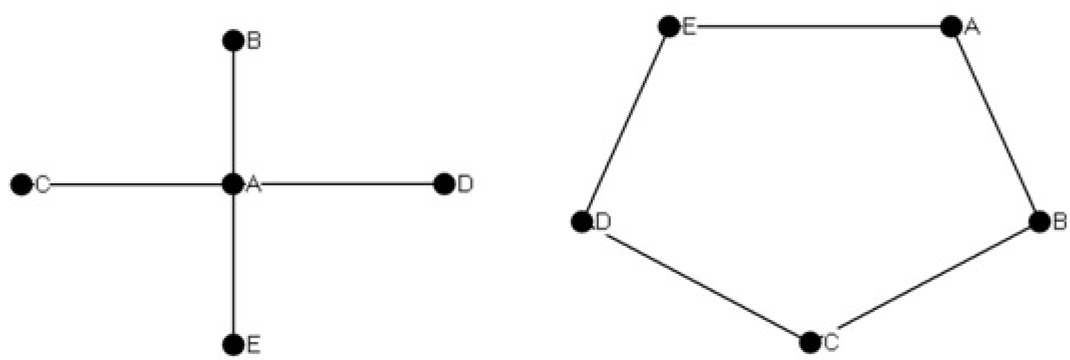
Descriptive statistics of the network are listed in Table 2. The network had a density of 8%, meaning that 8% of the total possible friendship ties formed. *Centralization* refers to the variation in centrality scores of the nodes in the network. It shows the extent to which there is a "center" of the network (i.e., girls with very high centrality scores) and a periphery (i.e., girls with very low centrality scores).

Table 2. Descriptive Statistics of Network

Network property	Definition	Statistic
Density	Proportion of possible ties that exist	.08
Centralization	Distribution of centrality in network	.10
Mean degree	# of friendships per girl	5.76
Isolates	Proportion of nodes with no friendships	.08
Dyads	# of possible node pairs	703
Mutual	# of dyads with reciprocated friendship	28
Asymmetric	# of dyads with unreciprocated friendship	63
Null	# of dyads where no friendship existed	612
Edgewise reciprocity	Proportion of friendship ties reciprocated	.47
Triangles	# of closed triads	172

Centralization can range from 0-1, with a perfectly centralized network (i.e., a network whose centralization is concentrated completely on a single node) obtaining a centralization score of 1 (see Figure 4).

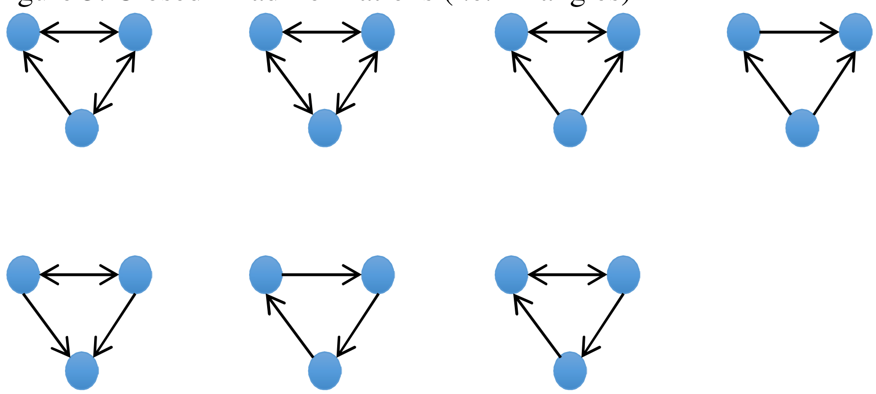
Figure 4. A Perfectly Centralized Network on the Left and a Decentralized Network on the Right



Note. From Valente (2010).

The observed network had a centralization score of 0.10, indicating a network in which centrality was spread among many different nodes. On average, each girl had 5.76 friends, including those they nominated and those who nominated them. Of the total nodes in the network, 8% were *isolates*, i.e., girls who did not send or receive any friendship ties from study participants. Most dyads (i.e., any two girls chosen at random) did not have a friendship tie between them, followed by dyads with an unreciprocated friendship tie, followed by dyads where the friendship as mutual. Almost half (47%) of friendship ties sent by girls were reciprocated (i.e., *edgewise reciprocity*). The network had 172 triangles, i.e. groups of three girls that formed a friendship cluster (see Figure 5). That is, the network demonstrated 172 instances in which if A was friends with B and C, B and C were likely to also be friends.

Figure 5. Closed Triad Formations (i.e. Triangles)



Note. Circles represent nodes, arrows represent direction of friendship ties.

Although data was not available to confirm participants in this study were not friends prior to participating in the program, data collected from another year of the same program (collected as part of a larger research study) may shed light on this likelihood. In the summer of 2014, 25 participants provided data on their friendships with other girls in the program and whether or not they had previously known or been friends with these girls. Of these participants, 49% had not known the friends they made at the camp prior to camp, while 51% of participants reported having been friends with someone at the program before joining the program. When examining total number of camp friendships established prior to the program for each participant, approximately 17% of participants' friendships at the program were established prior to the program. This equated to each girl having on average 1 friendship at the program she established prior to the program, and 4 friendships she made at the program with girls she had not known previously. If each iteration of the program tends to draw similar participants, we may be able to extrapolate that approximately half of participants may have known another participant prior to the program, but that the overwhelming majority of friendships made at the program were new relationships.

Obesity-Related Selection Patterns

To address Aim 1a (i.e., in the network that forms within the program, are overweight youth socially marginalized?), Pearson correlations were initially conducted and revealed that BMI percentile was not significantly associated with betweenness centrality, $r = .30$, $p > .05$. A progression of ERGM models were then constructed in order of simplest to most complex, with the final full model incorporating all terms to fully address Aim 1a as well as Aim 1b (i.e., Is the network that forms within the program characterized by homophily in weight status and obesogenic behaviors, and does this depend on weight status?).

Model progression is presented in Table 3. The initial and simplest model, Model 1, incorporated terms to estimate whether likelihood of friendship tie formation was affected by number of friendship ties observed in the network (*density*), age, race/ethnicity, team, and similarity between a dyad in terms of age, race/ethnicity, and team. Model 2 added terms to estimate the impact of structural aspects of the network on friendship tie formation, including the tendency for a friendship to be mutual (*reciprocity*), and the tendency to befriend friends of friends (*transitivity*).

Table 3. Exponential Random Graph Model (ERGM) Progression

	Estimate (SD)				
Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Density	-6.62**	-5.03**	-8.00**	-8.30**	-7.36***
	(1.41)	(0.76)	(1.43)	(1.45)	(1.62)
Race/Ethnicity Homophily	0.73**	0.47**	0.45**	0.48**	0.48**
	(0.22)	(0.16)	(0.16)	(0.17)	(0.17)
Age	0.14*	0.04	0.09°*	0.09*°	0.07
	(0.06)	(0.03)	(0.05)	(0.05)	(0.06)
Age Heterophily	-0.83**	-0.50**	-0.47**	-0.47**	-0.48**
	(0.19)	(0.15)	(0.16)	(0.16)	(0.17)
Team Homophily	1.98**	0.99**	0.65**	0.66**	0.70***
	(0.26)	(0.21)	(0.19)	(0.20)	(0.21)
Reciprocity		1.20**	1.15**	1.13**	1.07**
		(0.38)	(0.37)	(0.37)	(0.37)
Transitivity (GW-ESP, T = 0.5)		0.90**	0.75**	0.75**	0.73***
		(0.19)	(0.18)	(0.18)	(0.18)
GW-Indegree (S = 0.5)		-0.12	0.55	0.55	0.71
		(0.56)	(0.66)	(0.67)	(0.70)
GW Outdegree (S = 0.5)		1.36*	2.16**	2.20**	2.19*
		(0.67)	(0.83)	(0.85)	(0.86)
Community Homophily			2.19**	2.24**	2.27***
			(0.52)	(0.51)	(0.51)
WS Homophily (Healthy)				0.48*+	0.52*
				(0.26)	(0.26)
WS Homophily (Overweight/Obese)				0.29	0.29
				(0.18)	(0.18)
Net Snacking					-0.02
					(0.02)
Net Snacking Heterophily					-0.06°
					(0.03)
PA Heterophily					-0.01
					(0.01)
Akaike Information Criterion	660.25	605.59	565.94	566.05	563.43
Bayesian Information Criterion	687.01	653.75	619.45	630.26	643.70

Note: °p<0.1; *p<0.05; **p<0.01. GW = geometrically weighted, ESP = edgewise shared partners, indegree = # of friendships received, outdegree = # of friendships sent, WS = weight status, PA = physical activity.

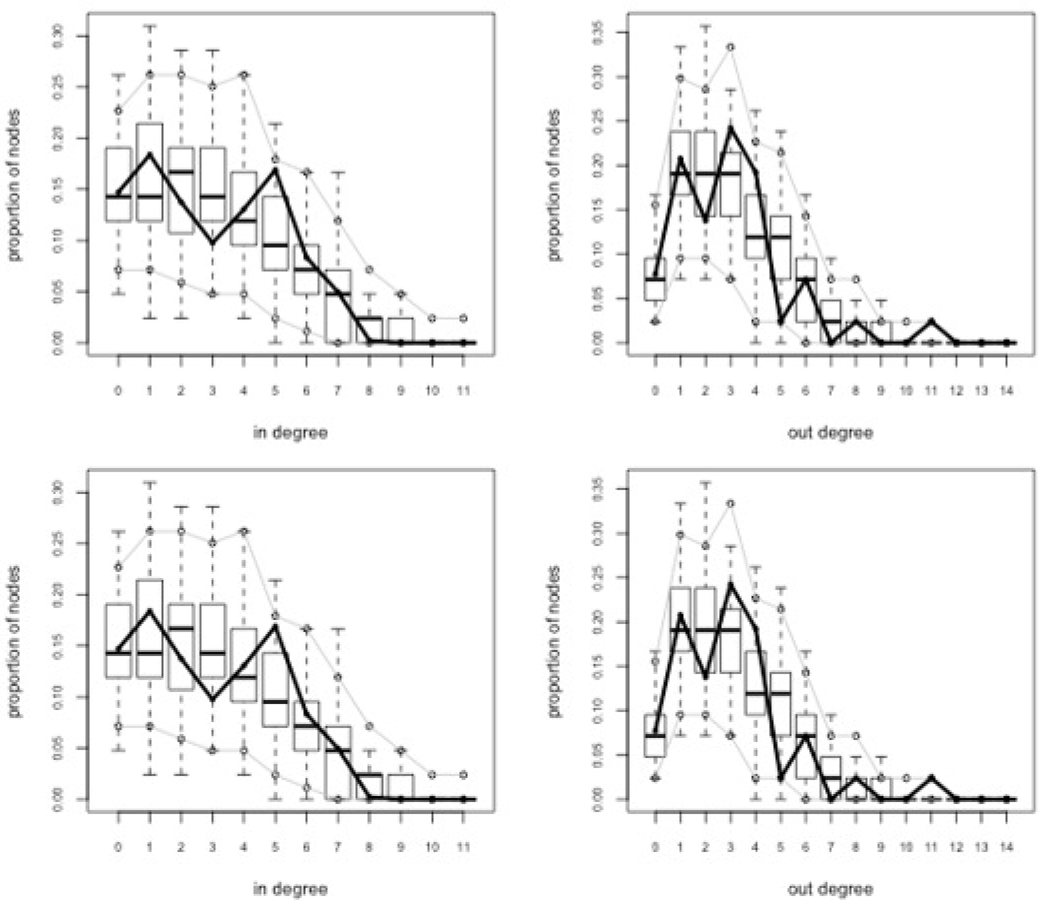
This model also added terms to control for the number of friendship nominations sent by a girl (*geometrically weighted outdegree*) and the number of friendship nominations received by a girl (*geometrically weighted indegree*) in estimating likelihood of tie formation. Model 3 added a term to account for the two distinct communities that network visualization suggested had formed within the network. The communities were identified using the Newman-Girvan edge-betweenness algorithm (Newman, 2004). Model 4 added terms to estimate whether likelihood of friendship tie formation was affected by weight status and similarity of weight status between friends (*weight status homophily*). Lastly, Model 5 added terms to estimate whether likelihood of friendship tie formation was affected by physical activity, dietary intake, and similarity of physical activity and dietary intake between a dyad.

As models were built and terms were added, removed, and modified to improve model fit, non-significant terms that were not helpful for model fit were dropped. For example, main effects of race/ethnicity (added in Model 1), weight status (added in Model 4), and physical activity and dietary intake (added in Model 5) were nonsignificant and thus not included in final models. Models also did not converge with inclusion of servings of healthy snacks or unhealthy snacks. In order to examine this to address study aims, an alternative snacking construct, net snacking, was created by subtracting average daily servings of unhealthy snacks from average daily servings of healthy snacks. Higher net snacking scores reflected more servings of healthy snacks than unhealthy snacks on average.

To compare model fit across the progression, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were examined (Akaike, 1973; Schwarz, 1978). These criteria are relative measures of how well a model fits a dataset (the amount of observed variation it accounts for), while adjusting for the ability of that model to fit any dataset (i.e., its complexity). In other words, these terms can be compared across models to determine the best-fitting model that is also the most parsimonious. Smaller AIC and BIC indicate improved model fit. Examination of AIC and BIC revealed that model fit improved with the increasing complexity of the models, with Model 5 demonstrating the best fit of the five.

To more comprehensively assess Model 5's fit, goodness-of-fit diagnostics were also examined. Goodness-of-fit diagnostics compare structural characteristics of the observed network (degree, transitivity) to those simulated by the model (see Figure 6).

Figure 6. Goodness-of-fit for Measures from Simulated Networks Based on Model 5

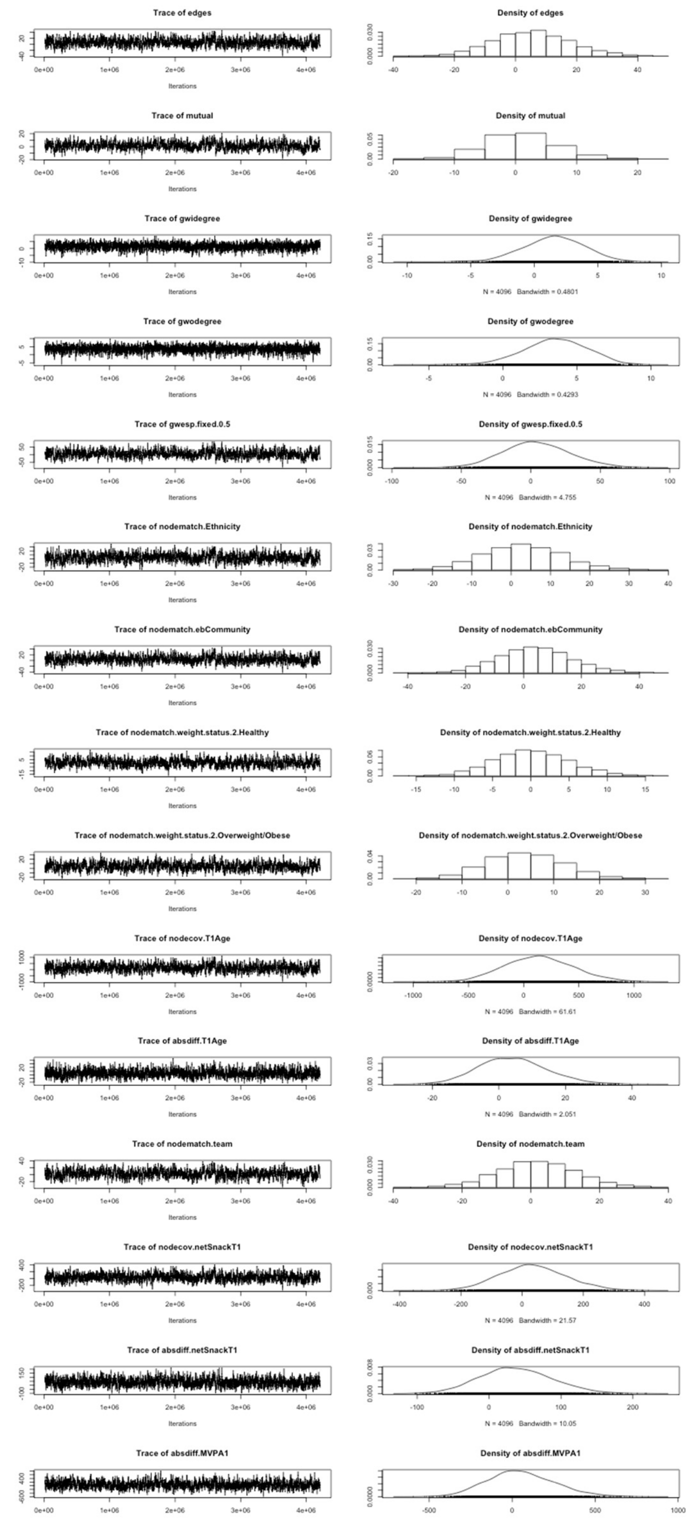


Note. Black lines represent the value in the observed network; gray lines and boxplots represent values simulated from Model 5.

Goodness-of-fit diagnostics suggested that the network simulated from Model 5 reflected a similar distribution to the observed network. Finally, to confirm that Model 5's estimating algorithm converged, Markov Chain Monte Carlo (MCMC) diagnostics were examined. Models that include dyadic dependence terms use an MCMC parameter estimation algorithm to calculate the likelihood of tie formation (Snijders, 2002). MCMC algorithms function by selecting a network at random from all possible networks that could exist with the given data, selecting a dyad from the network at random, toggling the dyad's friendship tie between existing and not existing, then comparing the new network to the pre-toggle network to determine which is a better fit (Harris, 2014). The algorithm then continues with the better fitting network and randomly selects a new dyad to use in the comparison process. This select-compare-decide process is repeated until the specified chain length is reached (Morris et al. 2008). Default chain length was used. Graphic MCMC diagnostics demonstrate statistics related to the final model selected by the algorithm (Figure 7). Following recommendations by Goodreau and colleagues (2008), the chain iterations of the final model were examined for each term in Model 5 as both time series (left side of Figure 7) and histograms (right side of Figure 7). Graphics for Model 5 reveal statistics for each term varying around a mean of zero, where zero represents the value of the statistic in the observed network; this suggests a stable, converged model (Harris, 2008).

Model 5 was thus selected as a well-fitting model and the best fitting of those tested. Several demographic characteristics of girls were revealed to account for significant variation in whether girls became friends. For every one year increase in age, girls were 1.08 times more likely to make a friend. Additionally, girls were more likely to befriend each other if they were of the same race/ethnicity (1.62 times more likely) or on the same team (1.99 times more likely).

Figure 7. Monte Carlo Markov Chain (MCMC) Diagnostics for Each Term in Model 5



Note. Left column represents statistics as time series. Right column represents statistics as histogram. A well-fitting model's statistics should vary stochastically around a mean of zero.

Several structural aspects of the network also contributed to friendship selection patterns: girls were likely to reciprocate friendships, to befriend friends of friends, and to befriend girls within their same endogenously formed community (i.e., one of the two distinct groupings of girls observed in network visualization, described above with Model 3) (see Figure 3). Weight status did not predict likelihood of forming friendship ties, such that girls of different weight statuses were equally likely to form friendships within the program. However, there was significant evidence for differential weight status homophily. That is, compared to dyads of different weight statuses, girls were 1.33 times more likely to be friends if they were both overweight or obese, and 1.71 times more likely to be friends if they were both healthy weight. Neither physical activity nor similarity of physical activity between friends predicted friendship tie formation. Snacking also did not affect friendship tie formation, but there was a marginally significant negative effect of snacking heterophily (p=.09). That is, for every 1 serving difference between two girls in their amount of healthy versus unhealthy snacks, girls were 0.94 times less likely to be friends with each other.

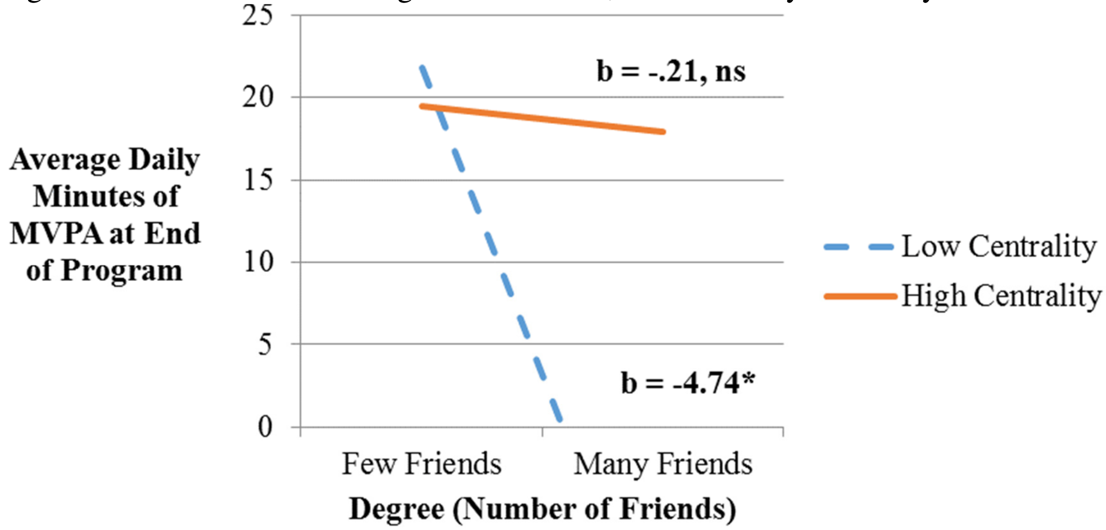
Relation of Selection Patterns to Change in Obesogenic Behaviors

Hierarchical multiple regression analyses were conducted to examine the relation of social inclusion to improvement in obesogenic behaviors, and whether this relation was affected by weight status (Aims 2a and b). Four separate hierarchical multiple regressions were conducted, examining outcomes for total physical activity, moderate-to-vigorous physical activity (MVPA), healthy eating, and unhealthy eating (see Tables 4 and 5). In Step 1 of each regression, number of friends (degree) and centrality in the network (betweenness centrality) were entered as simultaneous predictors, and the Time 2 obesogenic behavior was entered as the outcome. Step 2 of each regression equation included Time 1 obesogenic behavior (to control for baseline levels) and BMI percentile (to test as a moderator). All Step 1 and Step 2 predictor variables were entered after being centered by subtracting the mean from the raw data score. Two-way interaction terms were then entered into Step 3.

No significant main effects were found of social inclusion measures on Time 2 obesogenic behaviors. However, a significant Degree x Centrality interaction emerged predicting Time 2 MVPA ($p = .037$). Post-hoc probing of the significant two-way interaction was conducted with tests of simple slopes, using procedures outlined by Holmbeck (2002). Conditional moderating variables were created in order to test the relation between degree and MVPA at high and low centrality. Regressions were then run incorporating the main effects of degree and betweenness centrality, the conditional variables, and the two-way interactions they produced (Holmbeck, 2002). The interactions were then plotted by substituting high (1 SD above the mean) and low (1 SD below the mean) values of degree, centrality, and BMI percentile (see Figures 8 and 9).

These simple slopes tests revealed that among girls with high levels of centrality, degree was not significantly associated with MVPA. However, among girls with low levels of centrality, degree was significantly negatively associated with MVPA (ß = -.67, $t(32) = -2.70$, $p = .01$). This suggests that girls who occupied important social positions within the network engaged in the same amount of MVPA regardless of *number* of friends they had. In contrast, girls who occupied less important social positions engaged in more MVPA when they also had fewer friends.

Figure 8. Relation Between Degree and MVPA, Moderated by Centrality

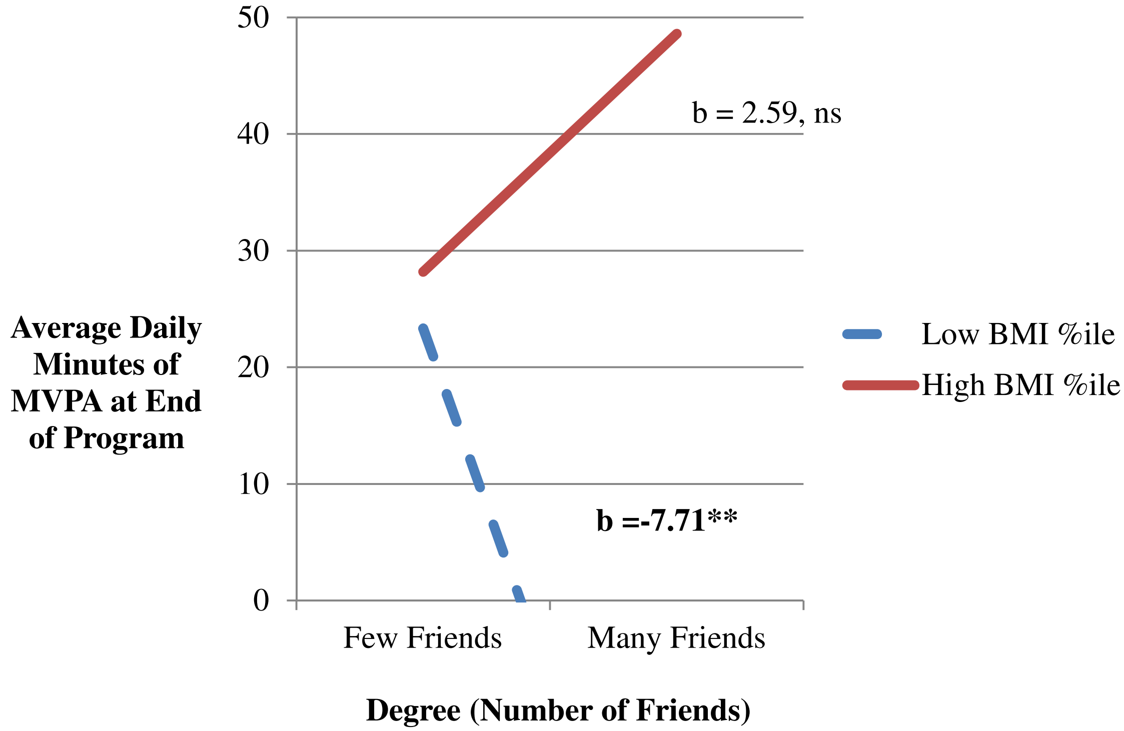


Note. *P<.01, Ns = Not Significant, MVPA = Moderate-To-Vigorous Physical Activity.

A second significant interaction also emerged predicting Time 2 MVPA: Degree x BMI. (p = .022). Simple slopes procedures were again followed using the above outlined procedures. These simple slopes test revealed that degree was significantly negatively associated with MVPA (ß = -1.10, t(32) = -2.89, p = .007) only among girls with low BMI percentile; among girls with high BMI percentile, degree was not related to MVPA. This suggests that among girls with lower BMI percentile, a higher number of friends in the program was associated with engaging in fewer minutes of MVPA.

In order to address Aim 2b (Is girls' change obesogenic behaviors over the course of the program related to the change in the obesogenic behaviors of their friends, and does this depend upon weight status?), network autocorrelation models were fit. In order to guide model building, relationships between obesogenic behaviors of girls and their friends were explored in several ways.

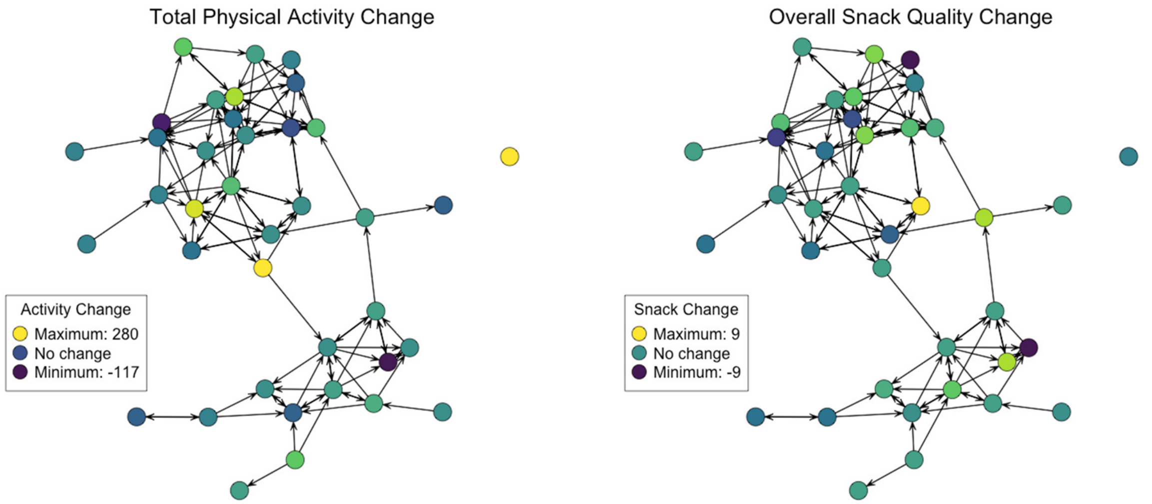
Figure 9. Relation Between Degree and MVPA, Moderated by BMI Percentile



Note. ***p*<.01, *ns* = not significant, MVPA = moderate-to-vigorous physical activity.

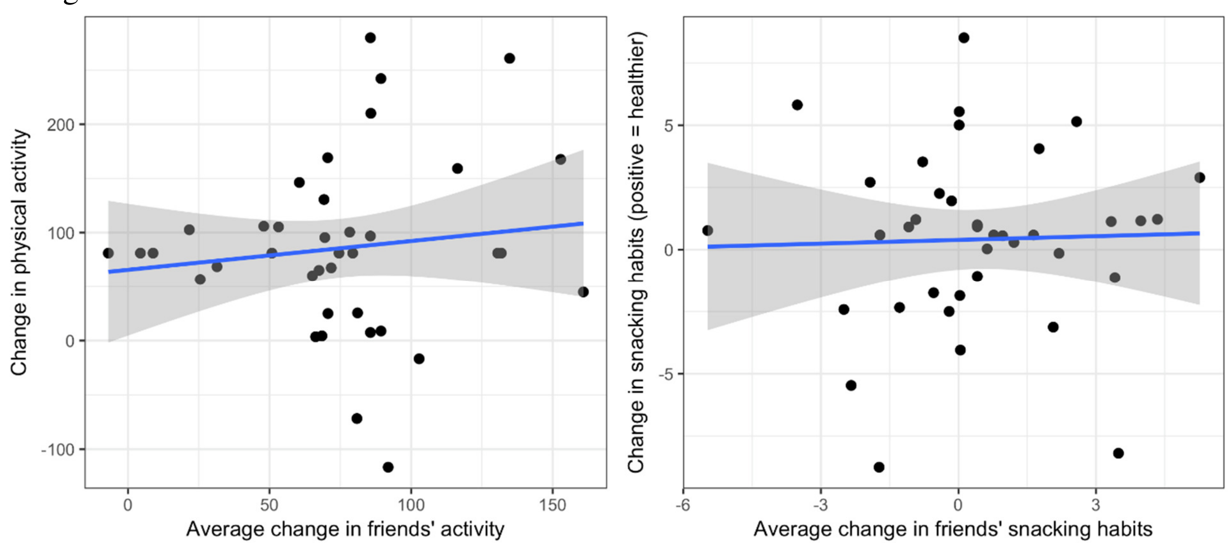
For each participant, change scores were calculated for physical activity (average daily minutes) and dietary intake (change in ratio of healthy to unhealthy snacks) between Time 1 and Time 2. The social network was then plotted with participant color coded by degree of change in these behaviors. Visual examination of the graphs suggested that neither positive nor negative changes in these behaviors appeared to be clustered, and participants in more central locations did not appear to demonstrate more or less change (see Figure 10). Two single variable linear regressions were then run to examine the relation between change in obesogenic behavior between participants and their friends. Regressions were run separately for physical activity and snacking and plotted with line graphs (see Figure 11). Both regressions suggested no significant relation between participants' change in obesogenic behavior and that of their friends (p>.05).

Figure 10. Network Visualization of Obesogenic Behavior Change



Note. Arrows indicate direction of friendship ties. Colors indicate amount of obesogenic behavior change, with darker colors reflecting decreased physical activity and healthy eating.

Figure 11. Relations Between Obesogenic Behavior Change and Friends' Obesogenic Behavior Change



Note. "Activity" represents average daily physical activity. "Snacking habits" represents average daily ratio of healthy to unhealthy snacks.

Finally, network autocorrelation models were built, excluding the four participants from whom social network data was unavailable. Change in obesogenic behavior was modeled as a function of change in obesogenic behavior of friends, with separate models for physical activity and dietary intake. As with ERGM, exploratory models were built guided by theories of social influence while also optimizing model fit, varying measurements of obesogenic behavior and well as covariates. Following recommendations from Leenders (2001), friendship influence was modeled as originating from the alters (e.g., nominated friends) and influencing the ego (participant), rather than stemming from the ego and influencing the alters. Influence was also normalized by the number of friends a participant had. That is, if a participant nominated 10 friends, each friend was specified as having 1/10 weighted influence on the participant. In contrast, if a participant nominated only 1 friend, that friend would have 100% of the possible influence on the participant. To compare model fit, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were examined (Akaike, 1973; Schwarz, 1978). Model choices were additionally guided by theories of social influence. With regards to the physical activity model, the model fit best using total physical activity rather than MVPA. With regards to the dietary intake model, the model fit best using dietary intake as measured by ratio of healthy to unhealthy snacks. Covariates tested included weight status, age, and social inclusion in the network (as measured by centrality as well as number of friends). Covariates that emerged as helpful for model fit and thus remained in the final model were number of friends (both models) and age (physical activity model). Final models (see Table 6) indicated no significant relation between friends' obesogenic behavior change and participants' obesogenic behavior change over the course of the program.

Table 4. Hierarchical Multiple Regression Analyses Predicting Time 2 Physical Activity from Social Inclusion (Degree and Centrality)

	Variable	*Δ R*^{2}	β
Total PA	Step 1	.02	
	Degree		-.09
	Centrality		-.07
	Step 2	.41***	
	T1 Total PA		.65***
	BMI %ile		-.03
	Step 3	.07	
	Degree x T1 Total PA		.06
	Centrality x T1 Total PA		.04
	Degree x BMI %ile		.05
	Centrality x BMI %ile		-.11
	BMI %ile x T1 Total PA		-.19
	Degree x Centrality		.17
	Total R^2 (Total Adjusted R^2)	.33 (83.28)	
MVPA	Step 1	.07	
	Degree		-.35
	Centrality		-.19
	Step 2	.07	
	Time 1 MVPA		-.18
	BMI %ile		-.18
	Step 3	.27	
	Degree x T1 MVPA		-.02
	Centrality x T1 MVPA		-.31
	Degree x BMI %ile		.88*
	Centrality x BMI %ile		-.68°
	BMI %ile x T1 MVPA		.13
	Degree x Centrality		.39*
	Total R^2 (Total Adjusted R^2)	.21 (24.52)	

Note. °p<.10, **p*<.05, ***p<.001. PA = physical activity, MV = moderate-to-vigorous.

Table 5. Hierarchical Multiple Regression Analyses Predicting Time 2 Dietary Intake from Social Inclusion (Degree and Centrality)

	Variable	ΔR^2	β
FV Servings	Step 1	.03	
	Degree		-.07
	Centrality		.08
	Step 2	.21*	
	T1 FV Servings		.52**
	BMI %ile		.13
	Step 3	.14	
	Degree x T1 FV Servings		-.36
	Centrality x T1 FV Servings		.33°
	Degree x BMI %ile		-.16
	Centrality x BMI %ile		-.01
	BMI %ile x T1 FV Servings		.28
	Degree x Centrality		.05
	Total R^2 (Total Adjusted R^2)	.17 (2.63)	
US Servings	Step 1	.01	
	Degree		-.16
	Centrality		.08
	Step 2	.03	
	Time 1 US Servings		.26
	BMI %ile		
	Step 3	.14	
	Degree x T1 US Servings		.11
	Centrality x T1 US Servings		-.51
	Degree x BMI %ile		-.38
	Centrality x BMI %ile		.35
	BMI %ile x T1 US Servings		-.88°
	Degree x Centrality		-.03
	Total R^2 (Total Adjusted R^2)	-.09 (.79)	

Note. °p<.10, *p<.05, **p<.01, ***p<.001. FV = fruit and vegetable, US = unhealthy snack.

Table 6. Network Autocorrelation Models of Obesogenic Behavior Change

	Estimate (SD)	
Variable	Physical Activity	Dietary Intake
Age	5.90** (2.07)	-0.08 (0.08)
Number of Friends	10.50 (6.29)	0.46 (0.26)
Change in Friends' Behavior	-0.26 (0.21)	-0.05 (0.23)
Akaike Information Criterion	447.5	208.6
Bayesian Information Criterion	454.1	215.1

Note. °p<.10, **p<.01. Physical activity measured as average daily physical activity in minutes. Dietary intake measured as difference between servings of healthy snacks and unhealthy snacks, with higher scores indicating more healthy snacks.

CHAPTER FOUR

DISCUSSION

This study investigated how the friendship network formed within community-based summer programming for girls may relate to obesity risk (i.e., weight status and obesogenic behaviors) and improvements in obesity risk over the course of programming. It has become clear that friendship selection patterns related to obesity (i.e., social marginalization of overweight youth and obesogenic friendship clusters) maintain and promote obesity risk among overweight youth (Salvy & Bowker, 2014). Identifying contexts such as summertime programming that may foster alternative friendship experiences for overweight youth and whether such patterns would relate to reduced obesity risk would provide evidence for intentionally developing programming with this goal in mind. Furthermore, research suggests that low-income girls of color may particularly need and benefit from programming that addresses friendship selection influences on obesity (e.g., Ogden et al., 2014; Jago et al., 2009; Jago et al., 2012), and that community-based summer programming may be an ideal vehicle to do so. However, to date, this is the first study to use social network analyses to examine the friendship network that emerges in community-based summertime girls' programming and how this friendship network may relate to girls' obesity risk. There were two broad questions examined in this study: (1) *how did selection patterns relate to obesity?* and (2) *what was the relevance of those selection patterns to girls' improvement in obesity risk over the course of programming?*

Obesity-Related Selection Patterns

It was expected the friendship selection patterns that emerged in the program would relate to obesity and obesogenic behaviors in ways distinct from those typically observed in adolescent friendship networks. Specifically, it was expected that in the network formed within the program, overweight youth would not be socially marginalized as they typically are in adolescent friendship networks. Consistent with hypotheses, overweight girls were socially included; regardless of BMI percentile, girls were equally likely to form friendships and to occupy central, well-connected, important positions within the network. These findings stand in stark contrast to previous research of school friendship networks, in which overweight youth occupied less important, more peripheral positions within the network, and the number of friendship nominations received decreased as adolescent BMI percentile increased (Strauss & Pollack, 2003). This suggests that a community-based summer program similar to GIG may be able to foster novel friendship experiences for youth that are distinct from that typically experienced within school related friendship networks. That it may be possible for community-based summer programming to foster friendships for overweight youth is exciting given that obesity risk is often maintained by social exclusion (Salvy & Bowker, 2013; Salvy, Bowker, Germeroth, & Barkley, 2012).

Most notable is that the social inclusion of overweight youth was observed in the setting of organized PA. During PA, overweight youth often experience teasing, weight-based criticism, and victimization, and this is associated with decreased enjoyment and participation in PA (Dishman, Motl, Saunders et al., 2005; Faith et al., 2002; Gray, Janicke, Ingerski, & Silverstein, 2008; Rittenhouse & Barkley, 2013; Rukavina & Li, 2008; De Bourdeaudhuij, Lefevre, Deforche, Wijndaele, Matton, & Philippaerts, 2005). These negative peer experiences and subsequent withdrawal from PA are more marked in organized PA settings (e.g., gym classes, sports teams) (De Bourdeaudhuij et al., 2005; Dishman et al., 2005; Gray et al., 2008; Salvy, Bowker, et al., 2008) and among overweight girls compared to boys (Faith et al., 2002). Thus, elucidating organized PA contexts in which overweight youth, particularly girls, are socially included is an important step towards fostering enjoyment of and participation in PA among youth at risk for obesity. Indeed, youth are more likely to participate in PA when they have positive relationships with friends and peers, and when they perceive that their friends support PA (Jago et al., 2009; Jago et al., 2011; Jago et al., 2012). Experimental research has demonstrated that when in the presence of peers, overweight youth engage in more PA than when alone (Rittenhouse, Salvy, & Barkley, 2011). Findings from this study suggest that community-based summer programming similar to GIG may be a context that can foster friendship networks that provide overweight youth with the friendship experiences necessary for PA.

A second friendship selection pattern that was expected to be absent from the observed friendship network was obesogenic friendship clusters. Specifically, it was expected that girls would be equally likely to form friendships with others regardless of weight status and dietary habits, though given the program's emphasis on PA it was expected they would select friends with similar PA levels. Results contradicted all predictions. Girls were more likely to befriend girls of the same weight status, particularly among healthy weight girls. Compared to dyads with unequal weight statuses (e.g., one girl who was healthy weight and one girls who was overweight), girls were 1.33 times more likely to be friends if they were both overweight, and

1.71 times more likely to be friends if they were both healthy weight. Results highlight that weight-based homophily is a strong phenomenon that persisted even when overweight youth were more socially included. Weight-based homophily is thought to often be driven by social exclusion of overweight youth, because overweight youth are left with only other overweight peers to befriend (de la Haye et al., 2011). Results from this study suggest, however, that such tendency for "birds of a feather to flock together" with regards to weight may persist even when overweight youth are not marginalized. Indeed, research suggests that adolescent friendships that persist are characterized by similarity across social, behavioral, and salient demographic characteristics (Aboud, Mendelson, & Purdy, 2003; Hartl, Laursen, & Cilletssen, 2015), which weight status may relate to in a number of ways (e.g., appearance, obesogenic behaviors, peer acceptance, etc.). An example of this can be found among adults and may extend to youth: in a study of mother-child dyads participating in a group pediatric obesity intervention aimed at preschool aged children, mothers tended to form new friendships in the program with mothers whose children had similar BMI (Gesell, Bess, & Barkin, 2012). Indeed, in the observed program, similarity in other characteristics besides weight were even more important in predicting program friendships: sharing the same race/ethnicity and being part of the same team. In a similar nature, the weight-based homophily observed in the program may be driven more by general tendency towards homophily than to social exclusion of overweight youth. Alternatively, it is also possible that although BMI percentile did not relate to number of friendships nor centrality of position within the network, overweight youth still experienced bias in friendships, such as differential qualitative aspects of those friendships. Developmental psychology research highlights that overall, adolescents consider physical appearance and athletic skill as critically important to popularity (Chase & Dummer, 1992). In Western culture, weight status may relate to both of these characteristics; as such, stigma towards overweight youth may relate strongly to developmental norms at adolescence and therefore may be difficult to erase altogether.

Predictions regarding friendship selection based on obesogenic behavior were also contradicted. Girls were just as likely to be friends regardless of similarity or difference in their PA levels. This finding stands in contrast to a recent systematic review of social network analyses of youth PA which found strong evidence for similarities in PA between youth and their friends (Macdonald-Wallis, Jago, & Sterne, 2012). However, a longitudinal study by Gesell and colleagues (2012) suggested that adolescent friends' similarity in PA may be more related to influence over time than to selection effects. Among an ethnically diverse sample of 5-12 year olds, youth did not select friends based on PA but rather based on similarity in age, school, and race/ethnicity (Gesell, Tesdahl, et al., 2012). However, over time youth heavily emulated the PA levels of their friends (Gesell et al, 2012). Thus, it is possible that the lack of PA homophily impacting friendships is because PA homophily is more often an effect of influence than selection. Alternatively, these findings also highlight the potential for summer programming to foster friendships between girls with very different levels of PA, with the long-term goal of harnessing friendship processes to reduce pediatric obesity. In fact, pediatric obesity investigators have recently called for programming that fosters friendships between sedentary and active girls within settings that overall promote PA, as a strategy for improving PA levels across the entire program social network (Salvy & Bowker, 2014; Gesell et al. 2012).

In contrast to the lack of a relation between PA and friendship formation, dietary intake did appear somewhat relevant to who girls selected as friends. Specifically, girls were more likely to befriend other girls in the program who consumed a similar net amount of healthy snacks (i.e., average number of healthy snacks minus unhealthy snacks per day). For every one serving difference between two girls in their net healthy snack servings, girls were 0.94 times less likely to be friends with each other. Only a few other studies have examined similarity in dietary intake among adolescent friends, and results have been mixed. In a study of Dutch adolescents using a food frequency questionnaire, friends demonstrated similarities in specific foods eaten but not fat consumption (Feunekes, de Graaf, Meyboom, & van Staveren, 1998). In a more recent study of Australian adolescents also using a food frequency questionnaire, de la Haye and colleagues (2013) found adolescent friend groups to generally consume the same amount of nutrient poor, energy dense foods. However, in another study of Australian adolescents by de la Haye and colleagues (2010), fast food consumption clustered only among male adolescent friends; fast food consumption was not related among adolescent female friends. Although some discrepancies exist across results from these studies and the present study, differences may be attributed to measurement issues (food frequency questionnaire vs. 24-hour dietary recall; specific type of dietary intake measured) and cultural differences (Dutch, Australian, American adolescents). In the present study which sampled American adolescent girls of color, friends tended to make similar choices with regards to amount of healthy versus unhealthy snacks. Indeed, among American adult friends, similarities in diet can be observed most strongly for snack foods (Pachucki, Jacques, & Christakis, 2011). However, some have argued that similarities in diet among friends may more related to influence of friends over time (e.g., de la Haye et al. 2013; Pachucki et al. 2011). The present results suggest that some adolescent friends may *select* friends with similar dietary habits, though it remains unclear whether dietary habits were a salient factor in friendship selection, or whether adolescents were simply selecting friends who are similar in other attributes and behaviors that may correlate with diet (de la Haye et al., 2013).

An additional friendship selection pattern that was observed in the program was the formation of two distinct communities, which were largely determined by age. Due to developmental changes that occur for girls at adolescence, age may be particularly important to friendship selection patterns among adolescent girls in contexts that involve PA. Age is a significant correlate of PA prevalence among adolescent girls, such that older adolescent girls may be less likely to engage in PA or more engage in different ways than younger adolescent girls (Butcher, Sallis, Mayer, & Woodruff, 2008; Pate et al., 2009). Age in adolescence is also associated with pubertal development, which has particular implications for girls compared to boys. Among girls, puberty brings about increased self-consciousness and discontent with their bodies (Davison, Werder, Trost, Baker, & Birch, 2007). Longitudinal research suggests that through these psychological mechanisms, pubertal development is associated with less PA, particularly MVPA, among girls (Davison et al., 2007). Furthermore, as girls move through adolescence, appearance and their bodies become increasingly important to their self-esteem and self-concept (American Association of University Women, 1991). Among girls of color, such as those included in this study, this increased valuing of physical appearance may feel incompatible with PA. A qualitative study by Taylor and colleagues (2000) with African American and Latina girls aged 11-15 found that PA was perceived as a barrier to maintaining an attractive appearance. Although the presence study may have diminished this concern somewhat by providing a single-sex environment, appearance concerns are pervasive for adolescent girls and may have persisted. Given these many developmental changes that occur for adolescent girls in ways that relate to PA, it is not surprising that age emerged as a relevant factor in friendship selection in the present study. Future research should examine the relevance of age to friendship-focused strategies for improving weight-related behaviors. For example, programming may need to be tailored to uniquely address the different needs of girls at different stages of development in adolescence.

Relation of Selection Patterns to Change in Obesogenic Behaviors

It was expected that the friendship selection patterns that emerged in the program would have implications for changes the adolescents demonstrated in obesogenic behavior over the course of the program. Specifically, it was hypothesized that girls who were more socially included would demonstrate larger improvements in PA and dietary intake during programming. Findings found that social inclusion did not relate to change in obesogenic behaviors, with the exception of a subset of girls for whom social inclusion related to change in MVPA in unexpected ways. For girls on the periphery of the friendship network and girls with lower BMI percentiles, having more friends in the program was associated with engaging in *less* MVPA. In contrast, among girls who occupied more central positions within the network, and among girls with higher BMI percentiles, number of friends did not relate to MVPA. That is, among overweight girls and girls who occupied central social positions in the program, having fewer friends did not impact their level of MVPA. Although research has underscored an association between more friends and more MVPA (e.g., Jago et al., 2012), findings from this study highlight that in some situations, *fewer* friends may be conducive to engaging in more MVPA. Findings suggest that the relation between number of friends and MVPA may depend upon weight status and how critical the adolescent is to the friendship network. This is consistent with a review by Salvy and Bowker (2014) suggesting that the presence of friends does not unequivocally increase PA among adolescents. It also matters, for example, whether those friends feel emotionally close to the adolescent and support PA (Vilhjalmsson & Thorlindsson, 1998), and whether the friendship group exists in a broader peer context that also promotes PA (Saunders et al., 2004). It is possible BMI and social position within the program were relevant to the qualitative experiences girls had within their program friendships, such that girls who were healthier weight and on the periphery of the social network experienced friendships in a way that did not promote more PA. For example, a qualitative study by Jago and colleagues (2009) found that among some adolescent female friendship groups, lower PA ability was perceived as desirable. Furthermore, research suggests that as girls move through adolescence, they increase priority of their social lives and deprioritize PA (Whitehead & Biddle, 2008). While PA and socialization may not be mutually exclusive at other stages of life, adolescent girls report often finding them to be incompatible (Whitehead & Biddle, 2008; Taylor et al., 2000). Indeed, research suggests that adolescence is a developmental stage in which girls are increasingly interested in spending time with friends, and that adolescent girls who are less physically active report not perceiving PA as fitting in with “what teenage girls do” (Whitehead & Biddle, 2008). Furthermore, adolescent girls who engage in more PA report doing so at a cost to their socialization needs, reporting it as challenging to fit both PA and socializing into their lives (Whitehead & Biddle, 2008). In sum, specific social circumstances, including physical activities that are structured to allow for significant socialization, may be needed to promote MVPA among adolescent girls.

It was also hypothesized that girls would be more likely to make improvements in PA and dietary intake if their friends did. Results did not support this hypothesis. This was surprising given that many studies suggest that youth are influenced by their immediate friends' eating and exercise behaviors (see Salvy & Bowker, 2014, for review). In particular, several observational longitudinal studies have suggested that adolescents emulate the obesity-related health behaviors of their friends over time. For example, in a three-month study of youth age 5-12 in after-school programs (40% African American, 39% white, 19% Latino), youth consistently made adjustments to their PA level of 10% or more to match the PA level of their immediate friends (Gesell, Tesdahl, et al., 2012). Similarly, in a study of Australian high schoolers, adolescents were especially likely to adopt or maintain a similar low amount of junk food consumption if their friends consumed low levels of junk food; in contrast, adolescents with friends who consumed a high level of junk food were likely to adopt or maintain high levels of junk food consumption (de la Haye, Robins, et al., 2013). Indeed, both studies concluded that the effect of friendship influence on obesogenic behaviors over time was marked, such that in order to address pediatric obesity, it will be critical to provide youth with friendship contexts that foster healthy eating and physical activity (Gesell, Tesdahl, et al., 2012; de la Haye, Robins, et al., 2013). However, these friendship influences on obesity-related behaviors were observed over a longer time frame than was possible in the current study (three months and one year, respectively). Thus, it is possible that the one-month duration of the program was insufficient time for youth to begin to emulate the obesity-related health behaviors of their friends. Indeed, a

Cochrane systematic review suggests that programming intended to improve obesity-related health behaviors should be at least twelve weeks in duration for behavior change to occur (Summerbell et al., 2005).

In addition to differences in duration, there are other key factors that may explain the discrepancies in findings between this study and the only previous observational (versus experimental), naturalistic (versus lab-based) study of adolescent friendship influence on dietary intake (de la Haye, Robins et al. 2013). De la Haye and colleagues (2013) measured dietary intake by asking adolescents to self-report their consumption of unhealthy foods over the last month. Self-report of dietary intake, particularly over a month-long period, tends to overestimate energy intake and is less reliable compared to the 24-hour, multiple pass dietary recall method (McPherson et al., 2000) used in this study. In addition to this difference in measurement, de la Haye's study includes only Caucasian Australian older adolescents. It is possible that the friendship influence observed on unhealthy snack consumption is not generalizable to younger American girls of color. Finally, it is also possible that the duration of programming was sufficient but that the small sample size limited detection of significant findings.

Limitations and Future Directions

Although results are promising, several limitations of the study hinder conclusions that can be drawn. Results are perhaps more strongly limited by the substantial proportion of participants in the program friendship network who were missing from data analyses. Although numerous steps were taken to minimize the impact of missingness on data analysis, missing data in social network analyses can result in inflated measurement error (Kossinets, 2006). Future studies of friendship networks in summer programming should collaborate with programming partners to prioritize obtaining complete network data in order to more accurately understand selection patterns and their relevance for behavior change. Furthermore, this study focused solely on the experiences of low-income, African American and Latina girls. Although this demographic group was chosen intentionally given they are disproportionately affected by obesity, findings may not generalize to more affluent youth, to boys, or to youth of other ethnicities. For example, the racial/ethnic makeup of study participants may have partially explained why BMI percentile did not relate to popularity or social importance within the observed network. Although adolescent females, compared to younger females and to child or adolescent males, demonstrate the strongest stigma towards overweight youth, Black females demonstrate significantly lower weight-based stigma compared to their Caucasian counterparts (Gray, Simon, Janicke, & Dumont-Driscoll, 2011). Furthermore, youth who participated in this very unique summer program may have unique characteristics. In general, participation in organized activities such as summer programs declines as youth transition into adolescence (Eccles & Gootman, 2002). Out-of-school-time programming is often unable to provide activities that interest adolescents (Mahoney, Larson, Eccles, & Lord, 2005). As such, youth who participated in this program may hold certain characteristics that render findings not generalizable to adolescents who did Future research should examine contexts that promote friendship network patterns that promote healthy weight among other groups of youth besides those studied here, including younger age, other races and ethnicities, and other types of programming.

Another limitation of this study is that its short duration may have curtailed the ability to observe the implications of fostering novel social experiences in the context of organized PA.

Indeed, this study found no evidence that girls' improvement in obesogenic behaviors over the course of the program was related to their social inclusion nor to their friends' behavior change. Although summer programming has shown promise in improving weight-related behaviors among youth in both the short and long-term (e.g., Gately, Cook, Butterly, Mackreth, & Carrol, 2000), research is still needed to determine how such summer programming can more reliably instigate long-term behavior change (Jago & Baranowski, 2004). Given the importance of friendship goals and influences on youth motivation to engage in healthy weight-related behaviors (e.g., Salvy & Bowker, 2014; Zarrett, Sorensen, & Skiles, 2013) and the potential summer programming offers for social regrouping and atypical friendship selection (e.g., Bohnert et al.,2013; Dworkin, Larson, & Hansen, 2003), summer programming offers a unique vehicle for leveraging social influences of friendship networks to increase and maintain healthy weight related behaviors in the long-term. While the short duration of this study may not have allowed for observation of social influence, longer studies of other out-of-school-time programming have demonstrated clear friendship influences on healthy eating and physical activity (Gesell, Tesdahl, et al., 2012; de la Haye et al., 2013). As such, there is growing evidence for the feasibility of network-based interventions to promote healthy weight among adolescent girls (e.g., Giannini et al., 2017). This study highlights the potential for summer programming to promote alternative friendship experiences for overweight youth in the context of organized PA. Future research should examine the relevance of selection patterns to obesity risk over the course of longer summer programming.

Implications and Conclusions

This study was interested in whether summertime programming may disrupt typical adolescent friendship network patterns that maintain and increase obesity risk among overweight youth: social marginalization of overweight youth and obesogenic friendship clusters. Evidence was found for disruption of only one of these patterns, social marginalization. That is, overweight youth were socially included, but they still tended to befriend other overweight girls with similar dietary habits. However, fostering social inclusion may be enough to instigate benefits for overweight youth, even if the friends they make may still tend to also be overweight. One experimental study of adolescent boys found that interacting with peers, regardless of the weight status of the peers, was important in increasing PA among overweight youth (Rittenhouse et al., 2011). Identifying organized PA contexts that foster socially inclusive experiences may be especially important to do for early adolescent girls, who are at disproportionately high risk for obesity. Longitudinal research by Jago and colleagues (2012) found that girls' continued engagement in MVPA during out-of-school time across the transition from elementary school to middle school was dependent upon having friendships. Each additional friend girls had during this developmental stage was associated with 3.7 more minutes of MVPA after school and 9.8 more minutes of MVPA on the weekend (Jago et al., 2012).

Friendship-focused strategies show promise for improving weight-related behaviors among adolescent girls (Camacho-Miñano et al., 2011). Results from this study extend previous research calling for understanding of friendship selection patterns that emerge in programming related to improving obesity risk among youth (Gesell, Tesdahl, et al., 2012). Findings corroborate the potential for summer programming to foster specific social experiences for youth that may translate into healthy weight attitudes (e.g., engaging in PA is fun regardless of weight status and prior skill level) and behaviors in the long-term (e.g., engaging in PA, choosing healthier snacks) (Gesell, Tesdahl, et al., 2012; Jago & Baranowski, 2004; Smart Richman & Leary, 2009).

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VITA

Kimberly Rosania received her doctor of philosophy degree in clinical psychology from Loyola University Chicago in August 2017. She received her B.A. in Psychology from Duke University in 2006. During her time at Duke, she completed an honors independent research project, for which she won the Duke's 2006 Karl E. Zener Award for Outstanding Performance of a Major in Psychology. After graduating from Duke, Dr. Rosania led an after-school program for urban girls in Boston, MA, for which she created a research-based curriculum to promote psychological and physical well-being. She later administered neuropsychological tests as Head Psychometrician at a private practice in Boston, MA. She received her Masters of Arts in Clinical Psychology in May 2014 from Loyola University Chicago. During graduate school at Loyola, Dr. Rosania was a member of Dr. Amy Bohnert's Activity Matters Lab. As part of this lab, Dr. Rosania worked on a variety of projects in pursuit of her diverse interests with regards to adolescent health. These included projects drawing on samples of low-income girls of color to examine the relations between obesogenic behaviors, discretionary time use, and social context; correlates of obesogenic snacking during the after-school hours; relations between physical activity, executive function, and obesity; the impact of school calendar on obesity risk; relations among executive functions, grit, and self-worth; how obesity and body image are spread across social networks; relations between body mass index, physical activity, and leadership qualities; and how engagement is measured in youth settings. Her master's thesis examined links among self-objectification, self-surveillance, body dissatisfaction, and self-worth. Her dissertation examined the relevance of friendship selection patterns to obesity and obesogenic behaviors in a network of adolescent girls. Work on these various projects has resulted in a paper presentation and numerous poster presentations in addition to several publications accepted and several more under review.