USING SOCIAL NETWORK ANALYSIS TO BETTER UNDERSTAND COMPULSIVE EXERCISE BEHAVIORS AMONG COLLEGE WOMEN

A Dissertation

by

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ABSTRACT

Compulsive exercise, or the drive to exercise despite physical, social, or emotional consequences, is a common precursor and symptom of eating disorders. College-aged women are at high risk of developing disordered behaviors including compulsive exercise compared to other population subgroups. Social network analysis (SNA) is a theoretical perspective and methodology that allows researchers to observe the effect of relational dynamics on people's behaviors and could be particularly useful in studying compulsive exercise. The purpose of this dissertation was to use SNA to investigate compulsive exercise among college women. To do so, we conducted two systematic literature reviews and two SNAs.

The first systematic review documented 38 studies investigating which factors shape disordered exercise and answered the question whether SNA has been employed in these reports. The second systematic review documented 15 studies using SNA to investigate the health of college-aged adults. This review provided insight into which health behaviors were studied among college-aged adults, and which network variables were related to their behavior. The first SNA employed a whole network design to measure network characteristics related to compulsive exercise within a sample of college women. The second SNA comprised an egocentric network analysis and measured the ego network characteristics related to compulsive exercise within the same sample.

Results from the two systematic reviews and two SNAs support the use of SNA in studying compulsive exercise among college women. Results suggest: (a) psychological influences on compulsive exercise, including personality and body dissatisfaction, are the most commonly reported factors in the literature; (b) network centrality and homophily influence drinking behavior (the most common health concern studied using SNA among college-aged adults); (c) eigenvector centrality, closeness, and clustering were the whole network variables related to compulsive exercise in the network analysis we conducted; and (d) ego network composition, specifically being close to roommates and siblings, was related to compulsive exercise behaviors in our egocentric network study. Implications for future research and practice are discussed.

DEDICATION

This dissertation is dedicated to my husband, Clint Patterson, and my mentor, Dr. Patricia Goodson. Clint, you have been with me every step of the way since I started graduate school. You are the most important connection in my network, and I am so grateful for your support, consistency, kindness, and love. Dr. Goodson, I also want to dedicate this project to you, because it was you that challenged me and inspired me from beginning to end. You have taught me more than you could ever know. Thank you.

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CHAPTER I

INTRODUCTION

Eating disorders carry the highest mortality rate of any mental illness (Sullivan, 1995), resulting in approximately 134,400 deaths per year in the United States (Sullivan, 1995; Walter, 2013). A common precursor to diagnosis of eating disorders, and often a characteristic of persons with eating disorders, is engagement in compulsive exercise (Dalle Grave, 2009; C. Davis, Kennedy, Ralevski, & Dionne, 1994; Epling & Pierce, 1996; Polivy & Herman, 2002). Compulsive exercise manifests itself as a drive or impulse to exercise, as prioritizing exercise over other activities, and as feelings of guilt and anxiety when exercise is postponed (Dalle Grave, 2009). While regular exercise is highly recommended due to resulting health benefits (U. S. Department of Health and Human Services, 2008), if exercise becomes compulsive it can be extremely hazardous (Dalle Grave, 2009; Dalle Grave, Calugi, & Machesini, 2008). Compulsive exercise can be physically and psychologically damaging and is often the most difficult behavior to treat among eating disorder patients (Meyer, Taranis, Goodwin, & Haycraft, 2011).

Of the 24 million people suffering from eating disorders in the United States, the majority are quite young: approximately 90% are between the ages of 12 and 25 (Szmukler & Patton, 1995; The Review Center Foundation for Eating Disorders, 2003). Eating disorders disproportionately affect college-aged women, compared to other groups (Cash, 2004; Massachusetts Eating Disorders Association, 2014; Pyle, Neuman, Halvorson, & Mitchell, 1991; Striegel-Moore & Franko, 2003), affecting about 10% of

at-risk females (females between the ages of 15 and 29 years; Polivy & Herman, 2002). In addition to being vulnerable to diagnosis of an eating disorder, recent research has shown a large prevalence of compulsive exercise among college women (Guidi et al., 2009; Thome & Espelage, 2007).

Eating disorders and compulsive exercise behaviors have biological, psychological, and sociocultural precursors, including body dissatisfaction (Dittmar, 2005; Vartanian et al., 2014), earlier physical maturation (Shisslak & Crago, 2001), perfectionism (Flett & Hewitt, 2005; Taranis & Meyer, 2011), internalization of media ideals (Goodwin, Haycraft, Willis, & Meyer, 2011; White & Halliwell, 2010), and social influences (Goodwin, Haycraft, Willis, et al., 2011; K. J. Homan & Lemmon, 2014; Rancourt, Choukas-Bradley, Cohen, & Prinstein, 2014; Rudd & Lennon, 2000). Social influence is especially important among college populations, as students are more prone to adopt and spread health behaviors (Hays & Oxley, 1986; Paul & Kelleher, 1995; Paxton, Schutz, Wertheim, & Muir, 1999) present in their social networks.

Social Network Analysis (SNA) is a theoretical perspective and set of techniques used to better understand connections among people (Valente, 2010; Wasserman & Faust, 1994). The chief assumption of SNA is that analysis is focused on the connections and relationships among people rather than on the individual persons that make up a system of relationships (Meadows, 2008). There are two main approaches to conducting SNA: whole network and egocentric network approach. Whole network studies pinpoint central players that influence large parts of an entire network and indicate subgroups of people that are distinctly influential within the network (McPherson, Smith-Lovin, &

Brashears, 2006; Paul & Kelleher, 1995). Egocentric network analysis allows insight into how one's personal network affects his or her behavior (McCarty, 2002; Paxton et al., 1999). Both egocentric and whole network studies have been conducted to better understand complex health behaviors (de la Haye, Robins, Mohr, & Wilson, 2010; Helleringer & Kohler, 2007; Pearson & Michell, 2000) and are being used more widely in the public health and health promotion fields. With SNA's rising popularity in the social, behavioral, and health sciences, more attention should be paid to what questions can be answered with the different approaches and to the variations in findings gleaned from each one.

Given the large prevalence of eating disorders in the college student population, the potential threat compulsive exercise poses to college students (Guidi et al., 2009; Quick & Byrd-Bredbenner, 2013; Thome & Espelage, 2007) and the substantial influence social networks have on these students' behavior (Hays & Oxley, 1986; Paul & Kelleher, 1995; Paxton et al., 1999), using SNA could significantly enhance the understanding of compulsive exercise among this population. Furthermore, analyzing the problem from both egocentric and whole network perspectives can add to the body of knowledge in ways only one approach may not be able to. An egocentric network analysis, for instance, might provide suggestions of the mechanisms through which social influences shape compulsive exercising among college students, while a whole network research might identify patterns of compulsive exercise within a larger, collective network. Though egocentric and whole network research are both considered SNA, the questions the researcher can ask, what measures can be derived, and what

conclusions can be made are vastly different. Using both approaches on the *same population* and the *same behavior* will clarify how these approaches differ and what can be learned from each perspective.

The long-term goal of this dissertation, therefore, is to: (1) provide intervention target points within social networks that would help minimize compulsive exercise behaviors among female college students, and (2) expand the use of SNA in health behavior research. Therefore, I hypothesize that this project will specify personal and whole network characteristics associated with compulsive exercise among college students, and will help clarify what can be known from each SNA approach. This project's results will have a positive impact on the field by providing a new way to understand and intervene on compulsive exercise among college students and add to the growing body of health research using SNA. Consequently, short term applications of this project's results may include new insight into compulsive exercises, as well as wider use and understanding of SNA to investigate complex health behaviors.

This dissertation is innovative because it uses a complex systems approach to identify specific relational and structural network characteristics that possibly affect compulsive exercise behavior. To date, the mainstream research on the social influences, eating disorders, and compulsive exercise has centered on linear models that measure the variance accounted for in individuals' behaviors. While linear models are an important first step in learning more about compulsive exercise, they cannot identify nor confirm the relational and structural patterns that affect compulsive behavior spread within networks or relationships (Meadows, 2008). Though interventions can certainly be

informed through linear models, knowing where to intervene within a network cannot be inferred from measures of variance. The use of SNA is a critical step in moving toward better understanding of social influence on compulsive exercise. Therefore, the aim of this dissertation is to investigate egocentric and whole network variables related to compulsive exercise behaviors among a sample of college women, members of a single sorority at a southwestern university in the US.

This dissertation consists of six chapters. Chapters II, III, IV, and V represent manuscripts that will be submitted for publication in peer-reviewed journals. The following is a description of each chapter:

- Chapter I provides the reader with a brief introduction and overview of compulsive exercise and social network analysis, as well as the purpose, significance, and innovation of the dissertation.
- Chapter II is a systematic review of the extant literature on disordered exercise, specifically in regards to the influences on disordered exercise that have been investigated in this body of research.
- Chapter III also comprises a systematic review, but its focus is how social network analysis has been applied in studying the health of college-aged adults.
- Chapter IV documents the findings from a whole network analysis on compulsive exercise among college-aged women. This study investigates which network variables (i.e., centrality, cliques) are associated with compulsive exercise behaviors among a network of college women (a sorority).

- Chapter V is an egocentric network analysis of the same network examined in Chapter IV. This egocentric analysis also considers which network variables are related to compulsive exercise behavior among college women, but employs an ego network design rather than a whole network design.
- Chapter VI provides a brief summary of the findings from chapters II-V. Implications for future research and practice concerning compulsive exercise and social network analysis are, also, discussed.

CHAPTER II

INFLUENCES ON DISORDERED EXERCISE: A SYSTEMATIC REVIEW

Introduction

Exercise is a common staple of a healthy lifestyle (Anokye, Trueman, Green, Pavey, & Taylor, 2012; CDC, 2012). Research has been devoted to unpacking the many physical and psychological benefits of regular exercise among various populations (Barnett, O'Loughlin, & Paradis, 2002; Eng & Martin Ginis, 2007; Ginis et al., 2011; Heli, 2012). Despite its many benefits, exercise can become unhealthy and disordered for some. Disordered exercise is characterized by and manifests itself as a drive or compulsion to exercise, prioritizing exercise over other activities, and feelings of guilt and anxiety when exercise is postponed (Dalle Grave, 2009). Disordered exercise can be physically and psychologically damaging and poses a particular threat due to its association with eating disorder development and maintenance.

Eating disorders carry the highest mortality rate of any mental illness including depression, schizophrenia, and bipolar disorder (Arcelus, Mitchell, Wales, & Nielsen, 2011; Chesney, Goodwin, & Fazel, 2014; Sullivan, 1995), resulting in approximately 134,400 deaths per year in the United States (Sullivan, 1995; Walter, 2013). A medical review conducted by Arcelus and colleagues (2011) suggests that anorexia carries twice the death risk of schizophrenia and three times the death risk of bipolar disorder. All mental disorders increase risk of mortality (Chesney et al., 2014; Walker, McGee, & Druss, 2015), and many people diagnosed with an eating disorder suffer from other

mental illnesses in addition to their eating disorder (Braun, Sunday, & Halmi, 1994), further increasing their risk of death. Given their severity, understanding eating disorders' determinants, development, and spread has become both urgent and important.

Researchers have identified multiple factors as precursors to, or determinants of, eating disorders, including body dissatisfaction (Dittmar, 2005; Vartanian et al., 2014), earlier physical maturation (Shisslak & Crago, 2001), perfectionism (Flett & Hewitt, 2005; Taranis & Meyer, 2011), internalization of media ideals (Goodwin, Haycraft, Willis, et al., 2011; White & Halliwell, 2010), and social influences (Goodwin, Haycraft, Willis, et al., 2011; K. Homan, 2010; Rancourt et al., 2014; Rudd & Lennon, 2000). Disordered exercise is associated with eating disorders and has proven particularly difficult to treat among eating disordered patients (Cash, 2004; Hudson, Hiripi, Pope, & Kessler, 2007; Meyer et al., 2011). Although disordered exercise can occur apart from an eating disorder diagnosis, it often leads to the development of eating disorders (Polivy & Herman, 2002). Thus, it is important to understand precursors to disordered exercise among various subpopulations, both in and outside of eating disorder diagnoses.

The Tripartite Influence model developed by Thompson and colleagues suggests social influences, namely those exerted by parents and peers, are core contributors to the development of body image issues and eating disturbances (J. K. Thompson, Heinberg, Altabe, & Tantlett-Dunn, 1999). The Tripartite Influence model has been tested on various samples and supports the social influence of weight-related behaviors, including disordered exercise (R. Rodgers, Chabrol, & Paxton, 2011; Stice, Ziemba, Margolis, &

Flick, 1996; van den Berg, Thompson, Obremski-Brandon, & Cooverty, 2002). While the Tripartite Model has served to shape some of the research in the field, most research around body image and eating disorders focuses on the psychological factors related to eating disturbances (Polivy & Herman, 2002; Szmukler & Patton, 1995; Vartanian et al., 2014), rather than the social influences themselves, as suggested by the model.

Recently, studies have begun to focus on disordered exercise and what influences its development and reinforcement, though research on the sociocultural precursors to disordered exercise is lacking. The purpose of this study, therefore, is to systematically review the body of literature on disordered exercise to answer the following questions: (1) What are the precursors to or determinants of disordered exercise reported in the research literature? and (2) Is the current body of research on disordered exercise focused on psychological and individual-level determinants or social and cultural determinants? We hypothesize that correlates to disordered exercise will be similar to those related to eating disturbances (i.e., body dissatisfaction). We also hypothesize the majority of the literature will focus on identifying psychological and individual-level influences, as opposed to social and cultural contexts associated with disordered exercise.

Systematic literature reviews uniquely add to a discipline by synthesizing and assessing all work related to a research question over a specified time period. This allows the reader to have a wide and accurate knowledge of the topic (Garrard, 2007; Mullen & Ramírez, 2006; Mulrow, 1994). Systematic literature reviews help to establish collective validity from individual study results through assessment of methodology and

research bias, help improve the reliability and accuracy of conclusions across an entire body of literature, and support evidence-based practice by integrating large amounts of information into one critically reviewed piece (Mulrow, 1994). By completing a systematic review on disordered exercise, we will help identify important influences on and determinants of disordered exercise, while also identifying key gaps in the current body of literature.

Background

The prevalence of eating disorders has greatly increased over the past 50 years (Hudson et al., 2007; Striegel-Moore & Franko, 2003; Walter, 2013). Eating disorders most often impact adolescent and young adult women (Massachusetts Eating Disorders Association, 2014; Stice, 1998; Striegel-Moore & Franko, 2003; The Emily Program Foundation, 2014; The Review Center Foundation for Eating Disorders, 2003), though new research suggests increasing incidences of eating disorders among men (Hoek & van Hoeken, 2003; Mosley, 2009), boys (Cohane & Pope, 2001; Presnell, Bearman, & Stice, 2004)(Presnell et al., 2004) and menopausal women (Mangweth-Matzek et al., 2006), among others. Anorexia nervosa, bulimia nervosa, and binge eating disorder are historically the most common eating disorders diagnosed (Hudson et al., 2007), with new categories of eating disorders developing over time. For instance, orthorexia is a fairly new type, characterized by someone who is so strict about eating healthy that they deprive themselves of important nutrients (Donini, Marsili, Graziani, Imbriale, & Cannella, 2013).

The consequences of eating disorders are physical and mental. Common mental symptoms of eating disorders are depression and anxiety disorders, irritability, loss of libido, and impaired concentration (Fairburn & Harrison, 2003). Physical symptoms can include weight loss, thinning hair and brittle nails, heart disturbances (i.e., irregular heartbeats), and decreased immune function, among others (Donatelle, 2013). Because eating disorders are mental illnesses that often manifest themselves physically, they are quite complex and often difficult to treat (Kaplan & Garfinkel, 1999). In fact, of those who seek treatment, up to 50% may never fully recover (Donatelle, 2013; Walsh, 2008).

Research suggests that eating disorders and associated traits commonly run in families (Berrettini, 2004; Kaye, 2008), indicating genetics as a potential risk factor in their diagnosis.. Environment and societal risk factors are also important, considering that living in a Western society is highly correlated with the onset of eating disorders (Makino, Tsuboi, & Dennerstein, 2004). In their review, Jacobi and colleagues (2004) identified family relationships and perceived social stress among the various psychosocial risk factors. Having a perfectionist personality and weight/shape concerns were also noted in the review (Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004).

Disordered exercise is both a risk factor for and a symptom of eating disorders (Dalle Grave et al., 2008; Polivy & Herman, 2002). Studies show that while many patients can overcome their disordered eating patterns and behaviors, oftentimes disordered exercise is the only element inhibiting full recovery (Dalle Grave et al., 2008). Similar to eating disorders, disordered exercise is prevalent among adolescents and young adults, though many other subgroups are affected, including athletes, middle-

aged women, and runners (Guidi et al., 2009; Quick & Byrd-Bredbenner, 2013; Thome & Espelage, 2007). Several studies investigating disordered exercise have focused on eating disorder *patients*, but it is important to understand the context of disordered exercise development in both clinical and non-clinical groups (Bratland-Sanda et al., 2011; Dalle Grave et al., 2008), especially considering the likelihood that disordered exercise behaviors can lead to an eating disorder diagnosis (C. Davis et al., 1994; Polivy & Herman, 2002).

Methods

The aim of this review is to examine which psychological, social, and cultural factors are related to disordered exercise. To do this, we systematically surveyed the peer-reviewed literature describing influences on disordered exercise behavior using the PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009). See Figure 1 for the PRISMA flow diagram of reviewed studies. We used Garrard's Matrix Method to guide the literature review (Garrard, 2007).

To be eligible for inclusion in the review, studies had to focus on disordered exercise. Studies that did not assess disordered exercise as the dependent variable in their analyses were excluded from the review. Eligible studies were included if they investigated influences on disordered exercise, and did not simply describe or measure the behavior itself (i.e., prevalence rates). Articles were excluded if they were not peer-reviewed, written in a language other than English, consisted merely of published abstracts, were measurement papers (e.g. a Confirmatory Factor Analysis), or only

included disordered exercise as non-focal variable in the study (e.g. compulsive exercise influences eating disorders).

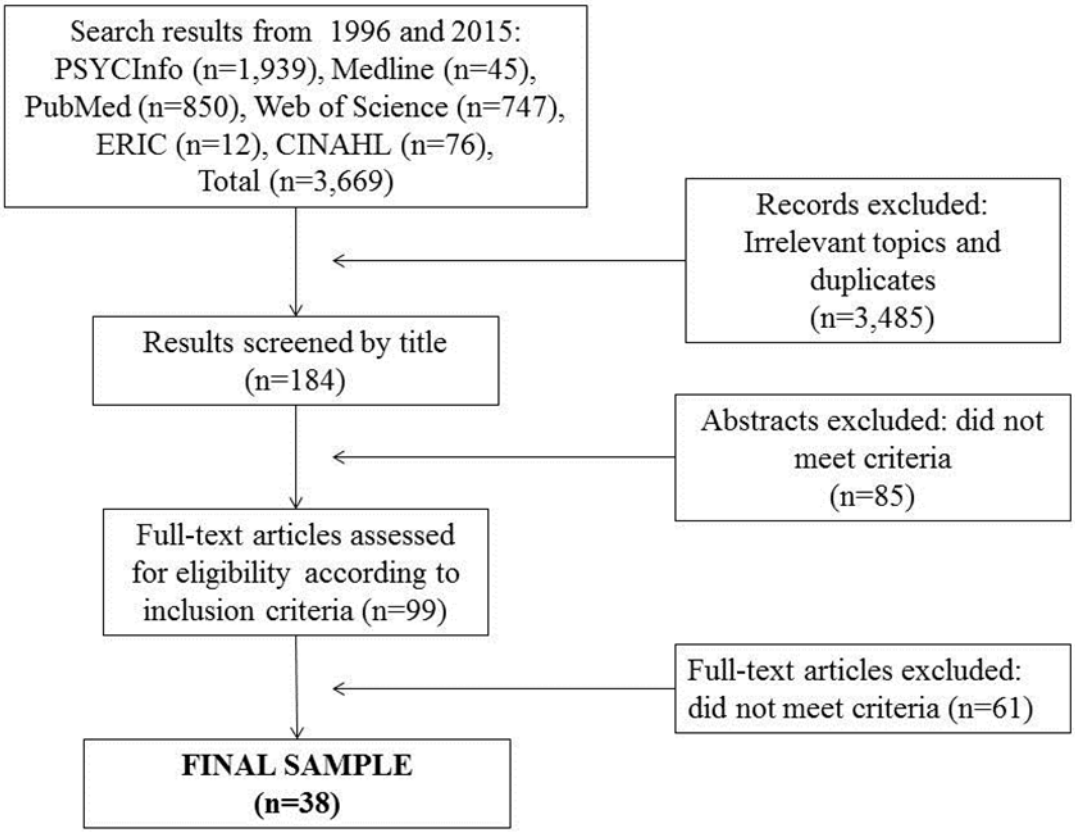

Figure 1. PRISMA flow diagram of studies investigating influences on disordered exercise

The search was conducted using six databases: PsycInfo, Medline, PubMed, ERIC, CINAHL, and Web of Science. The main search terms used were "compulsive exercise", "disordered exercise", "obligatory exercise", "exercise dependence", "excessive exercise", and "exercise addiction." All relevant literature's reference lists

were reviewed to identify additional related articles. In total, 3,669 articles published between 1996 and 2015 were identified through the database search. Of the original 3,669 articles, 184 were included for abstract review based on title. If articles clearly did not investigate correlates of disordered exercise, they were removed. Eighty-five articles were excluded after abstract examination because (a) the focus of the study was not on disordered exercise, (b) the study described disordered exercise but did not investigate influences on disordered exercise, or (c) the study was a measurement paper (i.e., Confirmatory Factor Analysis). Overall, the full texts of 99 articles were fully reviewed. Sixty-one articles were then excluded from the final sample because disordered exercise was not the focus of analysis (i.e., it was a predictor variable), or because the study was descriptive and did not assess other variables, resulting in 38 full text articles extracted and included in the review. Two trained researchers independently reviewed the 38 full text articles (Figure 1). The final 38 articles were extracted into a review matrix as suggested by Gerrard (see Appendix A for the full review matrix).

Findings

Terms and Definitions

Several terms are used interchangeably in the disordered exercise literature, including *obligatory exercise*, *compulsive exercise*, and *exercise dependence*. In fact, many articles address this absence of consensus as a problem (Gulker, Laskis, & Kuba, 2001; Penas-Lledo, Vaz Leal, & Waller, 2001; Zmijewski & Howard, 2003). This section will provide a summary of the terms used in the literature, as well as common themes within the definitions of these terms.

The term used most often in the reviewed literature was *exercise dependence* (30%), followed by *compulsive exercise* (25%). *Obligatory exercise* (17.5%) and *excessive exercise* (17.5%) were each used moderately throughout the literature, while *exercise addiction* (10%) was used least often.

Across the different definitions and terms, six themes emerged. The first and most common theme was compulsion, an extreme drive or need to exercise. The concept of compulsion implies that disordered exercise is more than just exercise in excess, though many authors do include quantity or rigid patterns to exercise as a part of the definition. Exercising out of guilt or to avoid negative emotion, continuing exercise despite consequences (i.e., injury, social isolation), exercise interfering with other obligations or priorities, and experiencing tolerance with increased exercise and withdrawal symptoms with less exercise were other themes included in the many definitions of disordered exercise. Overall, every definition mentioned at least two of the aforementioned themes, revealing the complexity of disordered exercise. The reviewed literature, therefore, proposes that engaging in disordered exercise represents more than merely exercising in excess. A psychological, social, or cultural effect must be involved as well.

Sample Characteristics and Study Designs

Sample characteristics. Of the studies reviewed in this paper, almost half studied samples of exercisers, or regularly active people (e.g., Gulker et al., 2001; W. M. Rodgers, Hall, Blanchard, & Munroe, 2001). Five of the articles who sampled active people studied runners or triathletes (Elbourne & Chen, 2007; Hall, Kerr, Kozub, & Finnie, 2007; Karr et al., 2013; Nuzzo, Schindler, & Ryan, 2013; Slay, Hayaki,

Napolitano, & Brownell, 1998), and two others focused on amateur or university athletes (Modolo et al., 2011; Nuzzo et al., 2013). Eleven studies sampled undergraduate students from a university or college (e.g., (Elbourne & Chen, 2007) and nine studied adolescents (e.g., (Goodwin, Haycraft, & Meyer, 2011). In- and out-patients receiving treatment for eating disorders were also among samples used in this literature (Bratland-Sanda et al., 2011; Dalle Grave et al., 2008; Penas-Lledo et al., 2001). Just over 20% of the studies used a female-only sample (e.g., (Ackard, Brehm, & Steffen, 2002; Gapin, Etnier, & Tucker, 2009), and over half were international samples (outside of the US; e.g., (Hall et al., 2007; Mathers & Walker, 2010). Sample sizes ranged from 24 to 2,421 participants, with the majority of studies sampling between 200 and 300 people. Seven studies had more than 500 participants, three of which had more than 1,000. See Table 1 for details.

Study designs. The vast majority of studies published in the disordered exercise literature used a cross-sectional study design (78.9. The remaining studies employed longitudinal or time series designs (e.g., Elbourne & Chen, 2007; Goodwin et al., 2014). No randomized control trials were reported, and no qualitative studies met inclusion and exclusion criteria for this review (i.e., Bamber, Cockerill, Rodgers, & Carroll, 2000).

Precursors to Disordered Exercise

The following variables were tested in relation to disordered exercise in the reviewed literature: attitude; motivation; personality; exercise imagery; exercise identity; emotion regulation; commitment; passion; age; sex; brain symmetry; sociocultural

pressure; personal relationships; eating disordered behaviors and diagnoses; and exercise behavior (See Appendix A for more details).

Attitudes, personality, and motivation. Studies included in this review looked at *attitudes* around food and exercise (Zmijewski & Howard, 2003), *personality* characteristics such as extraversion and perfectionism (Mathers & Walker, 2010; Taranis & Meyer, 2010), as well as intrinsic and extrinsic *motivation*, positive and negative *motivation*, and goal-setting (Gonzalez-Cutre & Sicilia, 2013; H. K. Hall et al., 2007; Slay et al., 1998) in relation to disordered exercise. In this body of literature we learn that higher disordered exercise scores are often related to perfectionism (Goodwin, Haycraft, Willis, et al., 2011; Gulker et al., 2001; H. K. Hall et al., 2007; Taranis & Meyer, 2010), negative attitudes toward food and eating (Slay et al., 1998; Zmijewski & Howard, 2003), and mood (Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2013; Pritchard & Beaver, 2012; Zmijewski & Howard, 2003).

Results were mixed concerning personality and mental illness in relation to disordered exercise. Some studies found extraversion and obsessive compulsiveness to be related with disordered exercise (Goodwin, Haycraft, Willis, et al., 2011; Gulker et al., 2001), while others either did not identify a relationship (Mathers & Walker, 2010) or found an inverse relationship (Bewell-Weiss & Carter, 2010). Depression (Bewell-Weiss & Carter, 2010), anxiety (Grandi et al., 2011), guilt for stopping exercise (Slay et al., 1998), and self-criticism (Taranis & Meyer, 2010) were also related to disordered exercise.

Exercise imagery. *Exercise imagery*, or the mental picture exercisers have about themselves or their behavior, is typically used by regular exercisers in three ways: 1). to improve or maintain physical appearance; 2). for psychological management and motivation; and 3). to improve technique (Gammage, Hall, & Rodgers, 2000; Hausenblas, Hall, Rodgers, & Munroe, 1999; Hausenblas & Symons Downs, 2002). According to the results of this review, energy-related imagery (i.e., "to get me energized, I imagine myself exercising"; Gammage et al., 2000) predicted disordered exercise in men and women (Hausenblas et al., 1999; W. M. Rodgers et al., 2001). In addition, one study found a relationship between appearance-related imagery (i.e., "I imagine a leaner me from exercising"; Gammage, Hall, & Rodgers, 2000; Hausenblas et al., 1999) and disordered exercise among women (Hausenblas & Symons Downs, 2002).

Exercise identity. A person develops an *identity* by classifying him/herself as being in a particular role and internalizing the meanings associated with that role (Stets & Burke, 2000). Identity theory postulates when a person's behavior is consistent with their perceived identity (e.g., I am a runner, and therefore I run), they experience positive affect, reinforcement of the behavior, and strength in their perceived identity (Stets & Burke, 2000). Conversely, if behavior and identity are not aligned, a person may experience negative affect, distress, and act to avoid or counteract the disturbance (Stets & Burke, 2000; Stryker & Burke, 2000). Two studies found a relationship between exercise identity and disordered exercise, both of which involved a third variable. The first found a correlation between exercise identity, exercise commitment, and disordered exercise (Lu et al., 2012). The other study resulted in a three-way interaction between

exercise identity, being female, and internalization of the athletic ideal body shape predicting disordered exercise (Gonzalez-Cutre & Sicilia, 2013).

Emotion regulation. *Emotion regulation* is a coping mechanism through which people control and express their emotions (Gross, 1998). Mood regulation is often cited as a strong motivation for exercise behavior (e.g., Markland & Ingledew, 1997), and therefore would likely relate with disordered exercise. Emotion regulation has garnered specific attention in the disordered exercise literature through Meyer, Taranis, Goodwin, & Haycraft's (2011) model of compulsive exercise which suggests that emotion regulation is a critical player in the maintenance of disordered exercise attitudes among populations with eating disorders. The model posits that exercise may become a disorder if it is used to avoid negative emotions (i.e., feeling ugly). Four mechanisms of measuring affect regulation were commonly cited in the disordered exercise literature, including internal functional regulation (an individual deals with something by him/herself in a positive way, such as by planning or putting the situation into perspective), internal dysfunctional regulation (a person handles a situation internally but in a negative way, possibly through self-harm or repression), external functional regulation (involving others in a positive way when coping, such as by seeking advice), and external dysfunctional regulation (taking feelings out on others, perhaps by fighting or lashing out; Phillips & Power, 2007). The studies reviewed herein found internal dysfunction regulation to be associated with disordered exercise in adults and adolescents (Bratland-Sanda et al., 2011; Goodwin, Haycraft, & Meyer, 2012). Disordered exercise in boys was also associated with internal and external functional

regulation, and disordered exercise in girls was related to internal function regulation (Goodwin et al., 2012).

Passion and commitment. Two studies in this review investigated the relationship between one's *passion* for and/or *commitment* to exercise, and disordered exercise behaviors. Passion and intrinsic motivation are defined differently, primarily because according to these studies, passion is a part of one's identity, and is therefore deeper than motivation (Paradis, Cooke, Martin, & Hall, 2013). Lu and colleagues (Lu et al., 2012) studied two aspects of exercise commitment proposed by Wilson and colleagues (2004) in relationship to disordered exercise: the voluntary "want-to" commitment and the obligatory "have to" commitment to exercise. Results of their study indicated that a “have to” commitment was related to exercise dependence, but a “want to” commitment was not. In other words, a person that feels obligated to exercise or has no choice but to commit to exercise is more likely to have high disordered exercise scores. Paradis and colleagues (2013) observed how passion was related to disordered exercise. Obsessive passion, or an internal compulsion to participate in an activity even when it is inappropriate to do so, was related to all dimensions of exercise dependence as defined by Hausenblas and Symons Downs (2002). These dimensions include : tolerance (need to increase exercise in order to achieve desired effects); withdrawal (physical and/or psychological symptoms such as insomnia or depression experienced with lack of exercise); intention effects (someone exercises more often or in greater duration than in principle, one wants); lack of control (the impossibility of reducing exercise); time (spending large amounts of time in exercise); reduction in other activities (neglecting

other priorities and commitments such as work or family); and continuance (continuing exercise despite consequence, such as an injury (Paradis et al., 2013)). Harmonious passion, or being in control of deciding when and when not to engage in an activity, was also related to the time and tolerance dimensions of exercise dependence (Hausenblas & Symons Downs, 2002; Paradis et al., 2013).

Disordered eating behaviors. Nearly half (n=18) of the studies examined links between disordered exercise and *eating disordered behaviors and/or pathology* (e.g., Dalle Grave et al., 2008). Disordered eating patterns (Bewell-Weiss & Carter, 2010; Grandi, Clementi, Guidi, Benassi, & Tossani, 2011; Zmijewski & Howard, 2003) and dissatisfaction with weight or appearance (Elbourne & Chen, 2007; Goodwin, Haycraft, Willis, et al., 2011; Pritchard & Beaver, 2012; Zmijewski & Howard, 2003) were both related to disordered exercise in the reviewed literature.

The athletic-ideal internalization and thin-ideal internalization are common threads of eating disorder development (Chalk, Miller, Roach, & Schultheis, 2011; Homan, 2010) and are based on someone behaving in order to reach a specific appearance-ideal, thin or athletic (Thompson & Stice, 2001). For instance, someone with high thin-ideal internalization scores tends to value looking thin and alters behaviors to achieve thinness, perhaps by restricting his/her diet or excessively exercising. Studies in this review most often investigated the tie between athletic-ideal internalization and disordered exercise among males, and thin-ideal internalization and disordered exercise among females (Homan, 2010; Karr et al., 2013). For instance, in Chalk and colleagues' study(2011), they found that "women who internalize the thin ideals of the Western

media are more likely to experience over commitment to exercise and exercise-related negative affect, both of which have been correlated with psychological maladjustment and increased risk factors for disordered eating" (Chalk et al., 2011, p. 109).

It is well understood that those diagnosed with an eating disorder often participate in disordered exercise (Davis et al., 1994; Polivy & Herman, 2002). Results of this review also support a positive relationship between disordered exercise and eating disorder scores (Bratland-Sanda et al., 2011; Dalle Grave et al., 2008; Elbourne & Chen, 2007). For eating disorder patients specifically, levels of depression, anxiety, and somatization (physical symptoms of a psychiatric condition) were high among those who excessively exercised (Penas-Lledo et al., 2001), especially among restricting-type anorexia-nervosa patients (Dalle Grave et al., 2008).

Biological precursors. The three biological predictors reported in the literature were *sex*, *age*, and *brain activity* (Costa et al., 2013; Gapin et al., 2009; Szabo, de la Vega, Ruiz-Barquin, & Rivera, 2013). All three biological predictor variables were related to disordered exercise in this review. Results were mixed regarding whether men or women were more prone to disordered exercise, with some studies suggesting women were more likely to engage in the behavior (e.g., Gapin et al., 2009) and others suggesting the opposite, that men are more likely to engage in disordered exercise (e.g., Costa et al., 2013). Disordered exercise among men and boys was associated with pressure to be muscular and with neurotic perfectionism (Goodwin et al., 2014; Hausenblas & Symons Downs, 2002), while media pressure and thin-ideal internalization were more frequently related with disordered exercise among women and

girls (Goodwin et al., 2012; Zmijewski & Howard, 2003). In addition, greater relative frontal brain activity predicted higher exercise addiction scores in highly active women (Gapin et al., 2009). Frontal brain asymmetry measured by electroencephalogram (EEG) has been linked to affect and mood (Beh, Mathers, & Holden, 1996; Wagemaker & Goldstein, 1980).

Exercise behavior. Several studies (n=6) sought to investigate the role *exercise behavior* plays on the development of disordered exercise. Several studies found a link between exercise frequency, exercise vigor, and disordered exercise (Bratland-Sanda et al., 2011; Costa et al., 2013; Hausenblas & Symons Downs, 2002; Phelan, Bond, Lang, Jordan, & Wing, 2011). For example, in the study conducted by Costa and colleagues (2013), mood state and age were related to disordered exercise, but exercise frequency was the strongest predictor in the final model. However, it is important to note that "the past work on the link between eating disorders and exercise has been seriously mistaken when excessive exercise is defined solely by the number of hours of daily exercise or by engagement in particular types of intense exercise…it is not only the amount of exercise that is important, but also the rationale and meaning of the exercise" (Ackard et al., 2002, p. 42-43).

Sociocultural factors. *Sociocultural factors* related with disordered exercise was the purpose of investigation in three studies (Goodwin et al., 2014; Goodwin, Haycraft, & Meyer, 2011; Szabo et al., 2013). Though only three studies included the investigation of sociocultural influences in their purpose statements or research questions, several included sociocultural factors in their results. Multiple articles measured the relationship

between disordered exercise and sociocultural pressures, including the sociocultural pressure to lose weight and build muscle (Bratland-Sanda et al., 2011), perceived pressure from dating partners (Chalk et al., 2011), and messages to become more muscular as well as media pressure to be thin (Goodwin et al., 2014; Goodwin, Haycraft, & Meyer, 2011). One study found that participants in team sports (e.g., soccer players) were more likely to report disordered exercise than individual athletes (e.g., golfers; (Szabo et al., 2013), suggesting a person's social context can be associated with disordered exercise in addition to his/her perceived pressure. Finally, one study found that persons with high disordered exercise scores reported interference with social, family, and work life; they also claimed to exercise for social reasons (MacLaren & Best, 2007).

In sum, the majority of the reviewed studies (68.4%) focused at least in part on assessing psychological influences on disordered exercise. Psychological influences studied in the literature included: attitude; motivation and personality; exercise imagery; exercise identity; commitment and passion; and emotion regulation (see Table 1 for more details). The studies that did consider sociocultural or biological determinants of disordered exercise all included psychological and individual-level factors in their analysis. Results do suggest a relationship between psychological factors and disordered exercise, though some results were contradictory.

Discussion

Disordered exercise is a complex behavior with psychological, social, and biological underpinnings, as well as a substantial overlap with disordered eating

behaviors. This review allowed a glimpse into which factors researchers are examining as potentially associated with disordered exercise. In order to answer the research questions we posed originally, namely (1) *What are the precursors to or determinants of disordered exercise reported in the research literature?* and (2) *Is the current body of research on disordered exercise focused on psychological and individual-level determinants or social and cultural determinants?*, we conducted a systematic review of the disordered exercise research literature and assessed which factors were tested for a relationship with disordered exercise.

Competing Terms and Definitions in the Literature

One common pattern found in the reviewed literature was the inconsistency in terminology. While many of the terms and definitions overlap, the varying terms have muddied the waters in the disordered exercise literature. We chose the term "disordered exercise" because it seemed to encompass all variations of the term - whether the exercise is compulsive, excessive, addictive, or all of these, it is *disordered*. Agreement on a single term would help in building a more congregated body of literature by pulling studies investigating the same topic under the same term or at least carving specific definitions for each term would be helpful. For instance, compulsive exercise and exercise dependence were defined in several different ways across studies, but had little disparity between the two concepts, overall. It is understandable that a researcher would choose to use the term that matches an instrument he/she uses (e.g., obligatory exercise with the Obligatory Exercise Questionnaire), but there is still confusion regarding the many terms and definitions. Several authors brought up this issue in their articles

(Bratland-Sanda et al., 2011; Lu et al., 2012), suggesting the use of several competing terms is an understood gap in the literature.

Most terms state in some way that if a person does not engage in exercise, they will experience depression, anxiety, or guilt. Definitions are similar in that exercise is being performed in extreme amounts and at the expense of other dimensions of a person's life, thus being psychologically and physically debilitating to the person. A few definitions do state a direct association between disordered exercise and eating disordered behaviors (e.g., food restriction, Ackard et al., 2002), though most do not imply a connection between disordered exercise and eating disorders.

Despite rationale for various terms and definitions in the literature, we need consensus regarding one appropriate term and definition. Using the encompassing term "disordered exercise" may help in this regard. Authors would still have the freedom to explore specific aspects of various definitions (e.g., tolerance and withdrawal from exercise addiction, and compulsivity from compulsive exercise). Settling on one all-encompassing term would allow for better study and understanding of disordered exercise.

Which Factors are Precursors to Disordered Exercise?

Results of this review suggest that disordered exercise is often related to perfectionism (Goodwin, Haycraft, Willis, et al., 2011; Gulker et al., 2001; H. K. Hall et al., 2007; Taranis & Meyer, 2010), negative attitudes toward food and eating (Slay et al., 1998; Zmijewski & Howard, 2003), disordered eating patterns (Bewell-Weiss & Carter, 2010; Grandi, Clementi, Guidi, Benassi, & Tossani, 2011; Zmijewski & Howard, 2003),

and dissatisfaction with weight or appearance (Elbourne & Chen, 2007; Goodwin, Haycraft, Willis, et al., 2011; Pritchard & Beaver, 2012; Zmijewski & Howard, 2003).These results are consistent with previous studies reporting similar factors associated with eating disorders (Dittmar, 2005; Vartanian et al., 2014) and strengthen the connection between eating disorders and disordered exercise. In addition, results of this review indicate support for the Tripartite Influence Model and the sociocultural influence on disordered exercise.

Sociocultural influence. As the Tripartite Influence Model (J. K. Thompson et al., 1999).suggests, peers (Chalk, Miller, Roach, & Schultheis, 2011; Goodwin et al., 2014; Szabo, de la Vega, Ruiz-Barquin, & Rivera, 2013), family (Goodwin, Haycraft, & Meyer, 2011; MacLaren & Best, 2007), and media (Goodwin et al., 2014; Goodwin, Haycraft, & Meyer, 2011) were all indicated as important variables related to disordered exercise in this review. While these studies did broaden the lens of investigation beyond psychological influences, measures were solely based on the perception of the individual. It seems that the Tripartite Influence Model might be more effective in explaining influences on disordered exercising and disordered eating if scientific inquiry drew from more than just the individual person. For instance, pressure from peers is a tenant of the Tripartite Influence Model. In the studies reviewed, pressure from peers was measured as perceived pressure. Perhaps taking a more complex perspective and applying network methodology to the study of disordered exercise would better illustrate pressure from peers by indicating structural and positional network variables important to disordered exercise, in addition to the individual-level factors such as personality or

perceived pressure. Nevertheless, the disordered exercise literature currently lacks an ecological perspective, according to our review. We will elaborate on this more in the next section.

The Current Literature's Focus on Psychological Influences

It is not surprising that psychological influences (e.g., drive, motivation, attitude, etc.) were the most common influences studied in the literature. There are likely two major reasons for this: (1) most health behavior research in the US mirrors this trend (Goodson, 2010), and (2) because most definitions of disordered exercise include psychological components (e.g., a craving for exercise that results in physiological symptoms, psychological symptoms, or both; Hausenblas & Symons Downs, 2002), it makes sense to include psychological constructs in the study of disordered exercise. The psychological antecedents to behavior (e.g. attitude, motivation, personality, etc.) have been of interest to behavioral scientists and psychologists for decades (Goodson, 2010). Assuming human agenda and rational decision making, these psychological constructs help deconstruct intention and behavioral choice (Azjen, 1991; Bandura, 1986, 1997). Though evidence suggests that psychological influences are a key factor in disordered exercise, the field would merit from widening the lens of investigation, as we mentioned before. As is the case in other health behavior research (Goodson, 2010), the reviewed studies had a strong bias toward measuring individual-level, psychological factors and constructs. Many psychological constructs such as motivation imply human agency and rational thinking (Bandura, 1986). However, the development of disordered exercise is

likely irrational, and therefore may not be appropriate for study in conjunction with psychological constructs.

A handful of studies were able to pinpoint sociocultural determinants of disordered exercise, including perceived pressure from family and friends (Goodwin et al., 2014; White & Halliwell, 2010), relationship with significant others (Chalk et al., 2011), the media (Goodwin, Haycraft, & Meyer, 2011), and participation in team sports versus individual sports (Szabo et al., 2013). This is a start in looking at other dimensions of disordered exercise and aligns well with studies supporting social influences in eating disorder research (Hardit & Hannum, 2012; Paxton et al., 1999), but this theory still limits the research to the individual and to linear models. Shifting the focus to relationships between people, rather than on people themselves, and operating out of a complexity perspective when investigating disordered exercise may lend new information to the foundation of disordered exercise literature (Goodson, 2015). Several health-related behaviors and issues are now being studied from a complexity perspective, including overweight and obesity (Christakis & Fowler, 2007; Hammond, 2009) and substance abuse (Perry, 2012; Valente & Vlahov, 2001), paving the way for a more complex, and one could argue more accurate, view of health.

Study Limitations and Recommendations for Future Research and Practice

Though this paper is strengthened by reviewing the disordered exercise literature in a systematic manner, a primary limitation is that it did not assess methodological quality of the studies. However, in order to answer our research questions, a methodological assessment was not needed. We were concerned with what associations

are documented in the literature, rather than magnitude of associations. However, a major strength of any systematic review of literature is assessment of methodology in order to understand how much trust can be put into reported findings. Future systematic reviews could incorporate an evaluation of research methodologies across studies.

Future research also should test dynamic models of disordered exercise, rather than rely on the continued use of the general linear model. The general linear model and associated methodology assumes that every unit of analysis (in our case, persons) is independent of others (B. Thompson, 2006). Considering that the Tripartite Influence Model posits social influence on disordered eating and exercise behavior, assuming independence in an analysis is not completely appropriate. Social Network Analysis (SNA), is a paradigm and set of techniques that focuses on the relationships between people, rather than on individual persons themselves (Borgatti, Everett, & Johnson, 2013; Valente, 2010). SNA provides structures, patterns, and positions in a network or group that are particularly influential to the spread of behaviors and ideas (van der Hulst, 2009). These network variables are then assessed using nonparametric statistical tests that do not assume independence (Borgatti et al., 2013). SNA would be a logical next step in disordered exercise research, as SNA builds on the Tripartite Influence Model, allows for important psychological variables to be included as attributes of each unit of analysis, and employs a complex, nonlinear point of view.

Alongside its contribution to the knowledge-base on disordered exercise, this review also is important for health practitioners for several reasons. Because eating disorders and associated behaviors are growing in incidence, because they are prevalent

across gender, race, ethnicity, sex, age, and sexual orientation, and because disordered exercise is strongly tied to eating disorders, practitioners must be aware of what influences disordered exercise. Typically, health educators and other health care providers promote exercise to the public due to the many associated health benefits (CDC, 2012). However, disordered exercise can be extremely dangerous, and therefore should be better understood by leaders in field.

Conclusion

By conducting this review, we were able to pinpoint valuable information concerning influences on disordered exercise, as well as gaps in the current body of research. The disordered exercise literature is rich with many terms, definitions, ideas, and mechanisms of influence. Most of what we know so far is that there is strong tie between disordered exercise and perfectionism, a drive related to body image (e.g., the thin- or athletic-ideal), and perceived pressure from others and the media. Putting all terms and definitions under one umbrella and taking a broader view beyond the psychological perspective may provide new insight into this issue. Importantly, we need to continue to expand upon the complexity of disordered exercise. As aforementioned, disordered exercise is a precursor to and a stubborn element of eating disorder diagnosis, which impacts large populations, especially those comprising young people (Cash, 2004; Massachusetts Eating Disorders Association, 2014; Striegel-Moore & Franko, 2003). The benefits of exercise typically outweigh its harms (CDC, 2012), and most people are applauded for an active lifestyle (Okun et al., 2003), increasing the chance that harmful patterns of exercise will go unrecognized and reinforced. In sum, this review provides a

start to identifying person-level predictors of disordered exercise patterns and gives direction to taking a more complex view of the problem.

CHAPTER III

SOCIAL NETWORK ANALYSIS FOR ASSESSING COLLEGE-AGED ADULTS' HEALTH: A SYSTEMATIC REVIEW

Introduction

Social Network Analysis (SNA) comprises both a theoretical perspective and a set of methods to better understand connections among people, organizations, or other units of analysis (Valente, 2010; Wasserman & Faust, 1994). SNA is a method in systems science, which has a different set of assumptions than traditional, positivist or post-positivist science (Meadows, 2008). The assumptions underlying SNA include the notion that a system (a) is more than the sum of its parts (effects stemming from individual components of a system are not additive), (b) shows adaptive, dynamic, self-preserving, and goal-setting behavior, (c) is nonlinear, and (d) its units of analysis are not independent of one another (Meadows, 2008).

Many calls have been made to health researchers to surpass the individual level of analysis in their work (see, for instance, Buchanan, 2000; Goodson, 2010, 2015; McLeroy, Bibeau, Steckler, & Glanz, 1988). This call dates back to 1951 with the introduction of Lewin's concept of psychological ecology, or the outside environment's influence on the person (Lewin & Cartwright, 1951). Ecological models were further developed with Bronfenbrenner's (1979) systems theory and McLeroy and colleagues' (1988) social ecological model, both of them emphasizing the impact exerted by social

relationships, community, environment, and policy on people's behavior (Bronfenbrenner, 1979; McLeroy et al., 1988). However, despite the rich contributions made by ecological models, there still is an overemphasis on person-level explanations and theories of health behavior, which have created "blind spots" in the available research. One of the most notable of these blind spots is the assumption that an individual person is completely independent, isolated, and distinct from other people and their environments (Goodson, 2010; McLeroy et al., 1988). Studying individual persons apart from their environments is arguably unrealistic, invalid, and potentially (according to some scholars) iatrogenic (Buchanan, 2000; Lincoln & Guba, 1985).

Thus, SNA satisfies the need — both theoretically and methodologically — to analyze more than the individual person in order to understand his/her (or a group's) health behaviors. SNA automatically shifts the focus of an analysis to multiple levels because relationships are mapped out and measured (Borgatti et al., 2013; Christakis & Fowler, 2007, 2008; Jeon & Goodson, 2015; Valente, Gallaher, & Mouttapa, 2004). SNA allows for consideration of personal attributes (data on individual people,) dyadic relationships, and structure of a network simultaneously (Borgatti et al., 2013; Valente, 2010). For instance, in their review of studies using SNA and Add Health data (data measuring adolescents' health risk behaviors), Jeon and Goodson (2015) concluded that SNA studies of adolescents' risky behaviors indicate those behaviors can be predicted by the risky behaviors of these adolescents' friends. The authors suggest that SNA "allows better understanding of phenomena that cannot be adequately studied with traditional analyses…[in that] linear analysis cannot provide measures of structural linkages among

individuals located inside a network as a supplement to measures of an individuals' health risk behaviors" (Jeon & Goodson, 2015, p. 24). Therefore, SNA offers the distinct advantage of analyzing complex behaviors in a more complex way, thus capturing these behaviors in a more valid manner.

Social influence is especially important among college populations, as students are more prone to adopt and spread health behaviors present in their social networks (Hays & Oxley, 1986; Paul & Kelleher, 1995; Paxton et al., 1999). Social Network Analysis (SNA) has been used to assess the social influence of binge drinking (Lorant & Nicaise, 2014), stress (Korneinko, Clemans, Out, & Granger, 2013), and study patterns (Hafferty, Castellani, Hafferty, & Pawlina, 2013) among college student networks. Considering the evidence that social networks are of particular importance to college student behavior, a review of the literature on how SNA has been applied to the study of behavior among college-aged adults is useful. Such a review would: (a) allow assessing what types of networks are being examined related to college-aged adults' health (i.e., whole network or egocentric network studies – see distinction in Background section, below); (b) synthesize important findings related to social relationships among a population vulnerable to social influence; and (c) reveal evidence (obtained through SNA) that researchers cannot uncover with traditional analyses.

The aims of this study therefore are to: (1) systematically review the research employing SNA as a method/approach to study college-aged adults' health; and (2) compare whole network and egocentric network approaches used in the reviewed studies (see distinction between the two approaches, below).

Systematic literature reviews are important contributions to a body of research due to their ability to synthesize and assess research questions, methods, and results across time within a field of study. Systematic reviews are a critical resource for practitioners (i.e., nurses, physicians, physical therapists) and educators because they assist in managing a large body of research in order to make evidence-based decisions (Forbes, 2003; Bennet et al., 2005). Thus, systematic reviews help to inform the future of a field by surveying its past and providing a summary of results in a concise and useful way (Garrard, 2007; Mullen & Ramírez, 2006).

Background

SNA is an intriguing approach to understanding health behaviors because it moves beyond the individual level of analysis to focus on relationships. Researchers use SNA to examine the structures and processes of networks: instead of studying attributes of individual people to explain social mechanisms, SNA investigates the ties among units and the arrangements that emerge through interaction patterns (Kothari et al., 2012). Social networks play a significant role in complex behaviors (Borgatti et al., 2013) and can impact behavior above and beyond personal and individual attributes (Valente, 2010). SNA has been used in fields such as sociology, zoology, urban planning, criminology, business, management, and economics (Dempwolf & Lyles, 2012; Hanson et al., 2008; Parise, 2007; van der Hulst, 2009; Wey, Blumstein, Shen, & Jordan, 2008; Whitman, 2012) and is garnering increasing popularity in public health (Harris, Luke, Burke, & Mueller, 2008; Hawe, Webster, & Shiell, 2004; Kothari et al., 2012; Luke & Harris, 2007).

There are two primary approaches to studying networks: egocentric or whole network approaches. An egocentric network approach focuses on the personal networks of individual people, where the ego is the hub of the network connected to alters (Kothari et al., 2012). Whole network analyses study networks in their entirety, as a whole. In a whole network approach, all persons are treated equally, whereas in egocentric network research, the ego is the most important unit of analysis and all information used in analysis comes from the ego (Hansen, Shneiderman, & Smith, 2011). Both approaches constitute SNA, but they differ in terms of what the researcher can ask, what measures can be derived, and what conclusions can be made. In sum, the distinct perspectives shape how researchers design and conduct a network study. Because SNA is widely used in social and behavioral sciences, it is important for readers to understand how findings differ based on approach. Egocentric and whole network research will each provide a lens into the complexities of social relationships and how they impact health, but it is critical to understand how results from an egocentric design are different than those from a whole network design.

Egocentric Networks

Egocentric networks (also known as ego-networks, local networks, or personal networks) focus on the perspective of the ego. An ego is a single, focal node in a network analysis. For instance, say we are interested in conducting an egocentric network analysis on how social connections impact healthy eating in college. We could survey a sample of college students and ask each of them to report their own fruit and vegetable consumption, along with who they feel close to and how often those people

consume fruits and vegetables. If Lori, who occasionally eats fruits and vegetables, was surveyed, she might say she feels close to Don, who never eats fruits and vegetables, to Martha, who occasionally eats fruits and vegetables, and to Jim, who always eats fruits and vegetables. In this case, Lori is the ego, while Don, Martha, and Jim are the alters (see Figure 2). We would then take data from several egos and analyze whether the amount of fruits and vegetables consumed by an ego's alters is related to their own consumption of fruits and vegetables.

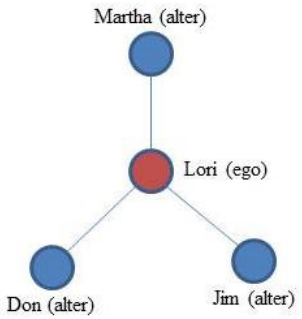

Figure 2. Example of an ego and alters

According to Feld (1981), egocentric networks are constrained by the environments and activities in which an ego is embedded. Factors external to the network itself influence the behaviors and foundations upon which someone builds and sustains social relationships (Feld, 1981; Perry, 2012), giving social and behavioral scientists reason to consider the use of egocentric network analysis in research. Additionally, egocentric networks have gained popularity in the social sciences because they fit well within a standard survey approach (Borgatti et al., 2013; McCallister &

Fisher, 1978). In other words, questions can easily be added to a standard instrument and do not require respondents to reveal their identity. While egocentric data can be collected from whole network data because egocentric networks are embedded within whole networks (Borgatti et al., 2013), this paper will distinguish the two by focusing on egocentric networks generated from data that are collected through a personal-network design. For example, if data are collected on an entire company (a whole network), but the researcher is interested specifically in the CEO (an ego within the network), the researcher may choose to run egocentric analyses based on the ego of interest. The limitation to this method of egocentric network analysis is that egos from whole network research only report on alters that are also in the specified network of interest. So in the example of the CEO, the researcher would only have information on the CEO's coworkers, and not on her family or friends.

As mentioned, data collected through egocentric network research represent only a particular respondent's personal network (Borgatti et al., 2013; Valente, 2010). This approach investigates the social context of a focal person by eliciting a set of people known to that ego, collecting information on those persons, and examining the ties among them (Marsden, 1990; Wasserman & Faust, 1994). In an ideal egocentric network design, three versions of data are collected. The first set of data is collected through name generators, which are open-ended questions that prompt the ego to generate names, nicknames, or initials of people in that ego's life. Examples of name generator questions include 'who do you talk to about important matters?', 'who do you talk to most frequently?', or 'who are your closest friends?' The names generated are called

alters. The second set of data the researcher will collect by asking questions called name interpreters which elicit data from the ego about each name mentioned in the name generator, including sociodemographic characteristics and/or behaviors (Borgatti et al., 2013; Valente, 2010; Wasserman & Faust, 1994). According to Valente (2010), it is common to measure the following characteristics among alters: (1) strength of relationship to the alter; (2) frequency of interaction; (3) type of relationship; (4) socioeconomic characteristics; (5) demographic characteristics; (6) substantive characteristics; and (7) content of communication or risk behavior. The ego is responsible for providing all information about alters. Finally, a third set of data gives the researcher the option of asking questions called name interrelaters, where the ego is asked about the ties among alters. These are also known as alter-alter ties (Borgatti et al., 2013) and allows for more structural measures to be considered from the egocentric perspective. For instance, back when we asked Lori about the people she felt closest to and their fruit and vegetable consumption, we might also ask her if the alters she nominated are connected to one another. In that example, Lori nominated Don, Martha, and Jim. If Don, Martha, and Jim are all connected to one another, Lori's reported ego network would have no structural holes. However, if she reported that Don and Martha are connected, but Jim is not connected to either Don or Martha, then her ego network would have two structural holes. Structural holes refer to the positional advantage or disadvantage of an ego based on how they are embedded within their networks (Burt, 1992). So, if in our example Lori's alters (Don, Martha, and Jim) were all connected to one another and there were no structural holes in Lori's egocentric network, Lori would

theoretically be more limited by her network because she would not benefit from outside influence directly or indirectly (Burt, 1992). See Figure 3 for an illustration of structural holes.

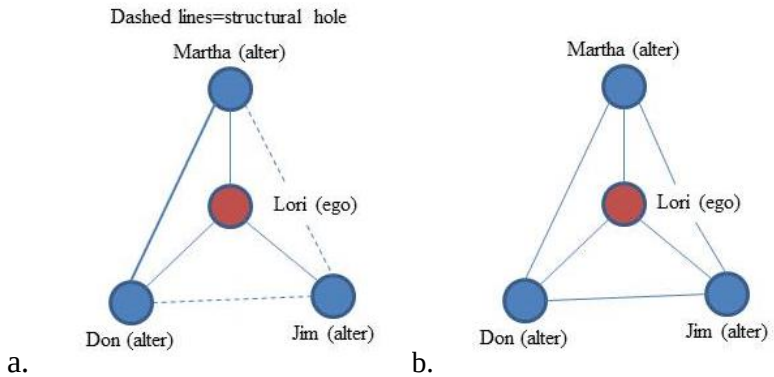

Figure 3. Egocentric networks with (a) and without (b) structural holes

Egocentric networks assess three relational dimensions including: network composition (attributes of network members and how they relate to the ego); types of interactions and support available through these relationships; and structural measures (i.e., density, centralization) of how the network is organized (Marsella & Snyder, 1981; McCarty, 2002; Min et al., 2013). Typical network measures derived from egocentric networks are size, composition, personal network exposure, tie strength, density, and constraint (Valente, 2010).

Size is simply a count of how many people the ego provided in response to a name generator. Oftentimes size is limited by the researcher because the survey only allows the ego to list a finite number of alters in the name generator. Some researchers

allow respondents to name as many people as he/she can think of, or at least increase the limit beyond the traditional five or six alters (McCarty, Bernard, Killworth, Shelley, & Johnson, 1997). The advantage of limiting the number of alters generated is a shorter survey because when more alters are named, additional information is required for each alter. Having more alters allows the researcher to see a more dynamic network with the inclusion of both strong and weak ties (Valente, 2010).

Personal network exposure is the degree to which an ego's alters engage in a particular behavior and captures social influence by measuring the extent someone's network participates in that same behavior (Valente, 2010). Tie strength assesses how close an ego is to an alter. People are more likely to be influenced by those close to them and with whom they have complex relationships (Valente & Vlahov, 2001). A complex relationship is demonstrated when a person in someone's network fits multiple roles. For instance, in our example of Lori, Jim might be Lori's friend, coworker, and brother-in-law. This relationship is more complex than if Jim was merely Lori's coworker. Weak ties are important at a more macro level because they connect different groups of people and thus aid the spread of information and behavior (Granovetter, 1973). Weak ties are defined based on how a researcher measures the strength of tie (Granovetter, 1973). For instance, if strength of tie was measured based on how often someone sees an alter in person, then the alters they see daily would be stronger ties than the alters they only see once a year. The alters they only see once a year would be weak ties in this example. When a name generator asks the ego to indicate which of the alters know one another, a personal network density variable can be constructed. Density is basically a measure of

the proportion of an ego's friends who are connected to each other (Borgatti et al., 2013). Dense personal networks reinforce norms and practices and tend to protect the ego from outside sources of risk or influence. On the other hand, radial (less dense) personal networks give the ego more access to information and influence circulating in the network (Valente, 2010). Density is usually seen as an indicator of constraint (Borgatti et al., 2013). Constraint, as opposed to density, measures the connections among alters from the alter's perspective (Burt, 2002; Valente, 2010) and is the extent to which an ego's alters are perceived to be tied to each other. Constraint is also a measure of the extent to which the ego invests time and energy in alters who invest in one another (Borgatti et al., 2013). People who display low constraint can access their networks better and span structural holes in their network better than those who are highly constrained within their networks (Burt, 2002).

Because egocentric networks arise strictly from the ego, egos can be randomly sampled. A sample of egos do not need to be related to one another in any way (i.e., from the same sorority) in a research study because each egocentric network is independent of someone else's egocentric network Therefore, statistical analyses using egocentric network data do not need to control for non-independence the way whole network data do (Valente, 2010). Egocentric analysis can be done with standard attribute-based statistical programs such as SPSS, although network based software packets (i.e., UCINET) have some of the same capabilities. Additionally, egocentric network data are more generalizable to the population being studied than whole network data (Valente, 2010). For instance, the researcher can randomly sample college students

from several universities and give each the same survey in egocentric network research, whereas whole network research is limited to just the members of a defined group, and therefore results can only refer to the group being measured.

Whole Networks

In a whole network study (also called complete networks, census, or sociocentric networks), the sets of ties among all members in a given network are studied, and therefore the perspective shifts from the ego to the network itself (Borgatti et al., 2013). A key distinction between egocentric networks and whole networks is this: alters generated in egocentric networks may or may not be among the set of nodes in a particular network, whereas whole network research is bound to just the members of a particular network set. Thus, all alters in a whole network are also egos, and vice-versa. Whole network studies have the distinct advantage of giving researchers the opportunity to investigate all levels of network analyses (individual, group, and network; Borgatti et al., 2013).

An assumption of whole network data is that the nodes represented in the data are bound within a particular network and that all nodes in the network are included in the data. The researcher is responsible for drawing those network boundaries. This is known as *boundary specification* and can make whole network data collection more complicated than egocentric network research. Boundary specification depends on the research question being asked and whether natural or social boundaries exist for a particular group of nodes. Because the researcher is tasked with sampling all members of a bounded network, random sampling is not an element of whole network research, and

whole network analysis is consequently less generalizable to the population of study (e.g.., college students) than egocentric network analysis (Borgatti et al., 2013; Valente, 2010).

According to Borgatti, Everett, and Johnson (2013), "the proper selection of network questions and formats is critical to the success of any network study" (p. 45). Complete network data, or census data, consists of responses from all members of a network and can be collected using open- or close-ended questions. Close-ended questions require the researcher provide a roster of all members in the network. Respondents are asked to check those on the roster that correspond to the researcher's question (i.e., Who in your network do you go to for advice? Check all that apply). Open-ended questions ask the respondent to nominate people in their network based on the researcher's question. Advantages of the nomination method are: unaided recall; less demand on the respondent (that person does not have to read through an entire list of names); if rank ordered, nominations can be analyzed for tie strength; the number of nominations allowed for each respondent can vary; and data entry/management is easier. Advantages of the roster method (or close-ended questions) are: strong and weak ties are measured and there is no ambiguity regarding the boundary of the network.

Whole network data consists of relational and structural variables. Relational variables are constructed from ties between specific nodes, whereas structural variables are constructed from the entire network of connections (Valente, 2010). Relational variables include connectedness and reach (degree any member of the network can reach other members of the network), reciprocity (whether a person's nominations are

reciprocated), group membership (who belongs to which groups in a network), network density (proportion of ties in a network relative to the total number possible) as well as the previously mentioned personal network density and constraint.

Examples of structural variables are centrality and position. Centrality measures, including degree (number of links to and from a person), closeness (average distance a node is from all other nodes in the network), and betweenness (the frequency a person lies on the shortest path connecting everyone else in the network), often help identify important nodes that may be influential in the spread of ideas and behaviors because they are located strategically in the network (Freeman, 1979). A position in a network is a set of nodes that has the same links to the same others or the same types of others. The idea is that positions arise in a network similar to roles, and that people who occupy the same space in the network often act similarly (Valente, 2010).

College Students

Research suggests that social influence, peer influence in particular, is especially powerful among college students (Borsari & Carey, 2001; Hays & Oxley, 1986; Paul & Kelleher, 1995). College students live, work, and socialize with their peers, and therefore are vulnerable to peer influence. Studies show that college students are likely to adopt the positive and negative behaviors of their peers, such as binge drinking (Lorant & Nicaise, 2014) or healthy eating (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2014). Considering the strong effect social networks have on college students, and the methodological and theoretical advantages SNA has on studying social influence, the purpose of this paper is to review the literature for studies using SNA to investigate

college student health. We hypothesize that studies will reveal strong associations between network measures and health behaviors. We also hypothesize the majority of studies found in the literature will use an ego network approach to SNA, as ego network research mirrors person-level theory more closely than whole network research.

Methods

The aim of this review was to synthesize the research using SNA to investigate college student health, in order to answer the following questions: (1) How has college-aged adults' health been studied using SNA and what were the findings? (2) Which SNA approach was most often used and how do they compare when studying college-aged adults? And (3) What are important considerations for use of SNA in health studies? To do this, we systematically surveyed the peer-reviewed literature that used SNA to investigate college-aged adults' health using the PRISMA guidelines (Moher et al., 2009). Please see Figure 4 for the PRISMA flow diagram of reviewed studies. We used Garrard's Matrix Method to guide the review and thoroughly survey the peer-reviewed literature describing the use of SNA to investigate health-related factors among college-aged populations.

To be eligible for inclusion in the review, studies had to employ SNA methodology to study health among college student populations. Egocentric and whole network studies were both eligible for inclusion. Studies that did not use SNA, did not investigate health, or did not examine college student populations were excluded. Articles were excluded if they were not peer-reviewed, were written in a language other

than English, comprised only abstracts, studied adolescents (younger than 18 years of age) or did not use SNA to study health.

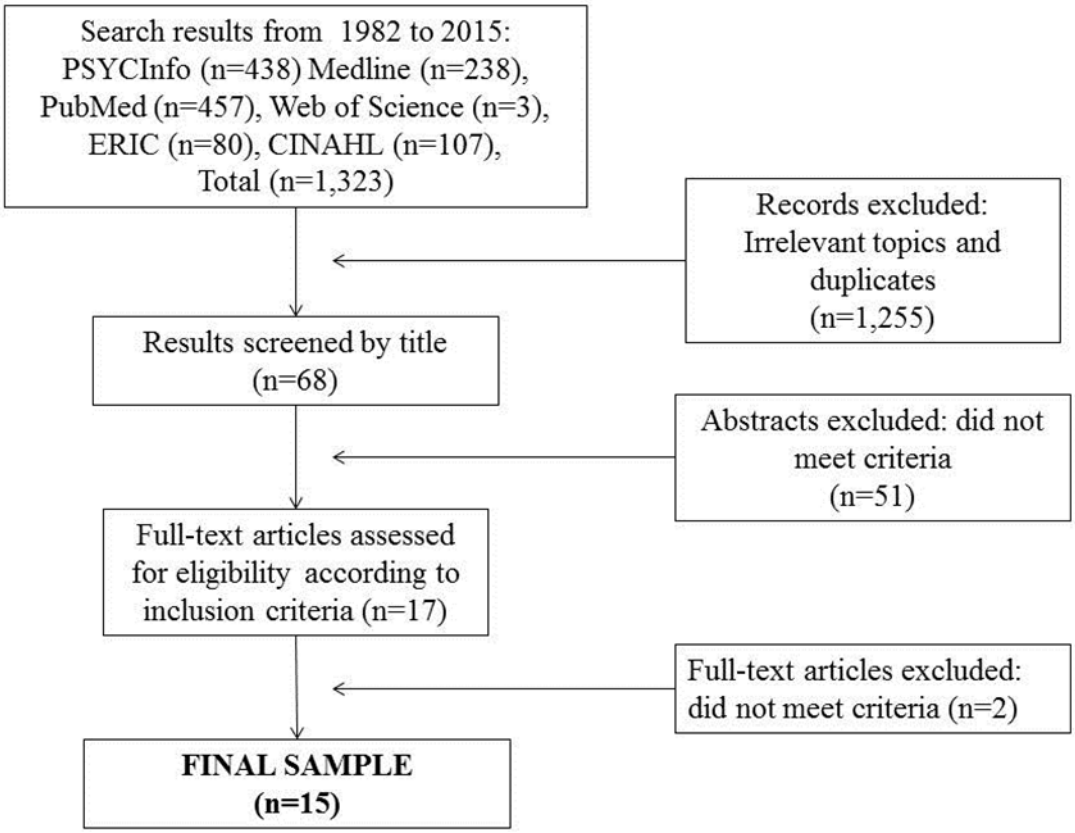

Figure 4. PRISMA flow diagram of studies using SNA in college student health research

We conducted the search in the following databases: PsycInfo, Medline, PubMed, ERIC, CINAHL, and Web of Science. The main search terms used were "social network analysis", "college students", "university students", "undergraduates", "network analysis", "ego networks", and "whole networks." All relevant literature was cross-referenced to identify additional related articles. Identified articles were fully

reviewed, and the following data were extracted from each publication: the year published; the purpose and research questions of the study; the sample characteristics; the network approach used; network characteristics measured; statistical analyses conducted; as well as results and implications of the study.

In total, 1,323 articles published between 1982 and 2015 were identified through the database search. One thousand two hundred and fifty five articles (1,255) were excluded before abstract review based on title. If articles clearly did not explore the health of college-aged adults or did not use SNA methodology, they were excluded. An additional 51 articles were removed after abstract examination because (a) the study did not use SNA, (b) the study was not related to health, or (c) the study measured a different population of interest (i.e., adolescents). Overall, the full texts of 17 articles were reviewed. Two articles were then excluded from the final sample because the network analysis defined in these articles did not use a whole or egocentric network study design (i.e., data from a social networking website was analyzed), resulting in 15 full text articles extracted and included in the review. See Figure 1 for the PRISMA flow diagram (Moher et al., 2009). Two trained researchers independently reviewed the full text of the 15 articles. See Appendix B for the extraction matrix.

Findings

Research Question 1: How Has the Health of College-Aged Adults Been Studied Using SNA, and What Were the Findings?

The most popular health behavior studied using SNA among college-aged adults was drinking (Dorsey, Scherer, & Real, 1999; Dumas, Graham, Bernards, & Wells,

2014; Dumas, Graham, Maxwell-Smith, & Wells, 2015; Dumas, Wells, Flynn, Lange, & Graham, 2014; Fondacaro & Heller, 1983; Lorant & Nicaise, 2014; Phua, 2011; Reifman, Watson, & A., 2006). These studies accounted for half (53%) of the studies in this review. Other substance abuse also was a popular topic of interest, with one study on smoking (Phua, 2011), one on marijuana use (Wister & Avison, 1982), and one on drug use in general (Duncan, Boisjoly, Kremer, Levy, & Eccles, 2005). Sexual behaviors (and attitudes) were researched in three of the studies (Duncan et al., 2005; Holloway, Rice, & Kipke, 2014; Swartout, 2013), aggressive behaviors in two studies (Dumas et al., 2015; Swartout, 2013), followed by stress (Korneinko et al., 2013), homesickness (Hendrickson, Rosen, & Kelly Aune, 2011), and dating (Lamkin, Campbell, vanDellen, & Miller, 2015).

Several network characteristics were assessed in the studies reviewed. Across both whole network studies and egocentric studies, centrality, including degree centrality (Dumas et al., 2015; Dumas, Wells, et al., 2014; Holloway et al., 2014; Korneinko et al., 2013; Lorant & Nicaise, 2014; Wister & Avison, 1982) and closeness centrality (Lorant & Nicaise, 2014), as well as network composition (Dorsey et al., 1999; Hendrickson et al., 2011; Lorant & Nicaise, 2014; Reifman et al., 2006; Wister & Avison, 1982) were the most commonly reported network variables. Centrality is often a measure of power or popularity (Freeman, 1979), and was demonstrated as such in Kornienko and colleagues' (2013) study on stress among a cohort of nursing students. Findings suggest that isolated students in the nursing cohort had higher stress levels than the more popular and connected students (the students with higher centrality scores). Though each person

has a unique centrality score, this score reveals how a person is positioned within a group or network. This information is not accessible to the researcher unless a network analysis is conducted, and is, therefore, a deviation from what is learned from traditional statistics.

Measures of network structure including core-periphery (Holloway et al., 2014), clustering (Phua, 2011), density (Fondacaro & Heller, 1983; Korneinko et al., 2013; Swartout, 2013; Wister & Avison, 1982), homophily (Lamkin et al., 2015; Phua, 2011), and network size (Fondacaro & Heller, 1983) were measured across whole and egocentric networks. And finally, cohesion (Dorsey et al., 1999; Dumas, Wells, et al., 2014; Holloway et al., 2014; Lorant & Nicaise, 2014), and tie strength (Dorsey et al., 1999; Hendrickson et al., 2011; Lamkin et al., 2015) were also measured. For example, in Swartout's (2013) study assessing the effect of peer groups on college men's sexual aggressive behaviors and attitudes, results indicated men with tightly knit peer groups (high density peer groups) tend to have less hostility toward women. With sexual assault increasing in prevalence on college campuses (Franklin, Bouffard, & Pratt, 2012; Lund & Thomas, 2015), these findings provide key social characteristics of men more likely to display sexually aggressive behaviors and attitudes.

Findings from studies. The findings from all studies reviewed are a direct reflection of, and depend upon each study's purpose. Collectively, network studies of the health of college-aged adults reported the following major findings:

1. Several health behaviors were related with homophily (connecting to others who are similar in some way; Duncan et al., 2005; Wister & Avison, 1982). For

instance, in a network of freshmen fraternity pledges, those that smoked were more likely to be connected to others in the network who also smoked (Phua, 2011).

2. Drinking behaviors were predicted by network composition (Reifman et al., 2006), centrality (Dumas, Wells, et al., 2014), density (Fondacaro & Heller, 1983), and homophily (Lorant & Nicaise, 2014). For example, Reifman and colleagues (2006) demonstrated that egocentric networks composed of "drinking buddies" and Greek members, and those that were not composed of family members, predicted heavier college drinking.
3. The composition of ego networks determined homesickness among international students (Hendrickson et al., 2011). In their study, Hendrickson and colleagues (2011) showed the importance of international students' connecting with peers from their host country in order to avoid feeling homesick and in turn, feel more satisfaction and better adjusted away from home.
4. Outdegree predicted less stress among nursing students in one study(Korneinko et al., 2013). Korneinko and colleagues (2013) were able to demonstrate that nursing students who were more socially isolated and more on the periphery of their academic network experienced more stress than those who were better connected. The higher outdegree a nursing student had (i.e., the more that student was nominated as a friend by other nursing students) the lower that student's cortisol and stress levels.

5. Density was negatively associated with aggressive attitudes toward women in one study (Swartout, 2013). When male college students reported a tight-knit group of peers, they were less likely to display sexually aggressive or hostile attitudes and behaviors toward women. On the contrary, college men that were not closely tied to a group of friends were more likely to display sexually aggressive behaviors and attitudes, and were also likely to connect with other men that were similarly hostile.
6. Tie strength (length of time in a romantic relationship) and similar narcissistic personality traits (entitlement and "exploitativeness") within romantic relationships predicted negative relational adjustment within couples (Lamkin et al., 2015). Couples who had been together longer and who scored high for entitlement and exploitativeness were less likely to be agreeable, affectionately expressive, or satisfied in their relationships.

Research Question 2: Which SNA Approach was Most Often Used and How Do They Compare when Studying College-Aged Adults?

Of the 15 articles reviewed, 11 were egocentric studies. Therefore, almost three-quarters (73.33%) of the research using SNA to investigate the health of college-aged adults is egocentric. This finding supports our hypothesis that the majority of health-related studies using SNA to study college-aged adults are, indeed, egocentric studies.

In this review, egocentric studies primarily sought to understand how composition of personal networks (i.e., percentage of ties with similar attitudes as the ego) predicts certain behaviors such as alcohol consumption (Dorsey, Scherer, & Real,

1999; Dumas, Graham, Bernards, & Wells, 2014; Fondacaro & Heller, 1983; Hendrickson, Rosen, & Kelly Aune, 2011; Reifman, Watson, & A., 2006; Wister & Avison, 1982). For example, in their egocentric study investigating international students' adjustment to life in the United States, Hendrickson, Rosem, and Aune (2011) found that student's whose networks were composed of more peers from their host country were more satisfied, content, and less homesick than those that had networks composed largely of peers from their home country.

A few egocentric studies also investigated structural variables, such as size (how many alters an ego nominates) or range (the various types of relationships an ego nominates) of the ego network, in relation to behavior (Dumas, Graham, et al., 2014; Dumas et al., 2015; Dumas, Wells, et al., 2014; Swartout, 2013). For instance, an ego that nominates more alters might be more prone to binge drinking. While these measures are structural, they only measure structural components of the ego network and not of an entire social network.

One study analyzed a network variable (composition of narcissistic persons in a romantic dyad) as the dependent variable, and used individual data (i.e., psychopathology) as independent variables (Lamkin et al., 2015). This was the only study that did not predict a health behavior, attitude, or marker using network variables as independent variables.

Among the reviewed studies employing a whole network approach, the most common purpose was to investigate the relationship between positions and structures in a network (i.e., homophily) and health behaviors or health markers such as cortisol

levels (Korneinko et al., 2013; Lorant & Nicaise, 2014; Phua, 2011), as well as specific points in the network to target for intervention (Holloway et al., 2014). For instance, the purpose of Holloway, Rice, and Kipke's (2014) whole network study was to map the connectivity between gay-friendly venues (i.e., coffee shops, bars). By surveying the gay community, researchers could create a social network of gay-friendly venues that provided target points, based on high traffic, for HIV prevention education. By conducting a whole network SNA and mapping the relationship between venues and patrons, researchers uncovered key points for future intervention concerning HIV education

Research Question 3: What Are Important Considerations for use of SNA in Health Studies?

Similar to traditional statistics, when conducting SNA, it is important for the researcher to consider the assumptions and data collection methods necessary to draw appropriate conclusions. This review suggests there is inconsistency in the college-aged adult health literature regarding: boundary specification of the network in whole network studies and collecting data from the entire network; use of interrelater questions when collecting egocentric research; limits on nominations in whole and egocentric network research; and employing statistics to account for nonindependence in the analysis of whole network data,

Boundary specification and data collection in whole network analysis. When conducting whole network research, it is important for the researcher to define the network prior to sampling/data collection, so all members of the network are identified

and data from all members can be collected (Borgatti et al., 2013). Boundary specification is a difficult task in whole network research because oftentimes, specification can be very subjective (Laumann, Marsden, & Prensky, 1992). However, boundary specification has to be established in order for the researcher to know whether or not the entire network has been included in data collection, which is an important assumption for whole network SNA (Borgatti et al., 2013). One study used data collection to inform what would ultimately be the complete network. In their study on whether traditionally gay venues would be appropriate places for HIV-prevention intervention, Holloway, Rice, and Kipke (2014) asked young gay, bisexual, and other men that have sex with men to identify their "favorite three gay places to socialize." Thus, 438 participants identified a network of 110 venues. The authors specified the network this way because they wanted to ensure that any gay-friendly venue used by their population was included in the study. The researchers would not have been as familiar with this community and may have left important venues out. This is a deviation of normal practice in SNA in that the researcher did not specify *a priori* the boundaries of the network of interest, but seemed to be the appropriate procedure in this study because the researchers themselves were unable to specify the network any other way. Thus, health researchers using whole network analysis need to consider the best way to specify the network in their study, and should have boundaries clearly defined in order to include the entire network in the analysis.

In our review, only two of the four whole network studies collected data on 100% of the network. Lorant and Nicaise's (2014) study looking at binge drinking among two classes

at a university in Belgium was missing 40% of the data in one class network and 34% of the data in the other. Kornienko and colleagues (2013), who measured cortisol levels within a cohort of first-year nursing students, reported only a 56% participation rate from their measured network. Because whole network analysis assumes the entire network is represented in data, conclusions from partial representations of the network are in violation of assumptions. Thus, it is important for the researcher to consider how the network is specified and, in turn, weigh his or her ability to collect data on an entire network when using the whole network approach to SNA.

Interrelater questions in egocentric network research. Traditionally, egocentric network data are collected via name generator, name interpreter, and interrelater questions. These three questions allow the researcher to build the ego network, understand its composition, and measure its structure. Among the 11 egocentric network studies reviewed in this paper, two collected data using all three egocentric data questions (Swartout, 2013; Wister & Avison, 1982). The majority of egocentric studies (n = 6) used name generators and name interpreters only, and did not collect interrelater data (Dumas et al., 2015; Fondacaro & Heller, 1983; Hendrickson et al., 2011; Lamkin et al., 2015; Reifman et al., 2006). While name generator and name interpreter questions provide enough insight for the researcher to complete the analysis and draw meaningful conclusions, name interrelaters reveal important structural components that traditional statistics are unable to reveal. Thus, researchers should strongly consider using interrelater questions in their egocentric network design in order to capitalize on results from SNA that are above and beyond what can be learned with traditional statistics.

Nomination limits in whole and egocentric network research. In both egocentric and whole network research, the researcher has the option of capping how many ties are listed by participants. In this review, studies were split on whether or not to use nomination limits.

Most egocentric network studies limited the number of ties nominated or represented in the final sample. Several studies collected egocentric data on predetermined dyads (Dorsey et al., 1999; Dumas et al., 2015; Dumas, Wells, et al., 2014; Duncan et al., 2005). For instance, in Duncan and colleagues' (2005) study of the likelihood an incoming freshman would binge drink, the dyads studied were roommates, which are predetermined and not required by a name generator. Thus, if dyads are predetermined, there is a limit to the number of ties represented in the analysis. For the studies that asked participants to nominate ties through name generators, most put a numerical limit (between one and 15) on the number of alters listed (Duncan et al., 2005; Fondacaro & Heller, 1983; Reifman et al., 2006). However, two studies did not put any limit on how many alters an ego could name in the name generator (Hendrickson et al., 2011; Wister & Avison, 1982).

Three of the four whole network studies did not limit the respondent on how many alters they nominated in their network (Korneinko et al., 2013; Lorant & Nicaise, 2014; Phua, 2011). Two studies provided rosters of the complete network to respondents (Korneinko et al., 2013; Lorant & Nicaise, 2014), and the other two relied on recall (Holloway et al., 2014; Phua, 2011). Limiting nominations may be more realistic in data collection (the more nominations, the longer data collection will take), but it also may

impact the conclusions of the study, which is why nomination limits are an important consideration when conducting SNA.

Statistics used in analysis of whole network data. A key aspect of network analysis is its focus on relationships, assuming interdependence among nodes (Borgatti et al., 2013). However, traditional statistical analyses under the general linear model (i.e., linear regression) maintain the assumption that all units of analysis are independent (Cummings, 2012; B. Thompson, 2006). Therefore, statistical analyses should be adjusted to account for interdependence when conducting whole network analysis. However, according to the results of this review, only two of the four whole network studies (Lorant & Nicaise, 2014; Phua, 2011) incorporated non-parametric statistical tests that allow for interdependent data. Health researchers must consider using statistical analyses that account for nonindepedence, such as quadratic assignment procedures (QAP) or exponential random growth models (ERGM), in order to accurately describe findings from SNA.

Discussion

This paper reviewed 15 articles that used SNA to investigate the health of college-aged adults. From this review, we learned that alcohol use was the most common health concern studied using SNA, and several network variables (i.e., centrality, homophily) were related to drinking behaviors. Egocentric network designs were used in the majority of studies investigating the health of college-aged adults. This review also revealed important considerations when conducting SNA in the health field, including

whether to use nomination limits when doing SNA and appropriate statistical analyses that should be employed when analyzing network data.

The Study of College-Aged Adults' Health Using SNA

Among college-aged adults, SNA has been especially telling in the area of alcohol consumption. More than half of the studies included in this review tested network effects on alcohol consumption among college-aged adults. These findings provide important insight into the impact social networks have on heavy drinking, especially considering alcohol consumption is the largest public health problem among college student populations (Room, Babor, & Rehm, 2005; Wechsler & Nelson, 2008).

The results of this review affirm the use of SNA in college-aged networks, but also reveal the need to explore other important health issues within this population. For instance, eating disorders and body image issues, stress, and use of prescription drugs are especially prevalent among college-aged adults (Ackard et al., 2002; Massachusetts Eating Disorders Association, 2014; Schwitzer, Bergholz, Dore, & Salimi, 1998), but they have yet to be studied with SNA. Perhaps, like alcohol consumption and other health-related issues reported in this review, SNA could provide insight into what network variables are important to public health problems among college-aged adults and how to intervene in the future.

Comparing the Two Approaches to SNA

Egocentric and whole network research both focus analysis on relationships, and both produce measured network variables to be considered in scientific inquiry (Borgatti et al., 2013). Network variables are prudent in guiding intervention because they reach

beyond a personal profile – they allow researchers and practitioners to know what social and relational components are important and modifiable with educational interventions (Valente, 2010).

The network variables most commonly reported in the results of whole network studies reviewed was centrality (Korneinko et al., 2013; Phua, 2011), while composition was the most reported network variable reported in the results of egocentric network studies (Duncan et al., 2005; Reifman et al., 2006). The major distinction between results from whole networks versus those from egocentric networks is the emphasis on structural, relational, and positional findings available through whole network data.

While egocentric networks can analyze structure when interrelater questions are included in data collection, the structure is not network-wide, and most ego network analysts do not ask interrelater questions, according to this review. In other words, network variables measured through whole network research allows a researcher to know *where* (i.e., the periphery of the network) and *what* (i.e., beliefs about drinking) to target in an intervention for a particular network, whereas egocentric network research only provides the *what* (i.e., relationship with a parent), for an intervention.

Egocentric network analysis was the most common SNA approach used to study the health of college-aged adults in this review. This could be because egocentric data are similar to traditional research and fit well within a typical research design in the social and behavioral sciences. Variables measured through egocentric network analysis can be added as predictor variables in regression analyses, similar to any other measured

variable (i.e., BMI, scores on a personality test, and others), which makes egocentric SNA easier to apply for researchers not as versed in whole network analysis.

Important Considerations for Use of SNA in Health Studies

Whole network sampling. In this review, 50% of the whole network studies collected only partial network data. In consulting other SNA literature (beyond college-aged adult networks), several studies that claimed to be whole network by design only collected data on a percentage of the network (i.e., Valente et al., 2013). These studies beg the question: should network studies truly be dichotomized as either egocentric or whole network studies, or do the two approaches lie on a continuum? Can studies that do not collect data on the entire network still be deemed whole network studies?

Borgatti, Everett, and Johnson (2013), in their book *Analyzing Social Networks* , discuss how egocentric analysis is a stepping stone between social/behavioral survey research and whole network research, but to the best of our knowledge, the idea of a continuum has not been proposed. We believe it is important that assumptions of whole network research and egocentric research be adhered to if an author is going to characterize his/her approach as egocentric or whole network. However, because several studies fall somewhere in between, introducing a continuum could be useful. For instance, several studies that use the Add-Health data set (Jeon & Goodson, 2015) employ whole network methodology to *samples* of whole networks. This is in direct violation of the assumptions of whole network research, since the entire network was not surveyed in data collection. However, nominations in these studies were limited to a specific network, and therefore the study would not be considered a true egocentric

analysis since the ego could not nominate alters outside of a bounded network. Thus, these studies seem to land somewhere between whole and egocentric network research, which calls for a reconsideration of the dichotomized approaches to SNA.

Nomination limits. Several ego network and whole network studies included in this review limited the respondent to a certain number of alter nominations when completing network portions of a survey (Reifman et al., 2006; Swartout, 2013). Limiting the number of alters nominated by participants in a study has its strengths and weaknesses. When a limit is not issued, larger numbers of ties tend to be reported and can be extremely time consuming and complicate data collection (Valente, 2004). However, limiting the number of nominations can also remove weak ties from the network (McCarty, 2002). Granovetter (1978) argued for the importance of weak ties, especially in the exposure to new ideas and behaviors. For some research, such as assessments of risky behavior, it is likely that weak ties are the loci where new behaviors are introduced. For instance, consider a college student that has never drank alcohol before coming to college. The likelihood is that student's strong ties (their inner circle) are also people that do not drink. However, meeting someone new who does drink increases that student's risk of drinking. The odds are that new ideas and behaviors are introduced through weak ties in a person's network, rather than through strong ties (Burt, 2002; Granovetter, 1973). Thus, limiting alter nominations may remove important relationships present within the network. Merluzzi and Burt (2013) concluded in a study analyzing network data that five names is the most cost effective number of sociometric nominations to record, however most studies provided their own rationale for the

number of nominations asked of each participant. With the publication of Merluzzi and Burt's (2013) article, we might see an increase in the near future in the number of whole network studies limiting nominations to five alters.

Statistical analyses. For two of the four whole network studies reported in this review, traditional statistics (i.e., bivariate correlations, linear regressions) were used to analyze data. As aforementioned, to comply with the assumptions of SNA, nonparametric tests such as Quadratic Assignment Procedures (QAP) are needed to account for interdependence (Borgatti et al., 2013). QAPs are permutation tests that run bivariate correlations and regression analyses on matrices, rather than on individual scores of variables. Conversely, to comply with the assumptions of traditional statistics, independence must be assumed (B. Thompson, 2006). Therefore, as long as inferential statistics are being conducted on whole networks, the use of traditional statistics should be questioned.

As mentioned before, egocentric data more closely resemble traditional research because relational data are understood in the context of the individual person, and therefore network variables can be added as predictor variables in regression analyses, similar to the addition of other independent variables. Using traditional statistics makes for easier analysis and interpretation; however, it keeps network studies within the frame of the general linear model. One of the key assumptions of systems thinking according to Meadows (2008) is that systems science deals with non-linearity, or in other words, with phenomena that cannot be fully captured through linear equations and traditional statistics. In addition, SNA's focus shifts away from the individual components of a

system (i.e., persons) and centers on the connections among parts in the system (ties) and the phenomena that emerge from these connections. This poses a fundamental question: do egocentric networks actually meet the criteria to be deemed a part of systems science? We would argue that yes, it does, but its dynamic function may be limited, given the reliance on general linear models of analysis. Similar to scholars who view linearity as a special case of complexity, egocentric networks may represent a special case of network analysis (Philippe & Mansi, 1998).

CHAPTER IV

COMPULSIVE EXERCISE AMONG COLLEGE WOMEN: A SOCIAL NETWORK ANALYSIS

Introduction

The many benefits of regular exercise have justified its consistent promotion among various populations, including adolescents, older adults, persons with chronic illnesses, and college students (Anokye et al., 2012; CDC, 2012). However, in some instances, exercise can become harmful and dangerous. Many terms have been used to describe this notion of unhealthy exercise, including compulsive exercise, excessive exercise, obligatory exercise, exercise dependence, and exercise addiction (Chalk et al., 2011; Dalle Grave, 2009; Hausenblas & Symons Downs, 2002). In this paper, we will use the term *compulsive exercise*.

Compulsive exercise is characterized by: a drive or compulsion to exercise; prioritizing exercise over other activities; exercising despite physical, social, and emotional consequences; and feelings of guilt and anxiety when exercise is postponed or missed (Dalle Grave et al., 2008; Taranis, Touyz, & Meyer, 2011). Compulsive exercise can be physically and psychologically damaging and represents the most difficult behavior to treat among eating disorder patients (Dalle Grave, 2009; Dalle Grave et al., 2008). Not only is compulsive exercise a common symptom of eating disorders, it is often a precursor to its diagnosis (Polivy & Herman, 2002).

Of the 24 million people suffering from eating disorders in the US, about 90% are between the ages of 12 and 25 (Szmukler & Patton, 1995; The Review Center Foundation for Eating Disorders, 2003). Eating disorders are disproportionately diagnosed among college-aged women compared to other groups (Cash, 2004; Massachusetts Eating Disorders Association, 2014; Striegel-Moore & Franko, 2003) affecting 10% of at-risk females (females between the ages of 15 and 29 years; Polivy & Herman, 2002).

It is understood that body dissatisfaction is one of the primary reasons for the onset and maintenance of eating pathologies (Stice & Shaw, 2002), and is a powerful influence on shape-changing behaviors, such as compulsive exercise and restricting calories (Grogan, 2007; K. Homan, 2010; Klemchuk, Hutchinson, & Frank, 1990; Presnell et al., 2004; Stice & Shaw, 2002). Research continually supports a strong link between body dissatisfaction and eating disorders among college-aged women (Friedman, Dixon, Brownell, Whisman, & Wilfley, 1999; Lavine, Sweeney, & Wagner, 1999; Mangweth-Matzek et al., 2006; Stice & Shaw, 2002) and suggests large prevalence of compulsive exercise among college women (Guidi et al., 2009; Thome & Espelage, 2007).

The Tripartite Influence model developed by Thompson and colleagues suggests social influences, namely parents and peers, are core contributors to the development of body image and eating disturbances (J. K. Thompson et al., 1999). The Tripartite Influence model has been tested on samples of college women and supports the social influence of weight-related behaviors, such as compulsive exercise or anorexia, in this

population (R. Rodgers et al., 2011; Stice et al., 1996; van den Berg et al., 2002). Social influence is especially important among college students in general, as students are more prone to adopt and spread health behaviors present in their social networks (Hays & Oxley, 1986; Paul & Kelleher, 1995; Paxton et al., 1999).

When college students' social networks are of interest, researchers have employed Social Network Analysis (SNA) as a strategy to assess the social influence of various behaviors or traits, such as binge drinking (Lorant & Nicaise, 2014), stress (Korneinko et al., 2013), and study patterns (Hafferty et al., 2013). Given these precedents, it stands to reason that SNA has the potential to shed light on the social influence of compulsive exercise among college women.

Social Network Analysis (SNA) is both a theory and a method for examining connections among people, organizations, or other units of analysis (Valente, 2010; Wasserman & Faust, 1994). The primary aim of SNA is to shift focus from the individual units of analysis to the connections among them (Borgatti et al., 2013; Valente, 2010). SNA measures the social and behavioral impact of ties among people, and the structures created through those ties (Kothari et al., 2012; Meadows, 2008). Important network measures include centrality, group measures and cohesion, as well as position (Borgatti et al., 2013). According to network theory, people who hold central positions within a network likely have a unique influence on the rest of the network (Freeman, 1979) and can facilitate the adoption and spread of behaviors across the group (Alexander, Piazza, Mekos, & Valente, 2001; Rogers & Kincaid, 1981; Valente, Unger, & Johnson, 2005). In addition, network theory posits that persons who belong to the

same groups or cliques often participate in, or at the very least approve of, similar behaviors (Valente, 2010). Network theory also suggests that one's position in a network provides certain constraints and opportunities that he or she will encounter, and therefore impacts behavior (Borgatti et al., 2013). Due to the need for the behavioral sciences to focus beyond the individual level of analysis (Buchanan, 2000; Goodson, 2010), SNA is garnering popularity in fields such as sociology and public health (Valente, Fujimoto, Unger, Soto, & Meeker, 2013). Goodson (2010) suggests that the overemphasis on person-level explanations and theories of health behavior have created blind spots in our research, notably with the assumption that an individual person is completely independent, isolated, and distinct from other people and their environments. SNA theoretically and methodologically satisfies the need to analyze more than the individual person and assumes that each unit of analysis is embedded within a system, and therefore cannot be independent. The social networks in which people are embedded have significant influence on complex behaviors (Borgatti et al., 2013) and will impact a person above and beyond his/her individual attributes. Studies using SNA have shed light on the complexities of obesity (Christakis & Fowler, 2008; de la Haye et al., 2010), intravenous drug use (Wagner et al., 2013), and the spread of HIV (Helleringer & Kohler, 2007), among other health behaviors.

To the best of our knowledge, SNA has not been used to investigate compulsive exercise behavior. Given the large prevalence of eating disorders and compulsive exercise among college women, the potential threat compulsive exercise poses to college students' health and wellbeing (Guidi et al., 2009; Quick & Byrd-Bredbenner, 2013;

Thome & Espelage, 2007) and the substantial influence social networks have on college students' behavior (Hays & Oxley, 1986; Paul & Kelleher, 1995; Paxton et al., 1999), using SNA could significantly enhance the understanding of compulsive exercise among college women. SNA would identify if any network characteristics are associated with compulsive exercise within a college student network, while also identifying key persons and patterns within that network useful for future intervention. Thus, the purpose of this study was to conduct a SNA of a female college student network in order to configure which network characteristics, if any, are associated with compulsive exercise.

Methods

Participants and Procedure

Two hundred and forty eight college women were recruited for this study. All women recruited were members of the same sorority at a large private university in the southwestern US. For the purposes of doing a SNA, it is important that participants belong to a specified and bounded network. Thus, we used a sorority because it is a closed network with boundaries set by membership status. In addition, sororities are a concentrated network of college-aged women who are at increased risk for developing body image issues and disordered behaviors (Katzman & Wolchik, 1984; Schwitzer et al., 1998).

An email describing the study purpose was sent to the entire sorority prior to a meeting scheduled for data collection in the spring of 2015. At the meeting, the researcher clearly explained the informed consent document, which indicated: that the study was not mandatory and participants could drop out at any time; the aims of the

study; the potential risks and benefits of the study; confidentiality of data; and what would happen to data after they were collected. Of the 248 sorority members, 199 were present for the meeting and all agreed to participate. The 49 women not present at the meeting were invited by email to participate, at a later date and time. Nine of these members responded and completed the survey on campus, later. The final sample comprised 208 members of the sorority. The Institutional Review Board approved the study prior to data collection, and all participants gave consent with their signatures prior to data collection. Each person provided demographic data, attribute data, and network data by completing a paper survey handed out during a regularly scheduled chapter meeting.

Measures

For demographic data, participants were asked to indicate their birth date, year in school (i.e., freshman, sophomore,), pledge class in the sorority (the class of students that joined the sorority at the same time), race or ethnicity, home state or country of origin, as well as height and weight. A body mass index (BMI) score was calculated using the height and weight reported by each participant. Attribute data, which aggregate nodes based on common characteristics as well as indicate specific characteristics of change agents within a network (a person within a group or organization who helps transform the entire network), included questions measuring physical activity, compulsive exercise, and body dissatisfaction.

Two types of network data were collected in this study: (1) whole network data and (2) egocentric network data. Whole network data were collected via sociocentric

questions; in other words, participants were asked to identify the members they felt close to within their sorority, but not anyone outside of that established network. Since whole network research is conducted on an entire network, the respondent did not have to provide any information about those they nominated. Egocentric network data were collected via name generator and name interpreter questions. Participants were asked to list any five people they felt close to in their life (name generator) and provide information about each person they nominated (name interpreter). In this paper, we will focus on the demographic, attribute, and whole network data only.

Physical activity. The Godin-Shepard Leisure Time Exercise Questionnaire (Godin LTEQ), a 4-item scale that measures intensity and duration of strenuous, moderate, and mild physical activity during a typical 7-day period, was used to measure the sorority members' physical activity (Godin & Shephard, 1985). Participants report how many times on average they do various levels of exercise for more than 15 minutes in a week. Sum scores were created by multiplying reported instances of strenuous activity by 9, moderate activity by 6, and mild activity by 3, and adding those products together into a single score. Acceptable test-retest reliability has been previously established with the Godin LTEQ, with coefficient ranges between .74 and .80 (Godin & Shephard, 1985; Jacobs, Ainsworth, Hartman, & Leon, 1993; Joseph, Royse, Benitez, & Pekmezi, 2014). Difficulties with logistics prevented collection of test-re-test reliability data on the current sample.

Compulsive exercise. The Compulsive Exercise Test (CET) is a 24-item self-report measure used to assess the core features of compulsive exercise (Taranis et al.,

2011). The CET uses a 6-point Likert scale and comprises five subscales: (1) avoidance and rule-driven behavior; (2) weight control exercise; (3) mood improvement; (4) lack of exercise enjoyment; and (5) exercise rigidity. Avoidance and rule-driven behavior highlights someone's evasion of withdrawal symptoms as well as the guilt associated with the inability to exercise. Items from this subscale ask the respondent how true statements such as "I feel extremely guilty if I miss an exercise session" are to them. The weight control exercise subscale includes items such as "I exercise to improve my appearance." Weight control exercise is largely compensatory and is often linked to eating disorder diagnosis. Mood improvement focuses on how exercise makes a person feel, and includes items such as "I feel less anxious after I exercise." Lack of exercise enjoyment measures levels of compulsivity in exercise, and includes items such as, "I find exercise a chore." And finally, exercise rigidity assesses strict adherence to exercise with items such as, "my weekly pattern of exercise is repetitive." A CET score is created by summing the average score from each subscale. Reports of reliability coefficients in previous studies have ranged from .71 to .88 (Goodwin, Haycraft, Taranis, & Meyer, 2011; Goodwin, Haycraft, Taranis, et al., 2011; Taranis et al., 2011). Reliability was strong for the CET within our sample (Cronbach's α=0.84).

Body dissatisfaction. Body dissatisfaction was measured using the single-factor Body Shape Questionnaire (BSQ) created by Evans and Dolan (1993). This study used the short-form version of the questionnaire which includes 16 items measured on a 5-point Likert scale. Respondents' score on this scale was created by summing the total of all 16 items. Higher scores were indicative of greater body dissatisfaction. Previous

studies have reported acceptable reliability, with reported Cronbach's α ranging from .88 to .94 (Evans & Dolan, 1993; Pook, Tuschen-Caffier, & Brähler, 2008; Rosen, Jones, Ramirez, & Waxman, 1996). Reliability for the BSQ in this sample was very strong (Cronbach's α=0.94).

Network data. To collect sociocentric network data (data from all members of a specified network), a nomination method was used which allowed respondents to list the five people in their sorority that they felt closest to (Valente, 2010). Each respondent was provided a roster of all the women in their sorority to refer to when completing the network portion of the survey. For the sake of confidentiality, each person on the roster was assigned an identification number, and respondents were asked only to use identification numbers rather than names on the surveys. Thus, none of the completed surveys had identifying information. Once all data was entered, rosters that linked names to identification numbers were destroyed. Sociocentric data was entered as a square matrix, with identification numbers serving as the X and Y vertices. Forty women did not complete the survey and were removed from the matrix, resulting in 208 columns and 208 rows. Once data were entered, the following network measures were collected on this sample: structural equivalence, coreness, betweenness, edge betweenness, closeness, degree, eigenvector centrality, and cluster coefficients (see Table 1 for definitions of each network measure).

Analysis

SNA is a form of systems science, which has a different set of assumptions than traditional, positivistic science. Assumptions of systems science include: (1) a system is

more than the sum of its parts; (2) systems might show adaptive, dynamic, self-preserving, and goal-setting behavior; (3) nonlinearity (networks contain feedback loops and therefore by nature are not linear); and (4) units of analysis are connected to and dependent on one another (Meadows, 2008). A key methodological distinction between SNA and traditional statistical methods based upon the general linear model is that SNA does not assume independence (Borgatti et al., 2013). This has two major implications: (1) random sampling is not needed for best practice in SNA; and (2) in order to control for interdependence, permutation tests (i.e., QAP, ERGM) are used. In following the assumptions outlined above, SNA draws the focus of the researcher away from the individual and onto the connectivity between actors within a network.

Descriptive statistics were calculated using SPSS for demographic and attribute data and UCINET for network data. Visualization graphs of the network were created using NETDRAW. Quadratic assignment procedures correlations (QAP correlations) and multiple regression quadratic assignment procedures (MR-QAP) were conducted in UCINET. QAPs are permutation tests that run bivariate correlations and regression analyses on matrices, rather than on individual scores of variables. In order to complete a QAP, all data must be in square matrix form. Therefore, in this study, each attribute was transformed into a square matrix based on similarities or differences between nodes. For example, below, Figure 5 depicts three people with scores on variable X and gender. To create a square matrix based on attribute X as depicted in Figure 6, one could take the absolute difference of variable X scores between each pair of persons. For categorical data, the attributes matrix could be coded based on how nodes are similar (i.e., if Person

A and Person B were both female, they would receive a “1” in their shared cell in the square matrix (See Figure 7).

	Score on Variable X	Gender
Person A	5	Female
Person B	10	Female
Person C	100	Male

Figure 5. Individual persons’ scores on attribute variable X

	Person A	Person B	Person C
Person A	0	5	95
Person B	5	0	90
Person C	95	90	0

Figure 6. A square attribute-to-attribute matrix reflecting absolute differences on attribute variable X

	Person A	Person B	Person C
Person A	1	1	0
Person B	1	1	0
Person C	0	0	1

Figure 7. A square attribute-to-attribute matrix reflecting similarities on a categorical variable

In this study, pledge class, BMI, and year in school were categorical attributes converted into square matrices. Compulsive exercise scores, CET subscale scores, body dissatisfaction scores, physical activity scores, and all network characteristics were

converted into difference square attribute matrices. For example, Table 1 depicts the individual compulsive exercise scores of four study participants. To create the attribute square matrix on compulsive exercise score, we made the X and Y axis both the ID numbers of each participant, and then the difference scores between members were input into shared cells (see Table 2).

Table 1. Compulsive exercise scores from four participants in this study

Member ID Number	Compulsive Exercise Score
1145	16.44
1163	15.57
1248	15.64
1251	14.23

Table 2. Square attribute matrix of the difference in four participants' compulsive exercise scores

	1145	1163	1248	1251
1145	0	0.87	0.80	2.21
1163	-0.87	0	-0.70	1.34
1248	-0.80	0.07	0	1.41
1251	-2.21	-1.34	-1.41	0

Once all variables were converted into square matrices, QAP correlation and MR-QAPs were conducted. When conducting a QAP analysis, the software first correlates all the observed matrices. For instance, when comparing CET scores to BSQ scores, a new correlation matrix is created reflecting the Pearson r coefficients for each

cell. This new correlation matrix is now the observed matrix. Then, UCINET permutes the rows and columns of each matrix to create new matrices and correlates those new matrices to the observed matrices. This process is repeated for thousands of permutations, resulting in a QAP effect size equivalent to Pearson R or Multiple R^2, and a p-value that is the proportion of correlations as large as or larger than the original observed correlation (Borgatti et al., 2013). QAP correlations were conducted on all variables, and six MR-QAP analyses were conducted. For each MR-QAP, the independent variables included attribute variables and network variables. Dependent variables were compulsive exercise sum score, as well as the total score for each subscale of the CET (avoidance and rule-driven behavior, weight control exercise, mood improvement, lack of enjoyment, and exercise rigidity).

Results

Descriptive Statistics

The network we examined comprised 87% White, 1.2% Black, 6.3% Hispanic, and 3.9% Asian sorority members. Just over a third of the network consisted of freshmen (39.1%), followed by sophomores (24.9%), then juniors (19.3%) and seniors (15.9%). The average CET sum score was 12.37 (SD=2.55), ranging from 5.27 to 19.81. The mean body dissatisfaction score was 48.57 (SD=15.47) with scores ranging from 18 to 94. Participants reported an average physical activity score of 48.84 (SD=23.65), with a range of scores from 9 to 141.

The network comprised 1,018 ties and resulted in a density of 0.024. The average degree for nodes in this network was 4.918 (SD=2.045), with two isolates (degree=0)

and two sorority members reporting a maximum degree of 12. Just over half (58%) of the ties reported were reciprocal. The overall clustering coefficient of this network was 0.166. See Table 3 for all descriptive statistics of network measures.

QAP Correlations

In order to examine the relationships between network variables and compulsive exercise, QAP correlations were conducted between CET scores (sum and subscales), attribute variables, and network variables. QAP correlations ultimately informed the researcher which network variables to include in MR-QAP regression analyses. For bivariate analyses, network variables were split into groups by the characteristic they measure (i.e., centrality). In other words, all network variables that measured centrality were tested together, and all network variables that measure positional structure were analyzed together.

QAP correlation analysis revealed statistically significant relationships between compulsive exercise and BMI, physical activity, and body dissatisfaction. While all variables were related with total CET score, BMI had the strongest association (QAP r=.231) with weight control exercise, physical activity with exercise rigidity (QAP r=.437) and body dissatisfaction with weight control exercise (QAP r=.619). See Table 4 for all QAP correlation coefficients between CET scores and attribute variables.

Table 3. Descriptive statistics and definitions of network variables for a sorority sample from a private university in Texas

	Network Characteristic	Definition	M	SD
Degree	Centrality	The number of ties connected to a given node	4.92	2.05
Eigenvector	Centrality	Connection to nodes that are themselves well connected	.29	.047
Betweenness	Centrality	How often a given nodes falls along the shortest path between two nodes; a connector	1.40	1.15
Closeness	Centrality	Inverse measure of centrality; large numbers mean nodes are highly peripheral	.25	.03
Structural Equivalence	Positional Structure	Nodes are structurally equivalent if they are connected to similar alters	n/a	n/a
Coreness	Positional Structure	Core nodes are connected to each other and to others	2.73	.611
Clustering coefficient	Group Structure	Density of ties in each node's ego network; measure of "clumpiness"	.166	.166
Factions	Group Structure	Partitions of the network into cohesive subgroups	n/a	n/a
Alters in common	Relational Structure	The number of alters two nodes have in common	n/a	n/a
Geodesic distance	Relational Structure	The shortest path between two nodes	3.9	1.2
Edge betweenness	Relational Structure	The number of geodesics going through a tie	n/a	n/a

Table 4. QAP correlations between CET scores and attribute variables for a sorority sample from a private university in Texas

	BMI	PA	BSQ	Grade	Pledge	CET	CET A&R	CET WC	CET MI	CET LoE	CET R
BMI	-										
PA	-.017	-									
BSQ	.357*	.090	-								
Grade	.000	.000	.000	-							
Pledge	.000	.000	.000	.515*	-						
CET	.208*	.302*	.553*	.000	.000	-					
CET A&R	.153*	.345*	.438*	.000	.000	.822*	-				
CET WC	.231*	.178*	.619*	.000	.000	.711*	.500*	-			
CET MI	.013	.334*	.129*	.000	.000	.492*	.404*	.088	-		
CET LoE	.083	-.411*	.002	.000	.000	-.041	-.347*	-.092	-.466*	-	
CET R	.023	.437*	.273*	.000	.000	.777*	.699*	.422*	.439*	-.415*	-

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body satisfaction questionnaire score; CET=compulsive exercise score; CET A&R=compulsive exercise avoidance and rule driven behavior; CET WC=compulsive exercise weight control exercise; CET MI=compulsive exercise mood improvement; CET LoE=compulsive exercise lack of enjoyment; CET R=compulsive exercise rigidity; * $p<.05$

QAP correlations were conducted for each network measure (see Tables 5-8). For total compulsive exercise scores, eigenvector centrality (QAP r=.128) was the only variable with a statistically significant correlation coefficient. Eigenvector centrality reveals how connected a person is to popular or important people in a network. For instance, the chief of staff to the president of the United States would have a high eigenvector centrality score due to her proximity to the president, who is a powerful person in the network. Avoidance and rule-driven behavior, mood improvement, and exercise rigidity were not related to any network measures. Weight control exercise was significantly correlated with closeness centrality (QAP r=.137) and coreness (QAP

r=.150). Clustering coefficients were significantly related to lack of exercise enjoyment (QAP r= -.150). Measures of relational structure had no relationship to compulsive exercise.

Table 5. QAP Correlations between CET scores and centrality measures for a sorority sample from a private university in Texas

	Degree	Eigenvector	Closeness	Betweenness
Degree	-			
Eigenvector	.778*	-		
Closeness	.823*	.662*	-	
Betweenness	.761*	.455*	.603*	-
CET	.106	.128*	.114	.042
CET A&R	.081	.101	.087	.041
CET WC	.103	.089	.137*	.028
CET MI	.017	.030	-.019	.019
CET LoE	-.012	.041	.016	-.065
CET R	.075	.035	.059	.102

Note. n=208; CET=compulsive exercise score; CET A&R=compulsive exercise avoidance and rule driven behavior; CET WC=compulsive exercise weight control exercise; CET MI=compulsive exercise mood improvement; CET LoE=compulsive exercise lack of enjoyment; CET R=compulsive exercise rigidity; * $p<.05$

Table 6. QAP Correlations between CET scores and measures of positional structure for a sorority sample in a private university in Texas

	Structural Equivalence	Coreness
Structural Equivalence	-	
Coreness		-
CET	.000	.107
CET A&R	.000	.068
CET WC	.000	.150*
CET MI	.000	.012
CET LoE	.000	-.012
CET R	.000	.060

Note. n=208; CET=compulsive exercise score; CET A&R=compulsive exercise avoidance and rule driven behavior; CET WC=compulsive exercise weight control exercise; CET MI=compulsive exercise mood improvement; CET LoE=compulsive exercise lack of enjoyment; CET R=compulsive exercise rigidity; * $p<.05$

Table 7. QAP Correlations between CET scores and measures of group structure for a sorority sample from a private university in Texas

	Clustering Coefficient	Factions
Clustering Coefficient	-	
Factions	.000	-
CET	.013	.000
CET A&R	.020	.000
CET WC	.061	.000
CET MI	.087	.000
CET LoE	-.150*	.000
CET R	.004	.000

Note. n=208; CET=compulsive exercise score; CET A&R=compulsive exercise avoidance and rule driven behavior; CET WC=compulsive exercise weight control exercise; CET MI=compulsive exercise mood improvement; CET LoE=compulsive exercise lack of enjoyment; CET R=compulsive exercise rigidity; * $p<.05$

Table 8. QAP correlations between CET scores and measures of relational structure for a sorority sample from a private university in Texas

	Alters in Common	Geodesic Distance	Edge Betweenness
Alters in Common	-		
Geodesic Distance	-.519*	-	
Edge Betweenness	.163*	.000	-
CET	.000	.000	.000
CET A&R	.000	.000	.000
CET WC	.000	.000	.000
CET MI	.000	.000	.000
CET LoE	.000	.000	.000
CET R	.000	.000	.000

Note. n=208; CET=compulsive exercise score; CET A&R=compulsive exercise avoidance and rule driven behavior; CET WC=compulsive exercise weight control exercise; CET MI=compulsive exercise mood improvement; CET LoE=compulsive exercise lack of enjoyment; CET R=compulsive exercise rigidity; * $p<.05$

Multiple Regression QAP Analyses

Network variables (eigenvector and closeness centrality, clustering coefficient, and coreness), and attribute variables (BMI, physical activity, and body dissatisfaction) were regressed on total compulsive exercise sum score, as well as on each of the five CET subscales. CET sum score and subscale scores were converted into squared matrices by finding the differences between node scores in each shared cell (see example above). Independent variables included in the MR-QAP analyses were informed based on QAP correlation coefficients (see Tables 4-8). All MR-QAP analyses resulted in statistically significant models, explaining between 13.1% and 37.5% of the variance in CET scores (see Table 9).

Table 9. QAP R^2 values for CET scores for a sorority sample from a private university in Texas

	QAP R^2	QAP Adjusted R^2	p-value
CET Sum Score	.375	.375	>.0001
Avoidance and Rule Driven Behavior	.298	.297	>.0001
Weight Control	.358	.357	>.0001
Mood Improvement	.131	.131	>.0001
Lack of Enjoyment	.191	.191	>.0001
Exercise Rigidity	.246	.246	>.0001

CET sum score. Attributes and network variables together accounted for 37.5% of the variance in CET sum score. Of all the models tested, CET sum score resulted in the highest R^2 value compared to subscales. According to the QAP regression analysis (see Table 10), compulsive exercise was related most with physical activity (standardized coefficient[1]=.222, p=.001), body dissatisfaction (standardized coefficient=.520, p=.0005), and eigenvector centrality (standardized coefficient=.190, p=.039). BMI, closeness, coreness, and clustering were not significant predictors in the model.

CET subscales. Attribute variables and network variables accounted for variance in most of the CET subscales (R^2=.131–.358; see Table 11). Body dissatisfaction was a statistically significant predictor of variance in all subscales except lack of exercise enjoyment, and was the strongest predictor for avoidance and rule-driven behavior (standardized coefficient=.397, p=.0005) and weight control behavior (standardized

[1] These coefficients are simply called "standardized coefficients" and are interpreted the same way as standardized beta weights in linear regression analyses

coefficient=.524, p=.0005). Physical activity was a statistically significant predictor for all subscales, and was the strongest for mood improvement (standardized coefficient=.313, p=.0005), lack of enjoyment (standardized coefficient=-.400, p=.0005), and exercise rigidity (standardized coefficient=.385, p=.0005).

Table 10. MR-QAP on CET sum scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	-.020	.391
PA	.222	.001
BSQ	.520	.0005
Eigenvector	.190	.039
Closeness	.134	.151
Coreness	.033	.350
Clustering Coefficient	-.063	.392

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Network variables related to CET subscale scores varied. Closeness accounted for the most variance, of all the network measures, with statistically significant results for avoidance and rule-driven behavior (standardized coefficient=.217, p=.045), weight control exercise (standardized coefficient=.294, p=.036), and lack of exercise enjoyment (standardized coefficient=-.264, p=.027). In addition, clustering coefficient (standardized coefficient=-.165, p=.026) and coreness (standardized coefficient=.196, p=.039) were related to lack of exercise enjoyment. Mood improvement was not related to any network measure. See Tables 11-15 for MR-QAP results for each subscale.

Table 11. MR-QAP on avoidance and rule-driven behavior scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	-.029	.339
PA	.310	.0005
BSQ	.397	.0005
Eigenvector	-.049	.310
Closeness	.217	.045
Coreness	-.039	.347
Clustering Coefficient	-.049	.310

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Table 12. MR-QAP on weight control exercise scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	.003	.487
PA	.145	.010
BSQ	.524	.0005
Eigenvector	-.053	.310
Closeness	.294	.036
Coreness	-.020	.427
Clustering Coefficient	.059	.212

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Table 13. MR-QAP on mood improvement scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	.0004	.488
PA	.313	.0005
BSQ	.163	.017
Eigenvector	.012	.462
Closeness	.011	.465
Coreness	-.023	.411
Clustering Coefficient	.006	.481

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Table 14. MR-QAP on lack of exercise enjoyment scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	.064	.202
PA	-.400	.0005
BSQ	.022	.393
Eigenvector	.172	.058
Closeness	-.264	.027
Coreness	.196	.039
Clustering Coefficient	-.165	.026

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Table 15. MR-QAP on exercise rigidity scores for a sorority sample from a private university in Texas

	Standardized Coefficient	p-value
BMI	-.119	.041
PA	.385	.0005
BSQ	.263	.001
Eigenvector	-.099	.182
Closeness	.212	.061
Coreness	-.014	.440
Clustering Coefficient	-.052	.278

Note. n=208; BMI=body mass index; PA=physical activity; BSQ=body dissatisfaction

Discussion

The purpose of this study was to explore whether network variables were related to compulsive exercise behaviors among members of a sorority at a private university in the southwestern United States by conducting a social network analysis. Results indicate that several network characteristics are related to compulsive exercise, especially when considering the various subscales of compulsive exercise. Because compulsive exercise is a complex and multifaceted behavior (Caroline Davis, Brewer, & Ratusny, 1993; Johnston, Reilly, & Kremer, 2011; Steffen & Brehm, 1999), it was not surprising to see varying results among the subscales. Attribute variables traditionally associated with compulsive exercise were also correlated with compulsive exercise in our network.

Attribute Variables

Physical activity, body dissatisfaction, and BMI served as attribute covariates in the MR-QAP models. Difference in CET sum scores and subscale scores were significantly related with differences in exercise frequency as defined by the Godin

LTEQ (Godin & Shephard, 1985). The more nodes differ in exercise frequency, the greater chance they also differ on compulsive exercise. The literature supports a connection between exercise frequency and compulsive exercise (Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2013; Caroline Davis et al., 1993). In this study, exercise frequency was the strongest predictor of the mood improvement, lack of exercise enjoyment, and exercise rigidity subscales. These results in conjunction with the findings of several previous studies indicate the likelihood of exercise frequency as a probable risk factor for and component of compulsive exercise.

Body dissatisfaction was also a prominent attribute variable in this study. Body dissatisfaction was the strongest predictor for CET sum score, avoidance and rule-driven behavior, as well as weight control exercise. In addition, it was significantly related to mood improvement and exercise rigidity. Body dissatisfaction is a well-known risk factor in the development of eating disorders and associated behaviors (Striegel-Moore, McAvay, & Rodin, 1986; Striegel-Moore, Silberstein, & Rodin, 1986), especially among college-aged women (Massachusetts Eating Disorders Association, 2014; Stice et al., 1996; Striegel-Moore, Silberstein, Frensh, & Rodin, 2006; Szmukler & Patton, 1995; The Emily Program Foundation, 2014; The Review Center Foundation for Eating Disorders, 2003). In fact, many definitions of compulsive exercise and associated terms include body dissatisfaction as a key factor (Dalle Grave et al., 2008; Yates, 2013). Considering the CET and its subscales conceptually, it is not surprising that body dissatisfaction is a driving force behind feeling guilty when exercise is missed, exercising to control weight, improve mood (i.e., I feel better about my body and

therefore improve my mood if I exercise), or exercising rigidly. The only subscale that body dissatisfaction was not statistically related to was lack of exercise enjoyment. Therefore, women are likely to have similar body dissatisfaction scores despite variation in lack of exercise enjoyment score.

Though BMI was related to CET sum score and several subscales in the bivariate analyses, the regression model for exercise rigidity was the only one that retained BMI as a statistically significant predictor. And, BMI was negatively associated with exercise rigidity. Thus, the more two people are different in their BMIs, the less likely they will have similar exercise rigidity scores. Exercise rigidity refers to strict adherence and stringency in exercise routine (Taranis et al., 2011), which would likely result in normal weight BMI scores versus under or overweight BMI scores (Center for Disease Control and Prevention, 2013; Racette, Duesinger, Strube, Highstein, & Deusinger, 2005). If two people have high exercise rigidity scores, it is highly possible that they both fall in the BMI range for normal weight.

Network Variables

Compulsive exercise sum score. Eigenvector centrality was the only network variable related to total compulsive exercise score. Eigenvector centrality measures how connected a node is to the important or popular nodes in a network. A person with high eigenvector centrality score is a person that is tied to a highly connected node (Borgatti et al., 2013; Valente, 2010). QAP correlations and MR-QAP analysis confirmed the connection between compulsive exercise and eigenvector centrality. This means that the

more people differ on compulsive exercise score, the more they differ in eigenvector centrality score.

A possible reason for this finding could be the unfortunate relationship between perceived female beauty and female success. Research suggests that adhering to strict beauty standards, which often trigger body image issues (Dittmar & Howard, 2004; Stice & Whitenton, 2002; J. K. Thompson & Stice, 2001), is related to success and power among women (Berggren, Jordahl, & Poutvaara, 2010; Chapkis, 1986; Engeln-Maddox, 2006). Research also suggests that being connected to a person of power or popularity is related to success (Mortensen & Vishwanath, 1994; Nardi, Whittaker, & Schwarz, 2000). Therefore, if being connected to someone of power or prestige provides opportunity for success, and maintaining a certain appearance enhances likelihood of success, then it is possible that women who are connected to other women of importance in their network are also using compulsive exercise as a mechanism to reach a shape ideal of some sort to become more powerful, popular, and/or successful in their networks. This idea also supports the strong link between body dissatisfaction and compulsive exercise, which was demonstrated in this study. Body dissatisfaction is commonly linked with compulsive exercise in the literature, especially considering its tie to eating disorder development (Stice & Shaw, 2002). The quest for prestige and power in a network could underpin the connection between body dissatisfaction, eigenvector centrality, and compulsive exercise.

Avoidance and rule-drive behavior. Avoidance and rule-driven behavior is characterized by continuing exercise despite illness or injury, experiencing affective

withdrawal symptoms when exercise is stopped or missed, feelings of guilt and of having let one's self down, if unable to exercise, and needing to make up missed exercise sessions (Taranis et al., 2011). The sole network variable related to avoidance and rule-driven behavior as evidenced by MR-QAP analysis was closeness. Closeness is the average distance between a person and all others in the network. In other words, closeness is an inverse measurement of centrality. Thus, the greater someone measures on closeness, the greater their distance is from the center of the network (Borgatti et al., 2013). This result suggests that women who have similar closeness scores also have similar avoidance and rule-driven behavior scores. Exercising despite consequence, as avoidance and rule-driven behavior suggests, is likely to include social consequences as well physical or emotional ones. If a person: is prone to exercising beyond injury or illness; is preoccupied when exercise is missed: or feels required to make up lost exercise time, it is possible that person prioritizes exercise over social connection and, as a consequence, is more peripheral in the networks Thus, since the higher a person's closeness score the more peripheral they are, it is not surprising that avoidance and rule-driven behavior relates to closeness.

Results also suggest that exercise frequency was related with avoidance behavior and closeness, indicating that persons less connected to the network exercise more often. On the contrary, a person more central to the network may not be able to adhere to avoidance and rule-driven behavior, based on the demands and pressures of their social context (Welch, McNaughton, Hunter, Hume, & Crawford, 2009).

Weight control exercise. Like avoidance and rule-driven behavior, according to MR-QAP analysis, closeness was the only network variable related to weight control exercise. Weight control exercise is indicative of someone exercising out of concern for weight and shape (Taranis et al., 2011). Weight control exercise likely involves compensatory exercise, when someone compensates for calories consumed through exercise (Buchholz & Crowther, 2014). Based on the definition of weight control exercise, it is likely that those who score high on this subscale are exercising out of shame or discontentment, particularly regarding their body image. Typically, guilt and shame are socially isolating (Tangney, Miller, Flicker, & Barlow, 1996; Wicker, Payne, & Morgan, 1983), and therefore support the result that differences in weight control exercise are linked to differences in closeness. Body dissatisfaction was the strongest predictor of weight control exercise and supports the relationship between weight control exercise and closeness.

Mood improvement. Mood improvement was not statistically related to any of the network measures in this study. Mood improvement defined by the CET is using exercise to feel better emotionally (Taranis et al., 2011). Therefore, there were no patterns, structures, or positions that affected people's mood improvement scores. Body dissatisfaction and exercise frequency were the only two statistically significant predictor variables maintained in the MR-QAP model. In terms of body dissatisfaction, it is likely that someone might exercise in order to feel better about the way he/she looks (LePage, Price, O'Neil, & Crowther, 2012), therefore exercising for mood improvement. And, it makes theoretical sense that if someone believes exercise would make he/she feel

better (improve their mood), they would exercise more often (McDonald & Thompson, 1992).

Lack of exercise enjoyment. Lack of exercise enjoyment refers to the experience of exercising as a chore and deriving no enjoyment from it (Taranis et al., 2011). Closeness and clustering coefficient were both negatively related to lack of exercise enjoyment, while coreness was positively related to lack of exercise enjoyment. Clustering coefficients capture the "clique-ness" or "clumpiness" of a network and reveals if a node's connections are tied to one another. Thus, smaller clustering coefficient values indicate that while a node may have connections, its connections are not linked to each other and are therefore not clustered (Borgatti et al., 2013). Like clustering coefficients, coreness indicates a highly connected node, but coreness suggests that someone is connected to both central and peripheral people (Borgatti et al., 2013). In this network, being less connected and less central to the network predicted greater enjoyment in exercise. It is possible that sorority members at the core of the network, who are likely to be busier and more embedded in their social lives, are more likely to view exercise as a chore. Exercise frequency was also negatively associated with lack of exercise enjoyment, which would be expected. People tend to avoid things they do not enjoy, and therefore people with higher lack of exercise enjoyment scores would probably exercise less often (Bauman et al., 2012; Forsyth, 2014).

Exercise rigidity. Though closeness approached significance, none of the network variables tested were significantly related to exercise rigidity. This is surprising, considering exercise rigidity is the strict and repetitive adherence to exercise, which

could potentially be socially isolating (Bamber et al., 2000). However, strict and repetitive exercise does not imply continuing exercise through other commitments and priorities the same way avoidance and rule-driven behavior does, so it is possible to maintain a social life while also being strict about exercising.

Conclusion

Implications for future research and practice. This study makes an important contribution to the literature because it employs a complexity perspective in understanding a health behavior, and therefore seeks understanding beyond the individual level of analysis (Goodson, 2010). This study represents a new and substantive departure from the status quo by using a dynamic systems approach to identify specific relational and structural network characteristics that affect compulsive exercise behavior, which has recently been recommended in the field of behavioral science (Christakis & Fowler, 2008; Hammond, 2009; Valente, 2010). To date, the research status quo regarding social influence on eating disorders and compulsive exercise has centered on linear models that measure the variance accounted for in these behaviors. While linear models are an important first step in learning more about compulsive exercise, they cannot identify nor confirm the relational and structural patterns that affect compulsive behavior spread within, and shaped by social networks (Meadows, 2008). Though interventions can certainly be informed through linear models, social networks inform which relational variables are important in the adoption and spread of behaviors, providing pragmatic results to researchers and practitioners

alike. The use of SNA is a critical step in moving toward better understanding social influence on compulsive exercise.

This study identified specific points within a network for intervention on compulsive exercise. Results suggest that eigenvector centrality was a predictor of high compulsive exercise score among women in this sorority sample. Thus, sorority members who are strongly connected to popular or important people in their network can have an elevated risk for developing compulsive exercise behavior. While traditional statistics may help identify who might struggle with compulsive exercise (i.e., someone with a high body dissatisfaction score), it is impossible to know, with these methods, where in the network to intervene. For instance, Figure 8 shows a visualization graph of the network measured in this study. The nodes highlighted in red are the ten people with the highest eigenvector centrality scores. This visual may serve as an intervention map, providing specific direction into where an intervention could be aimed.

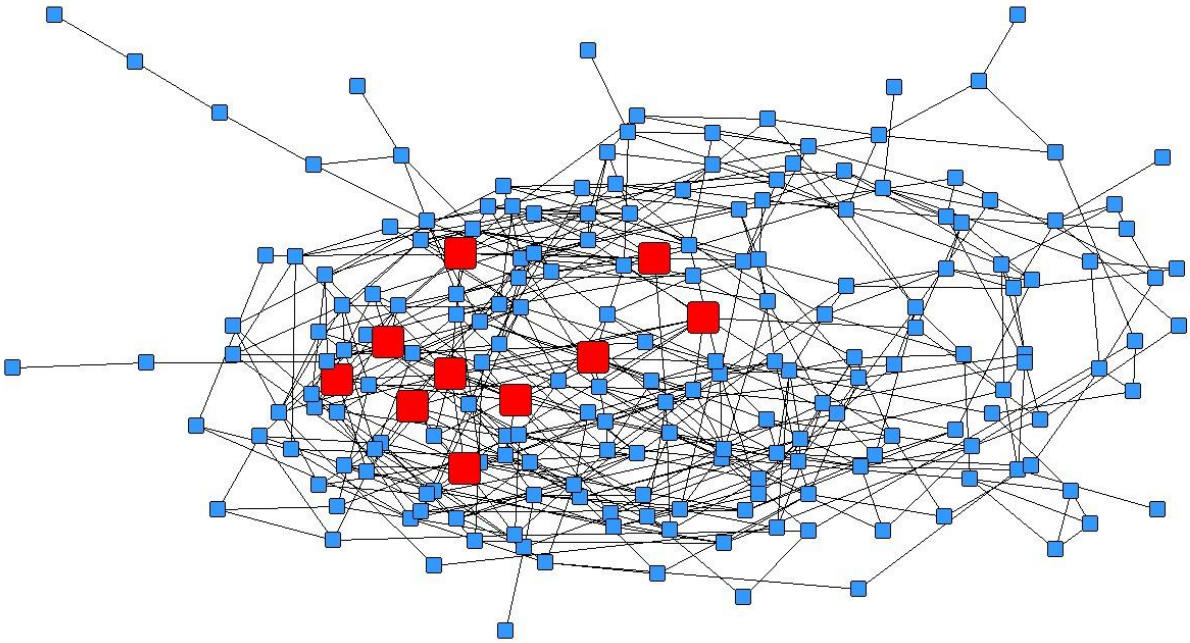

Figure 8. Graph of a sorority network from a private university in Texas with highlighted nodes that have a high eigenvector centrality score

Closeness was also a key network variable related to various dimensions of compulsive exercise. Thus, women who occupy more peripheral positions in their network (and in turn are less central) are more prone to compulsive exercising, in our sample. See Figure 9 for a visualization of the network with the ten highest closeness scores highlighted in red.

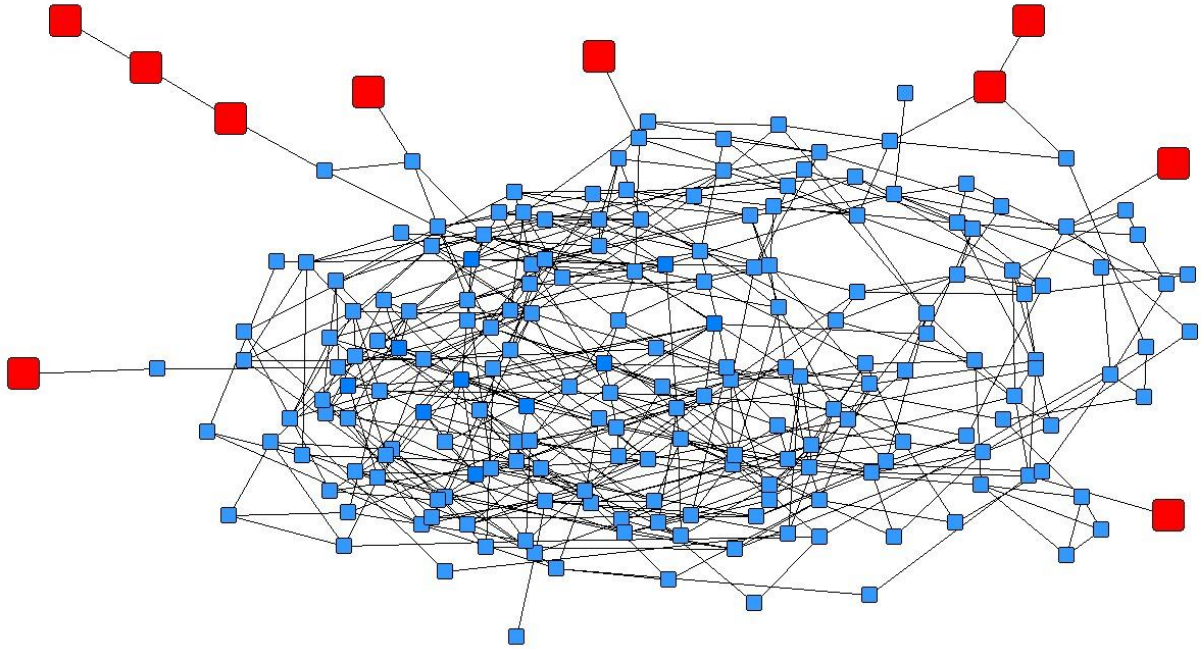

Figure 9. Graph of a sorority network from a private university in Texas with highlighted nodes that have a high closeness scores

For scholars conducting research on eating disorders and associated disordered behaviors, this study supports the rationale for looking into group dynamics and network structure in conjunction with compulsive exercise data, especially eigenvector centrality and closeness. Future research should consider using SNA to study compulsive exercise in other networks (i.e., adolescents, men) to see if similar network variables maintain their effect across groups. The interaction between compulsive exercise, body dissatisfaction, and eigenvector centrality should also be considered in future research on college-aged women.

For practitioners designing interventions to combat body dissatisfaction and compulsive exercise, this study indicates the need for tailored intervention techniques depending on how a person is positioned within his/her networks. In the network in this study, helping members who are less central become more connected could alleviate avoidance and rule-driven behavior, as well as promote healthy exercise that is enjoyable and feels less like a chore. On the other hand, women who are closely tied to members who hold positions of leadership and power might benefit from compulsive exercise education more than other people in this network because of their increased vulnerability to compulsive exercise.

These findings build upon the foundation of psychological risk factors uncovered through linear models, which ultimately informed this study and the selection of variables to consider when measuring compulsive exercise. This study's results also support the Tripartite Model, which posits the importance of social influence in disordered eating and body dissatisfaction (J. K. Thompson et al., 1999). Other complexity science methods such as systems dynamics or agent-based modeling might offer yet another unique insight into the workings of eating disorder and compulsive exercise pathogenesis.

Limitations. A few limitations are important to note for this study. First, members of the sorority were only able to list up to five people they felt close to in their network, and thus only nominated up to five other members. While this allows for easier and faster data collection (Valente, 2010), it possibly eliminates the nomination of both strong and weak ties within a network. While those nominees might vary in strength of

tie, it is likely that weaker ties are left out of the top five. For instance, we could have asked the sorority members to indicate any other member they spent time with more than once per week. This question would likely result in many more nominations, and in turn, more variation in strength of tie among nominations. Research suggests that there is strength in weak ties, particularly because weak ties allow for new information and behavioral exposure (Granovetter, 1973).

Another limitation was that 40 women did not complete surveys. While QAP analyses are robust for missing data (Borgatti et al., 2013), it is possible that important relationships were unaccounted for in this representation of the network due to missing members' data.

In summary, compulsive exercise is related to body dissatisfaction, exercise frequency, and network position in this sorority. These findings are important because they: justify the continued use of SNA to discern intervention target points within networks; contribute to the body of literature on compulsive exercise and body image; and support theoretical frameworks such as the Tripartite Model that highlight the importance of social influence on attitudes and behaviors related to body image.

CHAPTER V

THE ROLE OF EGO NETWORKS IN COMPULSIVE EXERCISE BEHAVIOR AMONG COLLEGE WOMEN

Introduction

An estimated 20 million women and 10 million men in the United States today will be diagnosed with clinical eating disorders at some point in their lifetime (The Review Center Foundation for Eating Disorders, 2003; Wade, Keski-Rahkonen, & Hudson, 2011). And many people either remain undiagnosed or struggle with associated disordered behaviors, such as compulsive exercise (Angold, Costello, Farmer, Burns, & Erkanli, 1999; Ressler, 1997). The consequences of eating disorders are severe, including psychiatric comorbidities such as depression (Fairburn & Harrison, 2003), physical side effects such as cardiac arrhythmias (Donatelle, 2013), and even death (Arcelus et al., 2011). In fact, eating disorders account for more deaths than any other mental illness (Arcelus et al., 2011; Chesney et al., 2014; Sullivan, 1995), and result in about 134,400 lost lives per year in the United States (Walter, 2013). Eating disorders are also difficult to overcome, with some studies reporting recovery rates as low as a 50% for those that seek treatments (Donatelle, 2013; Walsh, 2008). Thus, eating disorders pose a major public health threat.

Compulsive exercise, which typically describes a rigid pattern of exercise, often performed despite negative consequences, with compulsive exercisers reporting intense

feelings of guilt at any missed exercise sessions (Meyer et al., 2011; Patterson, 2016), is an important factor in the diagnosis and treatment of eating disorders. Evidence suggests that compulsive exercising oftentimes leads to an eating disorder diagnosis (Dalle Grave, 2009; Polivy & Herman, 2002) and can be the most resilient disordered behavior to overcome among people with such diagnosis (Cash, 2004; Hudson et al., 2007; Meyer et al., 2011). For instance, although disordered eating patterns (e.g., restricting calories) can often be alleviated in treatment settings, compulsive exercising tends to persist even after treatment (Dalle Grave, 2009).

Body dissatisfaction is a common precursor to disordered eating and exercise behaviors (Dittmar & Howard, 2004; Vartanian et al., 2014). Research on body dissatisfaction has found girls to be especially prone to body image issues at young ages (5-6 years old), and these feelings of body dissatisfaction as representing a lifelong problem (Cash & Smolak, 2011; Smolak, 2004). Researchers have also correlated body dissatisfaction with a drive for thinness (Grogan, 2007; Vartanian et al., 2014), sexual orientation (Beren, Hayden, Wilfley, & Grilo, 1996), poor self-esteem (Stice & Whitenton, 2002), eating pathology (Stice & Shaw, 2002), and compulsive exercise (Gulker et al., 2001).

The Tripartite Model, developed by Thompson and colleagues (1999), argues for the importance of social connections and personal relationships in the development of body dissatisfaction, particularly in regards to relationships with friends, family, and the media. Studies have shown that a family environment critical of weight and shape, as well as coercive parenting styles lead to body image issues (Haworth-Hoeppner, 2000;

Kluck, 2010). The feelings of one's peers regarding weight and shape are also correlated to body image difficulties, especially among adolescent girls (Phares, Steinberg, & Thompson, 2004; Hemal Shroff & Thompson, 2006). And the media has long been recognized as a determining factor in body image issues not only among women (Gibbs, 2010; J. K. Thompson & Heinberg, 1999), but also among men (Arbour & Martin Ginis, 2006), and adolescents of both genders (Field et al., 1999; Hargreaves & Tiggemann, 2004). The media has perpetuated appearance-ideals, such as the thin-ideal, which imprints a standard of beauty many people feel obligated to achieve (Dittmar & Howard, 2004; K. J. Homan, 2010; J. K. Thompson & Stice, 2001). The tripartite model suggests that these sociocultural factors are interrelated with body image concerns, and prompt researchers to look beyond personal psychology in the development of disordered eating and exercise behaviors (Hardit & Hannum, 2012; R. Rodgers et al., 2011; H. Shroff & Thompson, 2006; van den Berg et al., 2002).

College students, especially college women, are vulnerable to the development of eating disorders (Cash, 2004; Massachusetts Eating Disorders Association, 2014; Striegel-Moore & Franko, 2003). Eating disorders affect 10% of at-risk females (females between the ages of 15 and 29 years; Polivy & Herman, 2002). Considering the increased risk of eating disorder diagnoses among this population, it is not surprising that recent research has also shown a large prevalence of compulsive exercise among college women (Guidi et al., 2009; Thome & Espelage, 2007). In addition, the time someone spends obtaining higher education is socially infused, in other words, the attitudes and behaviors of peers are especially impactful during that time period. Peer

influences are critical during college because new identities, friendships, and peer group affiliations are solidified and parental influences become less dominant (Kobus, 2003; Simons-Morton & Farhat, 2010). Normative pressure, such as the pressure to conform to certain beauty and shape ideals, augments the effect peers have on one another (Huang et al., 2014; Paxton et al., 1999).

A useful approach to studying the impact of social forces on individuals' behaviors is social network analysis (SNA). SNA is rooted in network theory, which suggests that a person's position in a network provides constraints and opportunities, and therefore impacts behavior (Borgatti et al., 2013). In other words, individual behavior is viewed as at least partially dependent on the type and configuration of a person's set of social relationships (Burt & Minor, 1983).

Egocentric network analysis is one approach to conducting SNA. Egocentric networks are constrained by the environments and activities in which an ego (most commonly, a person) is embedded (Feld, 1981). Because factors external to the network itself influence the behaviors and foundations upon which someone builds and sustains social relationships (Feld, 1981; Perry, 2012), important behavioral and social patterns are revealed through egocentric network analysis (i.e., a young person that smokes is likely connected to other young people that smoke). . Additionally, egocentric networks have gained popularity in the social sciences because they fit well within a standard survey approach (Borgatti et al., 2013; McCallister & Fisher, 1978). For example, ego network questions can easily be added to a standard survey instrument and do not require respondents to reveal their identity.

Data collected through egocentric network research represent only the respondent's personal network (Borgatti et al., 2013; Valente, 2010). This approach investigates the social context of a local person by eliciting a set of people known to that ego, collecting information on those persons, and examining the ties among them (Marsden, 1990; Wasserman & Faust, 1994). Egocentric networks assess three relational dimensions including: network composition (attributes of network members and how they relate to the ego); types of interactions and support available through these relationships; and structural measures (i.e., density, centralization) of how the network is organized (Marsella & Snyder, 1981; McCarty, 2002; Min et al., 2013).

Several studies have employed egocentric SNA to the study of health behavior among college students. Most studies have investigated relational aspects of alcohol and drug use among this group (Dumas, Graham, et al., 2014; Dumas, Wells, et al., 2014; Huang et al., 2014), though some have studied homesickness (Hendrickson et al., 2011), sexual aggression (Swartout, 2013), and narcissism within romantic partnerships (Lamkin et al., 2015).

To the best of our knowledge, only three network analyses have been conducted on eating disorders and associated behaviors (Hutchinson & Rapee, 2007; Paxton et al., 1999; Rayner, Schniering, Rapee, Taylor, & Hutchinson, 2013), all of which used a whole network approach[2] to SNA. However, up until now, egocentric network analysis

[2] Whole network research is a form of social network analysis that is conducted on an entire network or defined group. All members of the network are included, and respondents only report on relationships within their specified network, whereas in egocentric network research, the ego can report on any relationship in their life.

has not been used to investigate whether social and relational influences affect compulsive exercise behaviors, specifically. Therefore, the purpose of this study is to use egocentric network analysis to study the relationship between network composition, network structure, and compulsive exercise behavior among a sample of female college students belonging to a sorority.

Methods

Participants and Procedure

Two hundred and four women participated in this study. All women were recruited from the same sorority at a large private university in the southwestern US. An email describing the study purpose was sent to the entire sorority prior to data collection. The principal investigator then attended a regularly scheduled chapter meeting to collect data in the spring of 2015. We chose to conveniently sample from a sorority because sororities are a concentrated network of college-aged women, and evidence suggests women in sororities are at increased risk for developing body image issues and disordered behaviors (Katzman & Wolchik, 1984; Schwitzer et al., 1998). This study was approved by the Institutional Review Board prior to data collection, and all participants signed an informed consent form. Each person provided demographic data, attribute, and network data by completing a paper survey.

Measures

For demographic data, participants were asked to indicate their birth date, year in school (i.e., freshman, sophomore, etc.), pledge class in the sorority, race or ethnicity, home state or country, and height and weight (which was converted into a body mass

index (BMI) score). Attribute data included questions assessing physical activity, compulsive exercise, and body dissatisfaction. Two types of network data were collected in this study: (1) whole network data and (2) egocentric network data. Whole network data were collected using a nomination method. Each respondent was provided a roster of her sorority and were asked to nominate five other members of their sorority they felt closest to. Egocentric network data were collected via name generator and name interpreter questions. Participants were asked to list up to any five people (may or may not be in their sorority) they felt close to in their life (name generator) and provide information about each person they nominated (name interpreter). In this paper, we will focus on the demographic, attribute, and egocentric network data only.

Physical activity. To measure physical activity, we used the Godin-Shepard Leisure Time Exercise Questionnaire (Godin LTEQ). The Godin LTEQ is a 4-item scale that measures intensity and duration of strenuous, moderate, and mild physical activity during a typical 7-day period (Godin & Shephard, 1985). Participants reported how many times on average they engaged in various levels of exercise for more than 15 minutes in a given week. To create sum scores, we multiplied reported instances of strenuous activity by 9, moderate activity by 5, and mild activity by 3, and added those products together into one score. Test-retest reliability was previously established with the Godin LTEQ, with coefficient ranging between .74 and .80 (Godin & Shephard, 1985; Jacobs et al., 1993; Joseph et al., 2014). Due to difficulties in logistics, we were unable to collect test-re-test reliability data on the current sample.

Compulsive exercise. The Compulsive Exercise Test (CET) is a 24-item self-report measure used to assess the core features of compulsive exercise (Taranis et al., 2011). The CET uses a 6-point Likert scale and comprises five subscales: (1) avoidance and rule-driven behavior; (2) weight control exercise; (3) mood improvement; (4) lack of exercise enjoyment; and (5) exercise rigidity. A CET total score was created by summing the average scores from each subscale. The higher someone's CET score, the stronger likelihood that person's exercise is compulsive. Reports of reliability coefficients in previous studies have ranged from .71 to .88 (Goodwin, Haycraft, Taranis, et al., 2011, 2011; Taranis et al., 2011). A Cronbach's α of 0.84 was found with this sample.

Body dissatisfaction. To measure body dissatisfaction we used the Body Shape Questionnaire (BSQ) created by Evans and Dolan (1993). This study used the short-form version of the questionnaire which is a single factor, 16 item scale. Each item is measured on a 5-point Likert scale. A total sum score was created by totaling all 16 items for each participant. Higher scores suggest greater body dissatisfaction. Previous studies have reported Cronbach's α ranging from .88 to .94 (Evans & Dolan, 1993; Pook et al., 2008; Rosen et al., 1996). A Cronbach's α of 0.94 was found for this sample.

Egocentric data. To collect egocentric network data, respondents were asked name generator and interpreter questions (Valente, 2010). Each respondent was asked to provide the initials of up to five people they felt closest to in their life. For each person nominated in the name generator, the respondent provided information on: how they know the person (i.e., parent, roommate, other); gender of the person; frequency of

communication with the person; length of relationship with the person; how often that person exercises; if that person makes them feel good about how they look (four point Likert scale, 0=never, 4=always); and if that person makes them feel guilty about their exercise habits (four point Likert scale, 0=never, 4=always).

Analysis

Descriptive, bivariate, and regression analyses were conducted on demographic, attribute, and ego network data. Name generator and interpreter data derived from egocentric questions were analyzed using E-Net (Borgatti, 2006) in order to create compositional and structural variables for use in analyses. Compositional variables describe the ego's network based on certain criteria (i.e., gender, relationship). For instance, a person's network may be composed entirely of work colleagues, or the network might be half work colleagues and half family. Both of these scenarios describe the composition of an ego's network based on the type of relationships in that network. Structural variables are created based on patterns and connections within an ego's network. Homophily and heterogeneity are two structural variables derived from E-Net. For example, an ego may only connect with people who share the same political views, which would lend to a high homophily score (Halgin & Borgatti, 2012). Another structural variable would assess the embeddedness of an ego based on whether nominated alters were connected. This study did not ask about alter-alter ties and therefore only considered homophily and heterogeneity variables. Once ego network variables were created, all statistical analyses were conducted using SPSS.

Results

Descriptive Statistics

In the final sample of 204 participants, nearly 40% were freshmen, 25.5% were sophomores, 19.6% juniors, and 15.2% were seniors. This sample was predominately White (88.2%), followed by Hispanic (6.4%) and Asian (3.9%). The average age of the sample was 19.43 (SD=1.14) and the average BMI was 21.97 (SD=3.05). The mean compulsive exercise score for this sample was 12.66 (SD=2.52), with scores ranging from 5.27 to 19.81. Body dissatisfaction scores ranged from 18 to 94, averaging at 48.47 (SD=15.51). The average Godin physical activity score was 49.22 (SD=23.46) ranging from 9 to 141, with 18.1% reporting they rarely engaged in regular activity, 52.5% reporting they sometimes engaged in regular activity, and 29.4% claiming they often engaged in regular activity. See Table 16 for all descriptive statistics.

With each participant naming up to five alters, we accumulated data on 1,113 alters. Of the 204 women that participated, 175 (85.8%) nominated at least one parent as an alter they felt closest to, and 81.9% nominated their mothers. Just under half (47.1%) nominated a sibling, 34.8% nominated a significant other, 38.3% nominated a roommate, 54.9% nominated someone in their sorority, and 92.2% nominated a friend. Five people nominated only friends, and only two people identified all nominees as friends in their sorority. Forty nine (24%) egos nominated only female alters, and none of the respondents nominated only males. See Figure 10 for visual graphs for two egos in this sample.

Table 16. Descriptive statistics for a sample of sorority members from a private university in Texas

	N	%	M	SD
Age	204		19.43	1.14
Year in School				
Freshman	81	39.7		
Sophomore	52	25.5		
Junior	40	19.6		
Senior	31	15.2		
Race/Ethnicity				
White	180	88.2		
Black	1	.5		
Hispanic	13	6.4		
Asian/Pacific Islander	8	3.9		
BMI			21.97	3.05
CET			12.66	2.52
BSQ			48.47	15.51
PA			49.22	23.46

Note. n=sample size; %=percentage; M=mean; SD=standard deviation; BMI=body mass index; CET=compulsive exercise test score; BSQ=body shape questionnaire score; PA=physical activity score

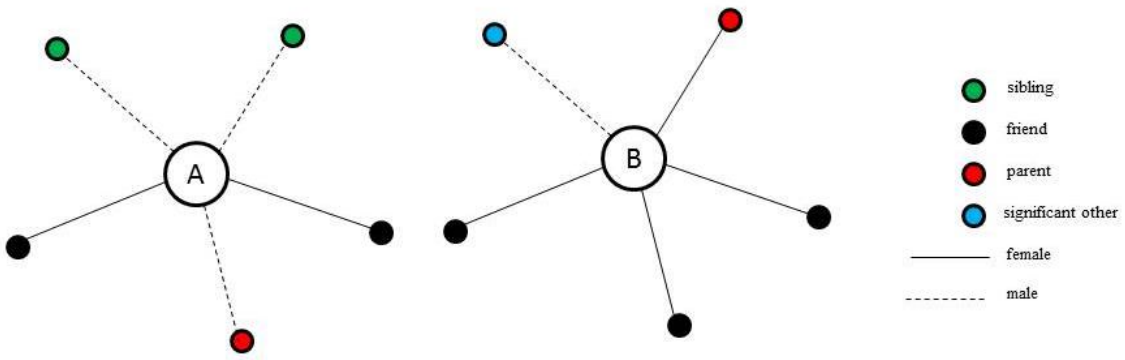

Figure 10. Graphs of two egos from an egocentric network analysis on sorority members from a private university in Texas

Of the 1,113 alters nominated in the egocentric data collection, only 16.7% were identified by the egos as never engaging in exercise, and 44.1% as engaging in exercise daily. Nineteen respondents indicated that they communicated with all of their nominees daily, and 17 indicated they didn't communicate with any alters on a daily basis. Thirty women (14.7%) reported that their entire ego network always made them feel good about their looks, while two women reported that their entire network always made them feel guilty about their exercise habits.

Regression Analyses

We used linear regression analysis to test which variables accounted for variance in participants' compulsive exercise scores in three models. The first model contained only demographic variables, including: BMI, whether the person was a member of the newest pledge class (dummy variable), and grade. The second model included attribute variables (body dissatisfaction and physical activity scores). And the third model added network variables, including compositional variables (composition of the network that: made the ego feel good about their looks; made the ego feel guilty about exercise habits; and was a family member, friend, significant other, roommate, or a member of the same sorority) and structural variables (heterogeneity in the ego's network concerning: how alters made the ego feel about her looks and exercise habits, and physical activity participation).

The first analysis yielded a statistically significant model (R^2=.091, F=6.694, df=202, p<.0001). With the attribute variables added to the model (model 2), the R^2 value increased to .311 (F=17.798, df=202, p<.0001). The final model (model 3) was

also statistically significant (R^2=.376, F=8.2, df=202, p<.0001), demonstrating that demographic, attribute, and network variables together explained 37.6% of the variance in compulsive exercise score.

Body dissatisfaction (β=.440, t=6.37, p<.0001), physical activity (β=.217, t=3.59, p<0.001), if an ego nominated a significant other (β=-.268, t=-3.184, p=.002), a sibling (β=-2.13, p=.035), and a roommate (β=-.195, t=-2.142, p=.034) were the only predictor variables to remain significant in the final model. See Table 17 for the all regression models.

Table 17. Three regression models predicting compulsive exercise among a sample of sorority members from a private university in Texas

Predictors	Model 1 R^2=.092			Model 2 R^2=.311			Model 3 R^2=.376		
	β	*t*	p	β	*t*	p	β	*t*	p
BMI	.195	2.888	.004	.041	.632	.528	.002	.031	.975
Freshman Pledge	.243	2.209	.028	.168	1.724	.086	.127	1.278	.203
Grade	.018	.159	.874	.048	.296	.620	.039	.404	.687
Body Dissatisfaction				.439	6.663	<.0001	.440	6.369	<.0001
Physical Activity				.214	3.588	<.0001	.214	3.588	<.0001
Composition of Network:									
Rarely makes ego feel good about her looks							.035	.536	.592
Parent							-.027	-.293	.770
Sibling							-.189	-2.128	.035
Friend							-.206	-1.524	.129
Significant other							-.268	-3.184	.002
Roommate							-.195	-2.142	.034
Not in Sorority							-.003	-.041	.967
Structure of Network:									
Het: alters make ego feel guilty about exercise							.060	.951	.343
Het: alters make ego feel good about her looks							-.033	-.493	.622
Het: alters activity levels							.072	1.189	.236

Note. β=standardized beta; Het=heterogeneity

Discussion

Compulsive exercise is a major public health concern, particularly for college-aged women (Guidi et al., 2009). Because compulsive exercise can lead to an eating disorder diagnosis (Polivy & Herman, 2002) and is likely to persist through treatment of eating disorders (Dalle Grave, 2009), understanding the factors associated with compulsive exercise is a priority. The current study sought to investigate if ego network variables were associated with compulsive exercise scores among a sample of female college students. To do this, we conducted an egocentric SNA on 204 members of the same sorority at a private university in the southwestern US. SNA is a method that allows behavioral scientists to breech the individual level of analysis, and shift their focus to the relational dynamics of behavior (Wasserman & Faust, 1994).

This sample of college women (n=204) was asked to name up to five people they felt closest to in their lives. In this sample, women mostly nominated family members and friends in their close networks. Though previous literature points to the importance of peer relationships in college due to separation of the student from family (Kobus, 2003; Simons-Morton & Farhat, 2010), this study does reveal that family relationships, particularly parental and sibling relationships, were salient within the networks we examined here, and could influence network members' attitudes and behavior. Only five women did not report alters that were family members, and were solely friends.

The mean CET score for this sample was 12.66 (SD=2.52). The highest possible score on the CET is 25. While the CET does not offer cut-off points or categories of risk (Taranis et al., 2011), previous studies on college-aged women have reported CET

means of 11.73 (Taranis & Meyer, 2011) and 11.9 (Duckham et al., 2012), suggesting a slightly higher mean score for this sample. Other studies that focused on female athletes (rather than general college students) reported higher mean CET scores for those samples (Duckham et al., 2012; Taranis & Meyer, 2010).

Social network analysis revealed that body dissatisfaction, physical activity, and network composition were related to compulsive exercise within this sample of college women. Body dissatisfaction was unsurprisingly the largest predictor of the compulsive exercise score. Regression analyses revealed almost no change in the body dissatisfaction variable once network variables were added to the model (see Table 2), suggesting body dissatisfaction has an independent effect on compulsive exercise, regardless of network variables. Body dissatisfaction has long been observed as an important variable in the eating disorder literature (Hardit & Hannum, 2012; K. Homan, 2010; Hemal Shroff & Thompson, 2006; Stice & Shaw, 2002). Stice and Shaw (2002) concluded in their review that body dissatisfaction is a risk factor for eating pathology and is fueled by sociocultural pressures, such as the thin-ideal internalization. Similar to its relationship to eating pathology, body dissatisfaction's relationship to compulsive exercise has been displayed repeatedly in the literature (Dalle Grave, 2009; Yates, 2013). The evidence within the eating disorder and compulsive exercise literatures supports our finding that body dissatisfaction is an important determinant of compulsive exercise and should be a key target for interventions aimed at preventing compulsive exercise.

The connection between physical activity and compulsive exercise, in our model(s) was also not surprising. Like body dissatisfaction, physical activity remained

an important contributor to compulsive exercise despite the addition of network variables in later models. Exercise in excess is commonly paired with compulsive exercise and is even included in some definitions of compulsive exercise (Costa et al., 2013; C. Davis et al., 1994). The odds are high that if someone is compulsively exercising, they are also exercising in large amounts. However, this is not always the case, and there are instances when someone exercises in excess (i.e., a professional athlete), but does not meet the criteria for compulsive exercise (Szabo et al., 2013).

Compositional network variables also were related with compulsive exercise in our sample. Based on network theory, we expected to find personal relationships associated with behavior (Wasserman & Faust, 1994). Results suggest that listing a significant other, a roommate, and a sibling in personal networks was of specific importance. It was relieving to find that all the relational variables associated with compulsive exercise score were negatively associated with these nominations, suggesting close relationships with significant others, roommates, and siblings were protective of high compulsive exercise scores, rather than risk factors for high compulsive exercise scores in this particular sample. The more a person's network was composed of those specific relationships, the lower their compulsive exercise scores tended to be.

Of the network variables tested, relationship with a significant other was the strongest predictor of lower levels of compulsive exercise. Previous research shows that being in a committed relationship enhances a person's physical and psychological health (Bradbury, Fincham, & Beach, 2000; Braithwaite, Delevi, & Fincham, 2010; House,

Landis, & Umberson, 1988). Berge and colleagues (2012) found that romantic partners promoted positive weight-related behaviors for one another in a sample of college students, supporting our finding that having significant others in one's network was related to lower compulsive exercise scores. Another possibility for the negative association between compulsive exercise and the presence of significant others in one's network is that relationships with a significant other can be time consuming because they oftentimes take precedence over other friendships and academic pursuits (Gilmartin, 2005). When factoring in academic and sorority obligations, it would be reasonable to assume that a large proportion of a student's free time is spent with a significant other if he/she is in a romantic relationship, leaving less time to exercise or compulsively exercise. Based on the idea that one participates in compulsive exercise despite physical, emotional, or social consequence (Meyer et al., 2011; Taranis et al., 2011; Yates, 2013), it would be sensible to assume that compulsive exercise could become socially isolating. Thus, it's plausible that someone who is invested in a romantic relationship might be less likely to compulsively exercise based on the risk of losing the partner and the limited extra time.

Roommates were also protective of compulsive exercising in our sample. As with significant others, roommates tend to be someone the ego interacts with on a regular basis. Therefore, the roommate is likely to have unique insight into the ego's life and behavior choices. One might deduce that if an ego lists a roommate as a close relationship, then that roommate is a positive person in the ego's life that could steer the ego from disordered behaviors such as compulsive exercise. Other studies have shown

that roommates can be a positive health influence for college students (Duncan et al., 2005; Daniel Eisenberg, Golberstein, Whitlock, & Downs, 2013; D. Eisenberg, Golberstein, & Whitlock, 2014). Also, as mentioned previously, compulsive exercise can be socially isolating. If the ego participates in compulsive exercise, they may be less likely to feel close to a roommate due to social isolation.

Finally, the presence of a sibling in the ego's network also was negatively associated with compulsive exercise in our sample. Research on family dynamics suggests that cohesive and close families that exhibit caring relationships are protective of eating disorder development (Lampis, Agus, & Cacciarru, 2013). On the contrary, studies have shown that less close knit families, families that communicate poorly, critical and hostile families, less supportive families, and families perceived as dysfunctional increase risk of eating pathology and eating disorder development (Haworth-Hoeppner, 2000; Latzer, Hochdorf, Bachar, & Canetti, 2002; Onnis et al., 2012; Wisotsky et al., 2003). It is probable that if a college student lists a sibling as one of the five people closest to him/her, then that student is a part of a cohesive, supportive, and close knit family, which is protective of eating disorder development and associated behaviors.

None of the structural patterns of heterogeneity or homophily were significant predictors in the final regression model, although some were significant in bivariate correlation analyses (not reported here). Heterogeneity measures how different the ego's alters are from one another, while homophily measures how similar alters are to the ego. For example, if an ego nominates a parent, a friend, a boyfriend, a professor, and a

sibling as the five people they feel closest too, their heterogeneity score will be high based on relation to the ego, since all the relationships are different. Contrarily, if the ego only nominates friends, heterogeneity will be zero. Homophily compares the ego to the alters, which means if an ego is a female and all the alters are female, then homophily on gender would reach the highest score (= 1.0). Heterogeneity compares alters to alters, homophily compares alters to ego (Halgin & Borgatti, 2012).

It might be expected for an ego with high CET scores to have little heterogeneity across alters regarding how alters make them feel about their looks or exercise patterns. Because these findings and the literature suggest a parallel between body dissatisfaction and compulsive exercise (Dalle Grave, 2009; C. Davis et al., 1994), and because compulsive exercise is associated with extreme guilt if exercise is missed or postponed (Meyer et al., 2011; Taranis et al., 2011), it would have made sense that the people listed in an ego's network might make her feel poorly about her looks and make her feel guilty about her exercise habits (i.e., little heterogeneity). However, these patterns were not significantly related to compulsive exercise in our model. We also expected that if an ego had high compulsive exercise scores, she would nominate alters with high physical activity levels. Correlations and regression analyses revealed a significant relationship between activity levels and compulsive exercise, suggesting the strong possibility that an ego with high exercise scores also had high compulsive exercise scores. Thus, based on network theory, we expected to see women who had high compulsive exercise and physical activity scores nominate alters with high exercise scores. But, homophily in exercise participation was not related to compulsive exercise. Again, it is important to

note that compulsive exercise and excessive exercise are not synonymous, which may account for the lack homophily.

Strengths and Limitations

This study is an important contribution to the compulsive exercise literature because it used a network approach to investigate the social context of compulsive exercise. Most studies to date have only considered psychological and sociocultural variables related to compulsive exercise (K. Homan, 2010; Taranis & Meyer, 2010; van den Berg et al., 2002). These studies are foundational to understanding compulsive exercise, but limited in their scope. To the best of our knowledge, this study was the first to use egocentric network analysis to understand compulsive exercise, and suggests an association between someone's personal, close relationships and compulsive exercise.

The findings of this research also support the Tripartite Model. The Tripartite Model suggests that peers, family, and the media are all important factors in the development of body dissatisfaction and disordered eating behaviors (J. K. Thompson et al., 1999). Our results found relationships with peers and family to be important in the study of compulsive exercise, especially relationships with roommates, siblings, and significant others.

Despite its contribution, this study has important limitations. First, the sample lacked diversity and therefore is not generalizable to all other college students. The sample used was asked whole network and egocentric network questions, which required respondents to belong to the same group to meet whole network assumptions. While whole network research cannot be generalized to general populations, egocentric

network research can employ methods such as random sampling that would allow for generalization (Borgatti et al., 2013; Wasserman & Faust, 1994).

An additional limitation concerns how the egos were limited to nominating a maximum of five alters they felt closest to in their lives. Though giving egos unlimited nominations can lead to an extremely time consuming data collection and analysis process, limiting the number of nominations only allows the ego to nominate her strongest ties, and thus removes weak ties from analysis (McCarty, 2002). Granovetter (1973) argued the importance of weak ties, especially in the exposure to new ideas and behaviors. In their analysis of the number of nominations an ego should be allowed in a network study, Merluzzi and Burt (2013) concluded that five names is the most cost effective number of nominations, which is why we decided to limit the ego's choices to five.

Another limitation was that the egos were not asked about their perceptions regarding the alters' body dissatisfaction. In hindsight, this would have been an important variable to consider in relation to the ego's body dissatisfaction and compulsive exercise behavior.

Finally, this study did not ask interrelater questions, or questions describing alter-alter ties. Asking about alter-alter ties vastly improves the study of the structural component of ego networks by placing the ego in a web of connections. For instance, an ego whose alters are all connected has less ability to "hide" behaviors from alters. However, if the alters an ego nominates are only connected to the ego and not to each

other, alters are only exposed to the ego's attitudes and behaviors through the ego, and not through other alters in the ego's network.

Implications for Research and Practice

Researchers interested in studying other behaviors using an egocentric network approach should consider including interrelater questions in their design. Interrelater questions give the researcher insight into how embedded the ego is within her personal network. This information would not only provide a structural variable to include in analysis, but it might also be important in the study of specific behaviors. For instance, if a researcher was interested in using an egocentric network approach to study overuse of alcohol among college students, the structure of an ego's network might suggest how likely that ego will persist in overusing alcohol, and how difficult it may or may not be for that ego to abstain, based on his/her connections. If all of the alters know one another and drink together, that ego is embedded within a tightly knit network that drinks.

Future research implementing an egocentric network approach could also consider employing a sampling method that would better represent the population of study, than the method employed in the current study. For example, a researcher might be interested in how the composition of working women's personal networks impacts their ability to return to work after having a child. If generalization is an aim of the study, that researcher should sample women of different ages, races, ethnicities, marital statuses, and economic backgrounds from various geographical locations and industries.

Future egocentric network research on compulsive exercise or disordered eating behaviors should consider asking name interpreter questions regarding body

dissatisfaction of alters. This study corroborated many others in supporting the important role body dissatisfaction plays in this area of research. The ego's perception of her alters' body dissatisfaction can potentially impact her own body dissatisfaction and compulsive exercise behavior.

The results of this study provide useful information for higher education employees, particularly housing directors, student group advisors, counselors, and wellness staff. Women who felt close to their roommates were less likely to have high compulsive exercise scores. Thus, housing directors might routinely check on how roommate relationships are going, or do friendly programs or competitions to promote roommate relationships. An example might be a roommate version of the newlywed game, where the two roommates that know each other the best win movie tickets. Student group advisors, especially sorority advisors, can promote the upkeep of relationships with siblings or significant others by hosting family events and date parties. For counselors or wellness staff working with women with poor body image or compulsive exercise behaviors, it would be worthwhile to evaluate the relationships between the client and people she feels close to, as they may be protective or hurtful in regards to compulsive exercise.

Conclusion

Due to the severity of eating disorders and the important connection between eating disorders and compulsive exercise, predictors of and influences on their development need to be studied and understood. College students are of particular concern regarding eating disorders due to its increased incidence within this segment of

the population. This study provided insight into important intrapersonal and interpersonal variables in association with compulsive exercise behaviors among college women. Findings support previous literature suggesting body dissatisfaction as a critical element of compulsive exercise which health educators and programmers should focus on, when serving college students. The relationship between a student and his/her significant other, college roommate, and siblings were positive influences in the lives of the students sampled here and could potentially protect from compulsive exercise behavior. The results of this study provide insight into the complexity of compulsive exercise and support continued use of SNA and other systems science in eating disorder and compulsive exercise research.

CHAPTER VI

CONCLUSION

Introduction

The central purpose of this dissertation was to use SNA to investigate compulsive exercise among college women. In order to achieve this purpose, four independent articles were written: (1) a systematic literature review documenting the various influences on disordered exercise (Chapter II), (2) a systematic literature review documenting the use of SNA to investigate the health of college-aged adults (Chapter III), (3) a report on the whole network variables related to compulsive exercise in a specified network of college women (Chapter IV), and a report on the egocentric network variables (Chapter V) related to compulsive exercise in a sample of college women (the same sample examined in Chapter IV).

Chapter Findings and Results

The systematic literature review on disordered exercise (Chapter II) resulted in three major findings. First was the inconsistency in terminology. The most common term used in the reviewed body of research was “exercise dependence”, followed by “compulsive exercise”, “obligatory exercise”, “excessive exercise”, and “exercise addiction.” Definitions of terms shared several themes, including the notion that a person will experience depression, anxiety, or guilt when exercise is postponed or missed, and that exercise is being performed in extreme amounts, at the expense of other dimensions of a person's life. All definitions pointed to conceptions of psychological and physical

harm. A few definitions did state a direct association between disordered exercise and eating disordered behaviors (e.g., food restriction, Ackard et al., 2002), though most did not imply a necessary relationship between disordered exercise and eating disorders.

The second major finding from the systematic review of disordered exercise was the factors related to disordered exercise documented in the literature. Perfectionism (Goodwin, Haycraft, Willis, et al., 2011; Gulker et al., 2001; H. K. Hall et al., 2007; Taranis & Meyer, 2010), negative attitudes toward food and eating (Slay et al., 1998; Zmijewski & Howard, 2003), disordered eating patterns (Bewell-Weiss & Carter, 2010; Grandi, Clementi, Guidi, Benassi, & Tossani, 2011; Zmijewski & Howard, 2003), dissatisfaction with weight or appearance (Elbourne & Chen, 2007; Goodwin, Haycraft, Willis, et al., 2011; Pritchard & Beaver, 2012; Zmijewski & Howard, 2003), sociocultural pressures (Chalk et al., 2011; Goodwin et al., 2014; Goodwin, Haycraft, Willis, et al., 2011; MacLaren & Best, 2007; Szabo et al., 2013), exercise behaviors (Bratland-Sanda et al., 2011; Costa et al., 2013; Hausenblas & Symons Downs, 2002; Phelan, Bond, Lang, Jordan, & Wing, 2011), and biological factors (Costa et al., 2013; Gapin et al., 2009; Szabo, de la Vega, Ruiz-Barquin, & Rivera, 2013), all had statistically significant associations with disordered exercise among the various populations studied.

The third major finding from our review on disordered exercise was the literature's focus on psychological influences, rather than social, cultural, or environmental influences. Constructs such as personality, drive, motivation, and attitude, were the most common influences studied in the literature. A bias toward individual-

level, psychological constructs is common in most health behavior research in the US (Goodson, 2010), and most definitions of disordered exercise included psychological components (e.g., a craving for exercise that results in physiological symptoms, psychological symptoms, or both; Hausenblas & Symons Downs, 2002). Thus, it was not surprising that psychological constructs dominated the study of disordered exercise. Though evidence suggests that psychological influences are a key factor in disordered exercise, this review justified taking a more complex approach to understanding disordered exercise.

The systematic review investigating ways SNA has been used to study the health of college-aged adults (Chapter III) also provided three key insights. The first was that SNA has been useful in the study of drinking among college-aged adults. This review suggests that drinking behaviors were predicted by network composition (Reifman et al., 2006), centrality (Dumas, Wells, et al., 2014), density (Fondacaro & Heller, 1983), and homophily (Lorant & Nicaise, 2014). Smoking (Phua, 2011), homesickness, (Hendrickson et al., 2011), romantic partnerships (Lamkin et al., 2015), stress (Korneinko et al., 2013), and aggression (Swartout, 2013) were also investigated using SNA in college-aged adult samples.

The second major finding from the review on using SNA to research the health of college-aged adults was the popularity of *egocentric network research* over *whole network research* in this body of literature. Most of the studies in this review employed an egocentric network design when doing SNA. Egocentric network research more

closely resembles traditional research in the social and behavioral sciences, which may be why it is represented more often in the literature.

The third key finding from Chapter III was important considerations for use of SNA in health studies. A few inconsistencies were revealed in this review that are important to consider when doing SNA in social and behavioral sciences, including: boundary specification of the network in whole network studies and collecting data from the entire network; use of interrelater questions when collecting egocentric data; limits on nominations in whole and egocentric network research; and employing statistics to account for nonindependence in the analysis of whole network data. In sum, it is important for future researchers that opt to use SNA to carefully consider the assumptions of SNA, and employ the appropriate design, data collection methods, and analysis. This review provided a rationale for using SNA to investigate other health behaviors among college-aged adults, including compulsive exercise.

Chapters II and III established support for using SNA to further investigate compulsive exercise among college women. Thus, Chapters IV and V employed each of the two approaches to SNA to study compulsive exercise in a sample of college women. Chapter IV was a whole network study and Chapter V was an egocentric network study of the same sample. Chapters IV and V report on 204 college women — members of a sorority at a private university in the southwestern US — and their responses to a one-time survey in the spring of 2015 measuring demographic variables, attribute variables (compulsive exercise, body dissatisfaction, and physical activity), and network variables.

The whole network examined in Chapter IV comprised the ties among the members of the sorority who participated in the study.

Compulsive exercise was measured with the Compulsive Exercise Test (CET; Taranis et al., 2011). The CET comprised five subscales: (1) avoidance and rule-driven behavior; (2) weight control exercise; (3) mood improvement; (4) lack of exercise enjoyment; and (5) exercise rigidity. Avoidance and rule-driven behavior highlights someone's effort to avoid withdrawal symptoms and guilt associated with the inability to exercise. Weight control exercise describes exercise that compensates for the calories one consumes. Mood improvement focuses on how exercise makes a person feel, and lack of exercise enjoyment measures levels of compulsivity in exercise. Exercise rigidity assesses strict adherence to exercise.

In the whole network study (Chapter IV), we conducted six MR-QAP analyses (multiple regression quadratic assignment procedure) predicting total compulsive exercise and each of the five subscales. MR-QAP analyses are regression analyses that account for non-independence present in network data. Each regression model included demographic variables, attribute variables, and network variables as predictor variables. Our results found that eigenvector centrality (being connected to nodes that are themselves well connected), closeness (an inverse measure of centrality; the larger someone's closeness score, the more peripheral they are), and clustering (density of ties in each node's ego network; measure of "clumpiness") were important network variables related to compulsive exercise.

Eigenvector centrality was the only network variable related to total compulsive exercise, while closeness was related to the avoidance and rule-driven behavior and exercise for weight control subscales of the CET, and clustering had a negative relationship with the lack of exercise enjoyment subscale. Physical activity and body dissatisfaction were also significant predictors in all regression models except in the model for lack of exercise enjoyment, which did not retain body dissatisfaction in the analysis.

In the egocentric network study (Chapter V), we ran three linear regression models predicting total compulsive exercise scores. The first model contained only demographic variables, the second added attribute variables, and the third included network variables. Results suggest that in addition to body dissatisfaction and physical activity participation, relationships with siblings, significant others, and roommates are protective of compulsive exercise behavior in our sample of college women.

Implications for Future Research and Practice

The findings of this dissertation have important implications for future public health research. The findings from our literature review documenting the influences on disordered exercise (Chapter II) supported the testing of dynamic models of disordered exercise, rather than relying on the general linear model alone. This dissertation conducted an SNA on disordered exercise, but other methods of systems science such as systems dynamics or agent-based models could also be considered in future research.

Chapter III, our second literature review documenting the studies that have used SNA to investigate the health of college-aged adults, supports the continued and future

use of SNA, especially when studying college students (who are especially prone to social influence; Paul & Kelleher, 1995). According to our findings, SNA could provide important information regarding health concerns prevalent among college students, such as stress or prescription drug use.

The whole network study (Chapter IV) that investigated compulsive exercise among a network of college women provides rationale for future research on group dynamics and network structure as they relate to compulsive exercise. SNA could reveal important network variables associated with compulsive exercise in other groups such as men, adolescents, or athletes.

Chapter V, which used an egocentric network design to study compulsive exercise among the same sample of college women assessed in Chapter IV, also provided a rationale for future use of SNA. When conducting egocentric network studies specifically, this chapter suggests researchers consider including interrelater questions (questions to assess whether the people each ego nominates are connected) to improve the scope of the egocentric results.

In addition to the implications for future research, there are also several implications for future health education and practice. Chapter II provided a summary of factors related to disordered exercise. These factors are important for practitioners to be aware of, especially when promoting exercise or working with eating disorder patients.

Chapter III identified important network characteristics related to various health concerns of college-aged adults, especially drinking. According to the findings of Chapter III, centrality and homophily were salient network predictors of alcohol use in

this population. Thus, practitioners and staff working in higher education are provided cautionary targets for intervention concerning drinking.

Chapter IV revealed specific points of intervention for preventing or combating compulsive exercise. In our sample of college women, members who were strongly connected to popular people were at elevated risk of engaging in compulsive exercise. Women who occupy positions on the outskirts of the network, and are therefore less connected, were also at higher risk of participating in compulsive exercise. Programs geared toward curbing compulsive exercise could strategically serve these members, according to their needs and their position in the network.

Finally, Chapter V also provided intervention points useful for higher education employees. For instance, the egocentric network study suggested that roommates were protective of compulsive exercise in our sample of college women. Thus, staff working in campus-housing should be aware of roommate relationships as potential barriers to compulsive exercise, or psychologists may help clients struggling with compulsive exercise develop strong relationships with their roommate(s).

In summary, the dissertation, as an integrated body of work, provided: (a) a rationale for future use of SNA to study the health of college-aged adults; (b) the most salient factors related to compulsive exercise; (c) ways in which SNA has been used in the health research literature, particularly the health of college-aged adults; and (d) specific leverage points for programmatic interventions aimed at preventing compulsive exercise among female college students.

REFERENCES

Ackard, D. M., Brehm, B. J., & Steffen, J. J. (2002). Exercise and eating disorders in college-aged women: Profiling excessive exercisers. *Eating Disorders*, *10*, 31–47.

Alexander, C., Piazza, M., Mekos, D., & Valente, T. W. (2001). Peer networks and adolescent cigarette smoking: An analysis of the national longitudinal study of adolescent health. *Journal of Adolescent Health*, *29*, 22–30.

Angold, A., Costello, E. J., Farmer, E. M. Z., Burns, B. J., & Erkanli, A. (1999). Impaired but Undiagnosed. *Journal of the American Academy of Child & Adolescent Psychiatry*, *38*(2), 129–137. http://doi.org/10.1097/00004583-199902000-00011

Anokye, N. K., Trueman, P., Green, C., Pavey, T. G., & Taylor, R. S. (2012). Physical activity and health related quality of life. *BMC Public Health*, *12*(1), 624. http://doi.org/10.1186/1471-2458-12-624

Arbour, K. P., & Martin Ginis, K. A. (2006). Effects of exposure to muscular and hypermuscular media images on young men's muscularity dissatisfaction and body dissatisfaction. *Body Image*, *3*(2), 153–161. http://doi.org/10.1016/j.bodyim.2006.03.004

Arcelus, J., Mitchell, A. J., Wales, J., & Nielsen, S. (2011). Mortality rates in patients with anorexia nervosa and other eating disorders: A meta-analysis of 36 studies. *Archives of General Psychiatry*, *68*(7), 724–731. http://doi.org/10.1001/archgenpsychiatry.2011.74

Bamber, D., Cockerill, I. M., Rodgers, S., & Carroll, D. (2000). "It's exercise or nothing": a qualitative analysis of exercise dependence. *British Journal of Sports Medicine, 34*(6), 423–430. http://doi.org/10.1136/bjsm.34.6.423

Barnett, T. A., O'Loughlin, J. O., & Paradis, G. (2002). One- and two-year predictors of decline in physical activity among inner-city schoolchildren. *American Journal of Preventative Medicine*, *23*(2), 121–128.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J., & Martin, B. W. (2012). Correlates of physical activity: why are some people physically active and others not? *The Lancet*, *380*(9838), 258–271. http://doi.org/10.1016/S0140-6736(12)60735-1

Beren, S. E., Hayden, H. A., Wilfley, D. E., & Grilo, C. M. (1996). The influence of sexual orientation on body dissatisfaction in adult men and women. *International Journal of Eating Disorders*, *20*(2), 135–141. http://doi.org/10.1002/(SICI)1098-108X(199609)20:2<135::AID-EAT3>3.0.CO;2-H

Berge, J. M., MacLehose, R., Eisenberg, M. E., Laska, M. N., & Neumark-Sztainer, D. (2012). How significant is the "significant other"? Associations between significant others' health behaviors and attitudes and young adults' health outcomes. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 35. http://doi.org/10.1186/1479-5868-9-35

Berggren, N., Jordahl, H., & Poutvaara, P. (2010). The looks of a winner: Beauty and electoral success. *Journal of Public Economics*, *94*(1–2), 8–15. http://doi.org/10.1016/j.jpubeco.2009.11.002

Berrettini, W. (2004). The Genetics of Eating Disorders. *Psychiatry (Edgmont), 1*(3), 18–25.

Borgatti, S. P. (2006). E-NET Software for the Analysis of Ego-Network Data (Version .41). Needham, MA: Analytic Technologies.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. London: Sage Publications.

Borsari, B., & Carey, K. B. (2001). Peer influences on college drinking: A review of the research. *Journal of Substance Abuse, 13*, 391–424.

Bradbury, T. N., Fincham, F. D., & Beach, S. R. H. (2000). Research on the Nature and Determinants of Marital Satisfaction: A Decade in Review. *Journal of Marriage and Family*, *62*(4), 964–980. http://doi.org/10.1111/j.1741-3737.2000.00964.x

Braithwaite, S. R., Delevi, R., & Fincham, F. D. (2010). Romantic relationships and the physical and mental health of college students. *Personal Relationships*, *17*(1), 1–12. http://doi.org/10.1111/j.1475-6811.2010.01248.x

Bratland-Sanda, S., Martinsen, E. W., Rosenvinge, J. H., Oyvind, R., Hoffart, A., & Sundgot-Borgen, J. (2011). Exercise dependence score in patients with longstanding eating disorders and controls: THe importance of affect regulation and physical activity intensity. *European Eating Disorder Review*, *19*, 249–255.

Braun, D. L., Sunday, S. R., & Halmi, K. A. (1994). Psychiatric comorbidity in patients with eating disorders. *Psychological Medicine, 24*(04), 859–867. http://doi.org/10.1017/S0033291700028956

Bronfenbrenner, U. (1979). *The Ecology of Human Development*. Cambridge, MA: Harvard University Press.

Buchanan, D. R. (2000). *An ethic for health promotion: Rethinking the sources of human well-being*. Oxford: Oxford University Press.

Buchholz, L. J., & Crowther, J. H. (2014). Women who use exercise as a compensatory behavior: How do they differ from those who do not? *Psychology of Sport and Exercise*, *15*(6), 668–674. http://doi.org/10.1016/j.psychsport.2014.06.010

Burt, R. S. (2002). Bridge decay. *Social Networks*, *24*, 218–224.

Burt, R. S., & Minor, M. J. (1983). *Applied Network Analysis: A Methodological Introduction*. Beverly Hills: SAGE Publications, Inc.

Cash, T. F. (2004). Body image: Past, present, and future. *Body Image*, *1*, 1–5.

Cash, T. F., & Smolak, L. (2011). *Body Image, Second Edition: A Handbook of Science, Practice, and Prevention*. Guilford Press.

CDC. (2012). *Physical activity and health*. Atlanta, GA. Retrieved from http://www.cdc.gov/physicalactivity/everyone/health/index.html

Center for Disease Control and Prevention. (2013). CDC - Workplace Health - Implementation - Physical Activity. Retrieved July 30, 2015, from http://www.cdc.gov/workplacehealthpromotion/implementation/topics/physical-activity.html

Chalk, H. M., Miller, S. E., Roach, M. E., & Schultheis, K. S. (2011). Predictors of obligatory exercise among undergraduates: Differential implications for

counseling college men and women. *Journal of College Counseling*, *16*, 102–114.

Chapkis, W. (1986). *Beauty Secrets: Women and the Politics of Appearance*. South End Press.

Chesney, E., Goodwin, G. M., & Fazel, S. (2014). Risks of all-cause and suicide mortality in mental disorders: a meta-review. *World Psychiatry*, *13*(2), 153–160. http://doi.org/10.1002/wps.20128

Christakis, N. A., & Fowler, J. H. (2007). The spread of obesity in a large social network over 32 years. *New England Journal of Medicine*, *357*(4), 370–379.

Christakis, N. A., & Fowler, J. H. (2008). The collective dynamics of smoking in a large social network over 32 years. *New England Journal of Medicine*, *358*(21), 2249–2258.

Cohane, G. H., & Pope, H. G. (2001). Body image in boys: A review of the literature. *International Journal of Eating Disorders*, *29*(4), 373–379. http://doi.org/10.1002/eat.1033

Costa, S., Hausenblas, H. A., Oliva, P., Cuzzocrea, F., & Larcan, R. (2013). The role of age, gender, mood states and exercise frequency on exercise dependence. *Journal of Behavioral Addictions*, *2*(4), 216–223.

Cummings, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis*. New York: Routledge.

Dalle Grave, R. (2009). Features and management of compulsive exercising in eating disorders. *Physician Sportsmed*, *37*(3), 20–28.

Dalle Grave, R., Calugi, S., & Machesini, G. (2008). Compulsive exercise to control shape or weight in eating disorders: Prevalence, associated features, ad treatment outcome. *Comprehensive Psychiatry*, *49*(4), 346–452.

Davis, C., Brewer, H., & Ratusny, D. (1993). Behavioral frequency and psychological commitment: Necessary concepts in the study of excessive exercising. *Journal of Behavioral Medicine*, *16*(6), 611–628.

Davis, C., Kennedy, S. H., Ralevski, E., & Dionne, M. (1994). The role of physical activity in the development and maintenance of eating disorders. *Psychological Medicine*, *24*(4), 957–967.

de la Haye, K., Robins, G., Mohr, P., & Wilson, C. (2010). Obesity-related behaviors in adolescent friendship networks. *Social Networks*, *32*, 161–167.

Deliens, T., Clarys, P., De Bourdeaudhuij, I., & Deforche, B. (2014). Determinants of eating behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, *14*, 53. http://doi.org/10.1186/1471-2458-14-53

Dempwolf, C. S., & Lyles, L. W. (2012). Social network analysis in planning: A review of the literature. *Planning Literature*, *27*, 3–21.

Dittmar, H. (2005). Vulnerability factors and processes linking sociocultural pressures and body dissatisfaction: An introduction to the second special issue on body image. *Journal of Social and Clinical Psychology*, *24*, 1081–1087.

Dittmar, H., & Howard, S. (2004). Thin-ideal internalization and social comparison tendency as moderators of media models' impact on women's body-focused anxiety. *Journal of Social and Clinical Psychology*, *23*(6), 768–791.

Donatelle, R. J. (2013). *Access to Health* (13 edition). Boston: Benjamin Cummings.

Donini, P. L. M., Marsili, D., Graziani, M. P., Imbriale, M., & Cannella, C. (2013). Orthorexia nervosa: A preliminary study with a proposal for diagnosis and an attempt to measure the dimension of the phenomenon. *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity*, *9*(2), 151–157. http://doi.org/10.1007/BF03325060

Dorsey, A. M., Scherer, C. W., & Real, K. (1999). The College Tradition of "Drink “Til You Drop": The Relation Between Students’ Social Networks and Engaging in Risky Behaviors.” *Health Communication*, *11*(4), 313–334. http://doi.org/10.1207/S15327027HC1104_1

Duckham, R. L., Peirce, N., Meyer, C., Summers, G. D., Cameron, N., & Brooke-Wavell, K. (2012). Risk factors for stress fracture in female endurance athletes: a cross-sectional study -- -- BMJ Open. Retrieved September 14, 2015, from http://bmjopen.bmj.com

Dumas, T. M., Graham, K., Bernards, S., & Wells, S. (2014). Drinking to reach the top: Young adults’ drinking patterns as a predictor of status within natural drinking groups. *Addictive Behaviors*, *39*, 1510–1515.

Dumas, T. M., Graham, K., Maxwell-Smith, M. A., & Wells, S. (2015). Being cool is risky business: Young men’s within-peer-group status, heavy alcohol consumption and aggression in bars. *Addiction Research & Theory*, *23*(3), 213–222. http://doi.org/10.3109/16066359.2014.972385

Dumas, T. M., Wells, S., Flynn, A., Lange, J. E., & Graham, K. (2014). The influence of status on group drinking by young adults: A survey of natural drinking groups on their way to and from bars. *Alcoholism: Clinical and Experimental Research*, *38*(4), 1101–1107.

Duncan, G. J., Boisjoly, J., Kremer, M., Levy, D. M., & Eccles, J. (2005). Peer effects in drug use and sex among college students. *Journal of Abnormal Child Psychology*, *33*(3), 375–385.

Eisenberg, D., Golberstein, E., & Whitlock, J. L. (2014). Peer effects on risky behaviors: New evidence from college roommate assignments. *Journal of Health Economics*, *33*, 126–138. http://doi.org/10.1016/j.jhealeco.2013.11.006

Eisenberg, D., Golberstein, E., Whitlock, J. L., & Downs, M. F. (2013). Social Contagion of Mental Health: Evidence from College Roommates. *Health Economics*, *22*(8), 965–986. http://doi.org/10.1002/hec.2873

Elbourne, K. E., & Chen, J. (2007). The continuum model of obligatory exercise: A preliminary investigation. *Journal of Psychosomatic Research*, *62*, 73–80.

Engeln-Maddox, R. (2006). Buying a Beauty Standard or Dreaming of a New Life? Expectations Associated with Media Ideals. *Psychology of Women Quarterly*, *30*(3), 258–266. http://doi.org/10.1111/j.1471-6402.2006.00294.x

Eng, J. J., & Martin Ginis, K. A. (2007). Using the theory of planned behavior to predict leisure time physical activity among people with chronic kidney disease. *Rehabilitation Psychology*, *52*(4), 435–442.

Epling, W. F., & Pierce, W. D. (1996). *Activity anorexia theory, research, and treatment*. Hillsdale, NJ: Erlbaum.

Evans, C., & Dolan, B. (1993). Body shape questionnaire: Derivation of shortened "alternate forms." *International Journal of Eating Disorders*, *13*(3), 315–321. http://doi.org/10.1002/1098-108X(199304)13:3<315::AID-EAT2260130310>3.0.CO;2-3

Fairburn, C. G., & Harrison, P. J. (2003). Eating disorders. *The Lancet*, *361*(9355), 407–416. http://doi.org/10.1016/S0140-6736(03)12378-1

Feld, S. (1981). The focused organization of social ties. *American Journal of Sociology*, *86*(5), 1015–1035.

Field, A. E., Cheung, L., Wolf, A. M., Hreczog, D. B., Gortmaker, S. L., & Colditz, G. A. (1999). Exposure to mass media and weight concerns among girls. *Pediatrics*, *103*, e36.

Flett, G. L., & Hewitt, P. L. (2005). The perils of perfectionism in sports and exercise. *Current Directions in Psychological Science*, *14*(1), 14–18.

Fondacaro, M. R., & Heller, K. (1983). Social support factors and drinking among college student males. *Journal of Youth and Adolescence*, *12*(4), 285–299. http://doi.org/10.1007/BF02088727

Forsyth, G. (2014). More a chore than a pleasure: Stopping exercise. *JOURNAL OF PHYSICAL ACTIVITY, SPORTS & EXERCISE*, *2*(1). Retrieved from http://www.jpaspex.com/index.php/JPASE/article/view/9

Franklin, C. A., Bouffard, L. A., & Pratt, T. C. (2012). Sexual Assault on the College Campus: Fraternity Affiliation, Male Peer Support, and Low Self-Control. *Criminal Justice and Behavior*, *39*(11), 1457–1480. http://doi.org/10.1177/0093854812456527

Freeman, L. (1979). Centrality in social networks: Conceptual clarification. *Social Networks, 1*(215-239).

Friedman, M. A., Dixon, A. E., Brownell, K. D., Whisman, M. A., & Wilfley, D. E. (1999). Martial status, marital satisfaction, and body image dissatisfaction. *International Journal of Eating Disorders, 26*, 81–85.

Gapin, J., Etnier, J. L., & Tucker, D. (2009). The relationship between frontal brain asymmetry and exercise addiction. *Journal of Psychophysiology*, *23*(3), 135–142.

Garrard, J. (2007). *Health sciences literature review made easy: The matrix method*. Sudbury, MA: Jones and Bartlett Publishers.

Gibbs, M. (2010). Media influence on body image dissatisfaction. *ETD Collection for Tennessee State University*, 1–69.

Gilmartin, S. K. (2005). The Centrality and Costs of Heterosexual Romantic Love among First-Year College Women. *The Journal of Higher Education, 76*(6), 609–633. http://doi.org/10.1353/jhe.2005.0040

Ginis, K. A. M., Latimer, A. E., Arbour-Nicitopoulos, K. P., Bassett, R. L., Wolfe, D. L., & Hanna, S. E. (2011). Determinants of physical activity among people with spinal cord injury: a test of social cognitive theory. *Annals of Behavioral*

Medicine: A Publication of the Society of Behavioral Medicine, *42*(1), 127–133. http://doi.org/10.1007/s12160-011-9278-9

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Science*, *10*, 141–146.

Goodson, P. (2010). *Theory in health promotion research and practice*. Sudbury, MA: Jones and Bartlett Publishers.

Goodson, P. (2015). Researching genes, behavior, and society to improve population health: A primer in complex adaptive systems as an integrative appraoch. *Genetics, Health, and Society - Advances in Medical Sociology*, *16*, 127–156.

Goodwin, H., Haycraft, E., & Meyer, C. (2011). Sociocultural correlates of compulsive exercise: Is the environment important in fostering a compulsivity towards exercise among adolescents? *Body Image*, *8*, 390–395.

Goodwin, H., Haycraft, E., & Meyer, C. (2014). Sociocultural risk factors for compulsive exercise: A prospective study of adolescents. *European Eating Disorder Review*, *22*, 360–365.

Goodwin, H., Haycraft, E., Taranis, L., & Meyer, C. (2011). Psychometric evaluation of the compulsive exercise test (CET) in an adolescent population: Links with eating psychopathology. *European Eating Disorders Review*, *19*(3), 269–279. http://doi.org/10.1002/erv.1109

Goodwin, H., Haycraft, E., Willis, A. M., & Meyer, C. (2011). Compulsive exercise: The role of personality, psychological morbidity, and disordered eating. *International Journal of Eating Disorders*, *44*, 655–660.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360.

Grogan, S. (2007). *Body Image: Understanding Body Dissatisfaction in Men, Women and Children*. Routledge.

Guidi, J., Pender, M., Hollon, S. D., Zisook, S., Schwarts, P. P., Farabaugh, A., … Petersen, T. J. (2009). The prevalence of compulsive eating and exercise among college students: An exploratory study. *Psychiatry Research*, *165*(1), 154–162.

Gulker, M. G., Laskis, T. A., & Kuba, S. A. (2001). Do excessive exercisers have a higher rate of obsessive-compulsive symptomatology? *Psychology, Health, & Medicine*, *6*(4), 391–398.

Hafferty, F. W., Castellani, B., Hafferty, P. K., & Pawlina, W. (2013). Anatomy and histology as socially networked learning environments: Some preliminary findings. *Academic Medicine*, *88*(9), 1315–1323.

Halgin, D. S., & Borgatti, S. P. (2012). An introduction to personal network analysis with E-Net. *Connections*, *31*(1), 37–48.

Hall, H. K., Kerr, A. W., Kozub, S. A., & Finnie, S. B. (2007). Motivational antecedents of obligatory exercise: The influence of achievement goals and multidimensional perfectionism. *Psychology of Sport and Exercise*, *8*, 297–316.

Hammond, R. A. (2009). Complex systems modeling for obesity research. *Preventing Chronic Disease*, *6*(3), A97.

Hansen, D., Shneiderman, B., & Smith, M. A. (2011). Social network analysis: Measuring, mapping, and modeling collections of connections. In *Analyzing*

social media networks with NodeXL: Insights from a connected world (pp. 31–52). Burlington: Elsevier, Inc.

Hanson, D., Hanson, J., Vardon, P., McFarlane, K., Speare, R., & Durrhelm. (2008). Documenting the development of social capital in a community Safety Promotion Network: It's not what you know but who you know. *Health Promotion Journal Australia*, *19*(2), 144–151.

Hardit, S. K., & Hannum, J. W. (2012). Attachment, the tripartite influence model, and the development of body dissatisfaction. *Body Image*, *9*(4), 469–475. http://doi.org/10.1016/j.bodyim.2012.06.003

Hargreaves, D. A., & Tiggemann, M. (2004). Idealized media images and adolescent body image: "comparing" boys and girls. *Body Image*, *1*(4), 351–361. http://doi.org/10.1016/j.bodyim.2004.10.002

Harris, J. K., Luke, D. A., Burke, R. C., & Mueller, N. B. (2008). Seeing the forest and the trees: Using network analysis to develop an organizational blueprint of state tobacco control systems. *Social Science & Medicine*, *6*, 1669–1678.

Hausenblas, H. A., & Symons Downs, D. (2002). Relationship among sex, imagery, and exercise dependence symptoms. *Psychology of Addictive Behaviors*, *16*(2), 169–172. http://doi.org/10.1037//0893-164X.16.2.169

Hawe, P., Webster, C., & Shiell, A. (2004). A glossary of terms for navigating the field of social network analysis. *Journal of Epidemilogy and Community Health*, *58*, 971–975.

Haworth-Hoeppner, S. (2000). The Critical Shapes of Body Image: The Role of Culture and Family in the Production of Eating Disorders. *Journal of Marriage and Family*, *62*(1), 212–227. http://doi.org/10.1111/j.1741-3737.2000.00212.x

Hays, R. B., & Oxley, D. (1986). Social network development and functioning during a life transition. *Journal of Personality and Social Psychology*, *50*, 305–313.

Heli, R. (2012). *Physical activity guidelines for children*.

Helleringer, S., & Kohler, H.-P. (2007). Sexual network structure and the spread of HIV in Africa: Evidence from Likoma Island, Malawi. *AIDS*, *21*(17), 2323–2332.

Hendrickson, B., Rosen, D., & Kelly Aune, R. (2011). An analysis of friendship networks, social connectedness, homesickness, and satisfaction levels of international students. *International Journal of Intercultural Relations*, *35*(3), 281–295.

Holloway, I. W., Rice, E., & Kipke, M. D. (2014). Venue-based network analysis to inform HIV prevention efforts among young gay, bisexual, and other men who have sex with men. *Prevention Science*, *15*, 419–427.

Homan, K. J. (2010). Athletic-ideal and thin-ideal internalization as prospective predictors of body dissatisfaction, dieting, and compulsive exercise. *Body Image*, *7*, 240–245.

Homan, K. J., & Lemmon, V. A. (2014). Attachment to God and eating disorder tendencies: The mediating role of social comparison. *Psychology of Religion and Spirituality*, *In press.*

House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science (New York, N.Y.), 241*(4865), 540–545.

Huang, G. C., Unger, J. B., Soto, D. W., Fujimoto, K., Pentz, M. A., Jordan-Marsh, M., & Valente, T. W. (2014). Peer influences: The impact of online and offline friendship networks on adolescent smoking and alcohol use. *Journal of Adolescent Health*, *54*, 508–514.

Hudson, J. L., Hiripi, E., Pope, H. G., & Kessler, R. G. (2007). The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biological Psychiatry*, *61*, 348–396.

Hutchinson, D. M., & Rapee, R. M. (2007). Do friends share similar body image and eating problems? The role of social networks and peer influences in early adolescence. *Behaviour Research and Therapy, 45*(7), 1557–1577. http://doi.org/10.1016/j.brat.2006.11.007

Jacobi, C., Hayward, C., de Zwaan, M., Kraemer, H. C., & Agras, W. S. (2004). Coming to terms with risk factors for eating disorders: Application of risk terminology and suggestions for general taxonomy. *Psychological Bulletin, 130*(1), 19–65. http://doi.org/10.1037/0033-2909.130.1.19

Jacobs, D. R., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Medicine and Science in Sports and Exercise*, *25*(1), 81–91.

Jeon, K. C., & Goodson, P. (2015). US adolescents' friendship networks and health risk behaviors: a systematic review of studies using social network analysis and Add Health data. *PeerJ*, *3*. http://doi.org/10.7717/peerj.1052

Johnston, O., Reilly, J., & Kremer, J. (2011). Excessive exercise: From quantitative categorisation to a qualitative continuum approach. *European Eating Disorders Review*, *19*(3), 237–248.

Joseph, R. P., Royse, K. E., Benitez, T. J., & Pekmezi, D. W. (2014). Physical activity and quality of life among university students: exploring self-efficacy, self-esteem, and affect as potential mediators. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *23*(2), 659–667. http://doi.org/10.1007/s11136-013-0492-8

Kaplan, A. S., & Garfinkel, P. E. (1999). Difficulties in treating patients with eating disorders: a review of patient and clinician variables. *Canadian Journal of Psychiatry. Revue Canadienne De Psychiatrie*, *44*(7), 665–670.

Karr, T. M., Zunker, C., Thompson, R. A., Sherman, R. T., Erickson, A., Cao, L., … Mitchell, J. E. (2013). Moderators of the association between exercise identity and obligatory exercise among participants of an athletic event. *Body Image*, *10*, 70–77.

Katzman, M. A., & Wolchik, S. A. (1984). Bulimia and binge eating in college women: A comparison of personality and behavioral characteristics. *Journal of Consulting and Clinical Psychology*, *52*(3), 423–428. http://doi.org/10.1037/0022-006X.52.3.423

Kaye, W. (2008). Neurobiology of Anorexia and Bulimia Nervosa Purdue Ingestive Behavior Research Center Symposium Influences on Eating and Body Weight over the Lifespan: Children and Adolescents. *Physiology & Behavior*, *94*(1), 121–135. http://doi.org/10.1016/j.physbeh.2007.11.037

Klemchuk, H. P., Hutchinson, C. B., & Frank, R. I. (1990). Body dissatisfaction and eating-related problems on the college campus: Usefulness of the Eating Disorder Inventory with a nonclinical population. *Journal of Counseling Psychology*, *37*(3), 297–305. http://doi.org/10.1037/0022-0167.37.3.297

Kluck, A. S. (2010). Family influence on disordered eating: The role of body image dissatisfcation. *Body Image*, *7*(1), 8–14. http://doi.org/10.1016/j.bodyim.2009.09.009

Kobus, K. (2003). Peers and adolescent smoking. *Addiction*, *98*, 37–55. http://doi.org/10.1046/j.1360-0443.98.s1.4.x

Korneinko, O., Clemans, K. H., Out, D., & Granger, D. A. (2013). Friendship network position and salivary cortisol levels. *Social Neuroscience*, *8*(4), 385–396.

Kothari, A., Hamel, N., MacDonald, J., Meyer, M., Cohen, B., & Bonnenfant, D. (2012). Exploring community collaborations: Social network analysis as a reflective tool for public health. *Systemic Practice and Action Research*, *27*(2), 123–137.

Lamkin, J., Campbell, W. K., vanDellen, M. R., & Miller, J. D. (2015). An exploration of the correlates of grandiose and vulnerable narcissism in romantic relationships: Homophily, partner characteristics, and dyadic adjustment. *Personality and Individual Differences*, *79*, 166–171.

Lampis, J., Agus, M., & Cacciarru, B. (2013). Quality of Family Relationships as Protective Factors of Eating Disorders: An Investigation Amongst Italian Teenagers. *Applied Research in Quality of Life*, *9*(2), 309–324. http://doi.org/10.1007/s11482-013-9234-x

Latzer, Y., Hochdorf, Z., Bachar, E., & Canetti, L. (2002). Attachment Style and Family Functioning as Discriminating Factors in Eating Disorders. *Contemporary Family Therapy*, *24*(4), 581–599. http://doi.org/10.1023/A:1021273129664

Lavine, H., Sweeney, D., & Wagner, S. H. (1999). Depicting Women as Sex Objects in Television Advertising: Effects on Body Dissatisfaction. *Personality and Social Psychology Bulletin*, *25*(8), 1049–1058. http://doi.org/10.1177/01461672992511012

LePage, M. L., Price, M., O'Neil, P., & Crowther, J. H. (2012). The effect of exercise absence on affect and body dissatisfaction as moderated by obligatory exercise beliefs and eating disordered beliefs and behaviors. *Psychology of Sport and Exercise*, *13*(4), 500–508. http://doi.org/10.1016/j.psychsport.2012.02.008

Lewin, K., & Cartwright, D. (1951). *Field Theory in Social Science*. New York, NY: Harper.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry* (1st edition). Beverly Hills, Calif: SAGE Publications.

Lorant, V., & Nicaise, P. (2014). Binge drinking at university: A social network stud in Belgium. *Health Promotion International, Epub ahead of print*.

Luke, D. A., & Harris, J. K. (2007). Network analysis in public health: History, methods, and applications. *Annual Review of Public Health*, *28*, 69–93.

Lund, E. M., & Thomas, K. B. (2015). Necessary But Not Sufficient: Sexual Assault Information on College and University Websites. *Psychology of Women Quarterly*. http://doi.org/10.1177/0361684315598286

MacLaren, V. V., & Best, L. A. (2007). Symptoms of exercise dependence and physical activity in students. *Perceptual & Motor Skills*, *105*, 1257–1264.

Makino, M., Tsuboi, K., & Dennerstein, L. (2004). Prevalence of Eating Disorders: A Comparison of Western and Non-Western Countries. *Medscape General Medicine*, *6*(3). Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1435625/

Mangweth-Matzek, B., Rupp, C. I., Hausmann, A., Assmayr, K., Mariacher, E., Kemmler, G., … Biebl, W. (2006). Never too old for eating disorders or body dissatisfaction: A community study of elderly women. *International Journal of Eating Disorders*, *39*(7), 583–586. http://doi.org/10.1002/eat.20327

Marsden, P. V. (1990). Network data and measurement. *Annual Review of Sociology*, *16*, 435–.

Marsella, A. J., & Snyder, K. K. (1981). Stress, social supports, and schizophrenic disorders. *Schinzophrenic Bulletin*, *7*, 152–163.

Massachusetts Eating Disorders Association. (2014). Eating Disorders Among College Students.

Mathers, S., & Walker, M. B. (2010). Extraversion and exercise addiction. *The Journal of Psychology: Interdisciplinary and Applied*, *133*(1), 125–128. http://doi.org/10.1080/00223989909599727

McCallister, L., & Fisher, C. S. (1978). A procedure for surveying personal networks. *Sociological Methods and Research*, *7*(2), 131–148.

McCarty, C. (2002). Structure in personal networks. *Journal of Social Structure*, *3*, Online.

McCarty, C., Bernard, H. R., Killworth, P. D., Shelley, G. A., & Johnson, E. C. (1997). Eliciting represntative samples of personal networks. *Social Networks*, *19*, 303–323.

McDonald, K., & Thompson, J. K. (1992). Eating disturbance, body image dissatisfaction, and reasons for exercising: Gender differences and correlational findings. *International Journal of Eating Disorders*, *11*(3), 289–292. http://doi.org/10.1002/1098-108X(199204)11:3<289::AID-EAT2260110314>3.0.CO;2-F

McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education Quarterly*, *16*(1), 17–30.

McPherson, M., Smith-Lovin, L., & Brashears, M. (2006). Social isolation in America: Changes in core discussion networks over two decades. *American Sociological Review*, *71*, 353–375.

Meadows, D. H. (2008). *Thinking in systems: A primer*. White River Junction, VT: Chelsea Green Publishing.

Merluzzi, J., & Burt, R. S. (2013). How many names are enough? Identifying network effects with the least set of listed contacts. *Social Networks*, *35*(3), 331–337. http://doi.org/10.1016/j.socnet.2013.03.004

Meyer, C., Taranis, L., Goodwin, H., & Haycraft, E. (2011). Compulsive exercise and eating disorders. *European Eating Disorder Review*, *19*(3), 174–189.

Min, M. O., Tracy, E. M., Kim, H., Park, H., Jun, M., Brown, S., … Laudet, A. (2013). Changes in personal netowrks of women in residential and outpatient substance abuse treatment. *Journal of Substance Abuse Treatment*, *45*, 325–334.

Modolo, V. B., Antunes, H. K. M., de Gimenez, P. R. B., Mello Santiago, M. L. D., Tufik, S., & de Mello, M. T. (2011). Negative addiction to exercise: Are there differences between genders? *Clinics*, *66*(2), 255–260.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med*, *6*(7), e1000097. http://doi.org/10.1371/journal.pmed.1000097

Mortensen, D. T., & Vishwanath, T. (1994). Personal contacts and earnings: It is who you know! *Labour Economics*, *1*(2), 187–201. http://doi.org/10.1016/0927-5371(94)90004-3

Mullen, P. D., & Ramírez, G. (2006). The promise and pitfalls of systematic reviews. *Annual Review of Public Health*, *27*, 81–102. http://doi.org/10.1146/annurev.publhealth.27.021405.102239

Mulrow, C. D. (1994). Rationale for systematic reviews. *BMJ (Clinical Research Ed.)*, *309*(6954), 597–599.

Nardi, B. A., Whittaker, S., & Schwarz, H. (2000). It's not what you know it's who you know. *First Monday*, *5*(5). http://doi.org/10.5210/fm.v5i5.741

Nuzzo, J. L., Schindler, C. L., & Ryan, W. J. (2013). Exercise dependence symptoms in a sample of exercise science students in the United States. *International Journal of Mental Health Addiction*, *11*, 611–618.

Okun, M. A., Ruehlman, L., Karoly, P., Lutz, R., Fairholme, C., & Schaub, R. (2003). Social Support and Social Norms: Do Both Contribute to Predicting Leisure-time Exercise? *American Journal of Health Behavior*, *27*(5), 493–507. http://doi.org/10.5993/AJHB.27.5.2

Onnis, L., Barbara, E., Bernardini, M., Caggese, A., Di Giacomo, S., Giambartolomei, A., … Vietri, A. (2012). Family relations and eating disorders. The effectiveness of an integrated approach in the treatment of anorexia and bulimia in teenagers: results of a case-control systemic research. *Eating and Weight Disorders: EWD*, *17*(1), e36–48.

Parise, S. (2007). Knowledge management and human resource development: An application in social network analysis methods. *Advanced Development of Hhuman Resources*, *9*(3), 359–383.

Patterson, M. S. (2016). *Influences on disorderd exercise: A systematic review* (Dissertation Chapter II). Texas A&M University.

Paul, E. L., & Kelleher, M. (1995). Precollege concerns about losing and making friends in college. *Journal of College Student Development*, *36*, 513–521.

Paxton, S. J., Schutz, H. K., Wertheim, E. H., & Muir, S. L. (1999). Friendship clique and peer influences on body image concerns, dietary restraint, extreme weight loss behaviors, and binge eating in adolescent girls. *Journal of Abnormal Psychology*, *108*, 255–266.

Pearson, M., & Michell, L. (2000). Smoke rings: Social network analysis of friendship groups, smoking and drug-takingq. *Drugs: Education, Prevention, and Policy*, *7*(21-37).

Penas-Lledo, E., Vaz Leal, F. J., & Waller, G. (2001). Excessive exercise in anorexia nervosa and bulimia nervosa: Relation to eating characteristics and general psychopathology. *International Journal of Eating Disorders*. http://doi.org/10.1002/eat.10042

Perry, B. L. (2012). Coming untied? Narrative accounts of social network dynamics from first-time mental health clients. *Sociology of Health and Illness*, *34*, 1125–1139.

Phares, V., Steinberg, A. R., & Thompson, J. K. (2004). Gender Differences in Peer and Parental Influences: Body Image Disturbance, Self-Worth, and Psychological Functioning in Preadolescent Children. *Journal of Youth and Adolescence*, *33*(5), 421–429. http://doi.org/10.1023/B:JOYO.0000037634.18749.20

Philippe, P., & Mansi, O. (1998). Nonlinearity in the epidemiology of complex health and disease processes. *Theoretical Medicine and Bioethics*, *19*, 591–607.

Phua, J. (2011). The influence of peer norms and popularity on smoking and drinking behavior among college fraternity members: A social network analysis. *Social Influence*, *6*(3), 153–158. http://doi.org/10.1080/15534510.2011.584445

Polivy, J., & Herman, C. P. (2002). Causes of eating disorders. *Annual Review of Psychology*, *53*, 187–213.

Pook, M., Tuschen-Caffier, B., & Brähler, E. (2008). Evaluation and comparison of different versions of the Body Shape Questionnaire. *Psychiatry Research*, *158*(1), 67–73. http://doi.org/10.1016/j.psychres.2006.08.002

Presnell, K., Bearman, S. K., & Stice, E. (2004). Risk factors for body dissatisfaction in adolescent boys and girls: A prospective study. *International Journal of Eating Disorders*, *36*(4), 389–401. http://doi.org/10.1002/eat.20045

Pyle, R. L., Neuman, P. A., Halvorson, P. A., & Mitchell, J. E. (1991). An ongoing cross-sectional study of the prevalence of eating disorders in freshman college students. *International Journal of Eating Disorders*, *10*(5), 667–677.

Quick, V. M., & Byrd-Bredbenner, C. (2013). Disturbed eating behaviours and associated psychographic characteristics in college students. *Journal of Human Nutrition and Dietetics*, *26*(s1), 53–63.

Racette, S. B., Duesinger, S. S., Strube, M. J., Highstein, G. R., & Deusinger, R. H. (2005). Weight Changes, Exercise, and Dietary Patterns During Freshman and Sophomore Years of College. *Journal of American College Health*, *53*(6), 245–251. http://doi.org/10.3200/JACH.53.6.245-251

Rancourt, D., Choukas-Bradley, S., Cohen, G. L., & Prinstein, M. J. (2014). An experimental examination of peers' influence on adolescent girls' weight-related behaviors. *International Journal of Eating Disorders*, *47*, 437–447.

Rayner, K. E., Schniering, C. A., Rapee, R. M., Taylor, A., & Hutchinson, D. M. (2013). Adolescent girls' friendship networks, body dissatisfaction, and disordered eating: examining selection and socialization processes. *Journal of Abnormal Psychology*, *122*(1), 93–104. http://doi.org/10.1037/a0029304

Reifman, A., Watson, W. K., & A., M. (2006). Social networks and college drinking: Probing processes of social influence and selection. *Personality and Social Psychology Bulletin*, *32*(6), 820–832. http://doi.org/10.1177/0146167206286219

Ressler, A. (1997). "A body to die for": eating disorders and body-image distortion in women. *International Journal of Fertility and Women's Medicine*, *43*(3), 133–138.

Rodgers, R., Chabrol, H., & Paxton, S. J. (2011). An exploration of the tripartite influence model of body dissatisfaction and disordered eating among Australian and French college women. *Body Image*, *8*(38-215), 20.

Rodgers, W. M., Hall, C. R., Blanchard, C. M., & Munroe, K. J. (2001). Prediction of obligatory exercise by exercise-related imagery. *Psychology of Addictive Behaviors*, *15*(2), 152–154. http://doi.org/10.1037//0893-164X.15.2.152

Rogers, E. M., & Kincaid, D. L. (1981). *Communication networks: A new paradigm for research*. New York, NY: Free Press.

Room, R., Babor, T., & Rehm, J. (2005). Alcohol and public health. *The Lancet*, *365*(9458), 519–530. http://doi.org/10.1016/S0140-6736(05)17870-2

Rosen, J. C., Jones, A., Ramirez, E., & Waxman, S. (1996). Body Shape Questionnaire: studies of validity and reliability. *The International Journal of Eating Disorders*, *20*(3), 315–319. http://doi.org/10.1002/(SICI)1098-108X(199611)20:3<315::AID-EAT11>3.0.CO;2-Z

Rudd, N. A., & Lennon, S. J. (2000). Body image and appearance-management behaviors in college women. *Clothing & Textiles Research Journal*, *18*(3), 152–162.

Schwitzer, A. M., Bergholz, K., Dore, T., & Salimi, L. (1998). Eating Disorders Among College Women: Prevention, Education, and Treatment Responses. *Journal of American College Health*, *46*(5), 199–207. http://doi.org/10.1080/07448489809600223

Shisslak, C. M., & Crago, M. (2001). Risk and protective factors in the development of eating disorder. In J. K. Thompson & L. Smolak (Eds.), *Body image, eating disorders, and obesity in youth: Assessment, prevention, and treatment* (pp. 103–125). Washington DC: American Pyschological Association.

Shroff, H., & Thompson, J. K. (2006). Peer Influences, Body-image Dissatisfaction, Eating Dysfunction and Self-esteem in Adolescent Girls. *Journal of Health Psychology*, *11*(4), 533–551. http://doi.org/10.1177/1359105306065015

Shroff, H., & Thompson, K. J. (2006). The tripartite influence model of body image and eating disturbance: A replication with adolescent girls. *Body Image*, *3*, 17–23.

Simons-Morton, B. G., & Farhat, T. (2010). Recent findings on peer group influences on adolescent smoking. *The Journal of Primary Prevention*, *31*(4), 191–208. http://doi.org/10.1007/s10935-010-0220-x

Slay, H. A., Hayaki, J., Napolitano, M. A., & Brownell, K. D. (1998). Motivations for running and eating attitudes in obligatory versus nonobligatory runners. *International Journal of Eating Disorders*, *23*, 267–275.

Smolak, L. (2004). Body image in children and adolescents: Where do we go from here? *Body Image*, *1*, 15–28.

Steffen, J. J., & Brehm, B. J. (1999). The dimensions of obligatory exercise. *Eating Disorders*, *7*(3), 219–226.

Stice, E., & Shaw, H. E. (2002). Role of body dissatisfaction in the onset and maintenance of eating pathology: A synthesis of research findings. *Journal of Psychosomatic Research*, *53*(5), 985–993. http://doi.org/10.1016/S0022-3999(02)00488-9

Stice, E., & Whitenton, K. (2002). Risk factors for body dissatisfaction in adolescent girls: a longitudinal investigation. *Developmental Psychology*, *38*(5), 669.

Stice, E., Ziemba, C., Margolis, J., & Flick, P. (1996). The dual pathway model differentiates bulimics, subclinical bulimics, and controls: Testing the continuity hypothesis. *Behavioral Therapy*, *27*, 531–549.

Striegel-Moore, R., & Franko, D. L. (2003). Epidemiology of binge eating disorder. *International Journal of Eating Disorders*, *34*, S19–S29.

Striegel-Moore, R., McAvay, G., & Rodin, J. (1986). Psychological and behavioral correlates of feeling fat in women. *International Journal of Eating Disorders*, *5*, 935–947.

Striegel-Moore, R., Silberstein, L., Frensh, P., & Rodin, J. (2006). A prospective study of disordered eating among college students. *Eating Disorders*, *8*(5), 499–509.

Striegel-Moore, R., Silberstein, L., & Rodin, J. (1986). Toward an understanding of risk factors for bulimia. *American Psychologist*, *41*, 246–263.

Sullivan, P. F. (1995). Mortality of anorexia nervosa. *American Journal of Psychiatry*, *152*(7), 1073–1074.

Swartout, K. M. (2013). The company they keep: How peer networks influence male sexual aggression. *Psychology of Violence*, *3*(2), 157–171.

Szabo, A., de la Vega, R., Ruiz-Barquin, R., & Rivera, O. (2013). Exercise addiction in Spanish athletes: Investigation of the roles of gender, social context and level of involvement. *Journal of Behavioral Addictions*, *2*(4), 249–252. http://doi.org/10.1556/JBA.2.2013.4.9

Szmukler, G. I., & Patton, G. (1995). *Handbook of eating disorders: Theory, treatment and research*. New York, NY: Wiley.

Tangney, J. P., Miller, R. S., Flicker, L., & Barlow, D. H. (1996). Are shame, guilt, and embarrassment distinct emotions? *Journal of Personality and Social Psychology*, *70*(6), 1256–1269. http://doi.org/10.1037/0022-3514.70.6.1256

Taranis, L., & Meyer, C. (2010). Perfectionism and compulsive exercise among female exercisers: High personal standards or self-criticism? *Personality and Individual Differences, 49*, 3–7.

Taranis, L., & Meyer, C. (2011). Associations between specific components of compulsive exercise and eating-disordered cognitions and behaviors among young women. *International Journal of Eating Disorders, 18*(44), 452–458.

Taranis, L., Touyz, S., & Meyer, C. (2011). Disordered eating and exercise: Development and preliminary validation of the compulsive exercise test (CET). *European Eating Disorder Review, 19*(3), 256–268.

The Emily Program Foundation. (2014). Eating disorders.

The Review Center Foundation for Eating Disorders. (2003). Eating disorders 101 guide: A summary of issues, statistics, and resources.

Thome, J. L., & Espelage, D. L. (2007). Obligatory exercise and eating pathology in college females: Replication and development of a structural model. *Eating Behaviors, 8*(3), 334–349.

Thompson, B. (2006). *Foundations of behavioral statistics: An insight-based approach*. New York: Guilford.

Thompson, J. K., & Heinberg, L. J. (1999). The Media's Influence on Body Image Disturbance and Eating Disorders: We've Reviled Them, Now Can We Rehabilitate Them? *Journal of Social Issues, 55*(2), 339–353. http://doi.org/10.1111/0022-4537.00119

Thompson, J. K., Heinberg, L. J., Altabe, M., & Tantlett-Dunn, S. (1999). *Exacting beauty: Theory, assessment, and treatment of body image disturbance*. Washington DC: American Psychological Association.

Thompson, J. K., & Stice, E. (2001). Thin-ideal internalization: Mounting evidence for a new risk factor for body-image disturbance and eating pathology. *Current Directions in Psychological Science*, 181–183.

U. S. Department of Health and Human Services. (2008). *Physical activity guidelines advisory committee report*. Washington DC.

Valente, T. W. (2010). *Social Networks and Health: Models, Methods, and Applications*. New York, NY: Oxford University Press.

Valente, T. W., Fujimoto, K., Unger, J. B., Soto, D. W., & Meeker, D. (2013). Variations in network boundary and type: A study of adolescent peer influences. *Social Networks*, (35), 309–316.

Valente, T. W., Gallaher, P., & Mouttapa, M. (2004). Using social networks to understand and prevent substance use: a transdisciplinary perspective. *Substance Use & Misuse*, *39*(10-12), 1685–1712.

Valente, T. W., Unger, J. B., & Johnson, A. C. (2005). Do popular students smoke? The association between popularity and smoking among middle school students. *Journal of Adolescent Health*, *37*, 323–329.

Valente, T. W., & Vlahov, D. (2001). Selective risk taking among needle exchange participants: Implications for supplemental interventions. *American Journal of Public Health*, *91*(3), 406–411.

van den Berg, P., Thompson, K. J., Obremski-Brandon, K., & Cooverty, M. (2002). The tripartite influence model of body image and eating disturbance: A covariance structure modeling investigation testing the mediational role of appearance comparison. *Journal of Psychosomatic Research, 53*, 1007–1020.

van der Hulst, R. C. (2009). Introduction to social network analysis (SNA) as an investigative tool. *Trends of Organized Crime*, *12*, 101–121.

Vartanian, L. R., Smyth, J. M., Zawadzki, M. J., Heron, K. E., Sulamunn, R. M., & Coleman, B. A. (2014). Early adversity, personal resources, body dissatisfaction, and disordered eating. *Eating Disorders*, *47*(6), 620–629.

Wade, T. D., Keski-Rahkonen, A., & Hudson, J. L. (2011). Epidemiology of eating disorders. In M. Tsuang & M. Tohen (Eds.), *Textbook in Psychiatric Epidemiology* (3rd ed., pp. 343–360). New York. NY: Wiley.

Wagner, K. D., Iverson, E., Wong, C. F., Bloom, J. J., McNeely, M., Davidson, P. J., … Lankenau, S. E. (2013). Personal social network factors associated with overdose prevention training participation. *Substance Use & Misuse*, *48*, 21–30.

Walker, E. R., McGee, R. E., & Druss, B. G. (2015). Mortality in Mental Disorders and Global Disease Burden Implications: A Systematic Review and Meta-analysis. *JAMA Psychiatry*, *72*(4), 334. http://doi.org/10.1001/jamapsychiatry.2014.2502

Walsh, B. T. (2008). Recovery from Eating Disorders. *Australian and New Zealand Journal of Psychiatry*, *42*(2), 95–96. http://doi.org/10.1080/00048670701793402

Walter, K. (2013). *Mortality and eating disorders*. nationaleatingdisorders.org: UCSD Eating Disorders Research and Treatment Program.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications (structural analysis in the social sciences)*. Cambridge, UK: Cambridge University Press.

Wechsler, H., & Nelson, T. F. (2008). What We Have Learned From the Harvard School of Public Health College Alcohol Study: Focusing Attention on College Student Alcohol Consumption and the Environmental Conditions That Promote It. *Journal of Studies on Alcohol and Drugs*, *69*(4), 481–490. http://doi.org/10.15288/jsad.2008.69.481

Welch, N., McNaughton, S. A., Hunter, W., Hume, C., & Crawford, D. (2009). Is the perception of time pressure a barrier to healthy eating and physical activity among women? *Public Health Nutrition*, *12*(07), 888–895. http://doi.org/10.1017/S1368980008003066

Wey, T., Blumstein, D. T., Shen, W., & Jordan, F. (2008). Social network analysis of animal behaviour: A promising tool for the study of sociality. *Animal Behavior*, *75*, 333–344.

White, J., & Halliwell, E. (2010). Examination of a sociocultural model of excessive exercise among male and female adolescents. *Body Image*, *7*(3), 227–233.

Whitman, M. (2012). Community connections: Social capital and community success. *Sociology Forum*, *27*(2), 441–457.

Wicker, F. W., Payne, G. C., & Morgan, R. D. (1983). Participant descriptions of guilt and shame. *Motivation and Emotion*, *7*(1), 25–39. http://doi.org/10.1007/BF00992963

Wisotsky, W., Dancyger, I., Fornari, V., Katz, J., Wisotsky, W. L., & Swencionis, C. (2003). The relationship between eating pathology and perceived family functioning in eating disorder patients in a day treatment program. *Eating Disorders, 11*(2), 89–99. http://doi.org/10.1080/10640260390199280

Wister, A. V., & Avison, W. R. (1982). "Friendly persuasion": A social network analysis of sex differences in marijuana use. *International Journal of Addictions, 17*(3), 523–542.

Yates, A. (2013). *Compulsive Exercise And The Eating Disorders: Toward An Integrated Theory Of Activity*. Routledge.

Zmijewski, C. F., & Howard, M. O. (2003). Exercise dependence and attitudes toward eating among young adults. *Eating Behaviors*, *4*, 181–195.

APPENDIX A

Review Matrix of Studies Investigating the Influences on Disordered Exercise

Author & Date	Purpose/Questions	Sample	Country	Variable of Interest	Key Findings
Ackard, Brehm, & Steffen (2002)	Aims to investigate further the association between excessive exercise and eating disordered behaviors and characteristics that the overlooked multidimensionality of exercise measures might have obscured in past research; replicating analysis of excessive exercise done among high school students with college women	women (n=586), aged 17 to 55; students at a large Midwestern university; recruited from psychology, women's studies, and continuing education classes	USA	obligatory exercise	"Frequency of exercise "per se" is not the only thing related to pathological eating and other psychosocial maladjustments, but rather the negative emotionality associated with the exercise. Eating disorders and exercise have been mistakenly linked with excessive exercise when it is solely defined by number of hours of daily exercise or by engagement in types of exercise. Rationale and meaning of the exercise is important. Clustering participants based on subscale scores turned out to be critical."

Bewell-Weiss & Carter (2010)	the aim of the present study was to replicate and amalgamate findings from previous research into a comprehensive regression model predicting excessive exercise in individuals with anorexia	n=153 consecutive first-admission patients with AN admitted to the Toronto General Hospital Inpatient Eating Disorders Program	Canada	excessive exercise	the final model included five variables that emerged as independent predictors of exercise status after shared variance was accounted for; individuals with AN who exercise excessively reported higher levels of dietary restraint, depression, and self-esteem; reported lower levels of obsessive-compulsive symptomology; and were more likely to be of the restricting subtype; all predictors included had been shown the be significant in previous studies; this study included bingeing in the definition of subtype - this could be problematic because some studies show that JUST purging is associated with excessive exercise, not bingeing;
Bratland-Sanda, Martinsen, Rosevinge, Ro, Hoffart, & Sundgot-Borgen (2011)	To examine associations among exercise dependence score, amount of physical activity and eating disorder symptoms in patients with longstanding ED and non-clinical controls; research question 1: are there differences in exercise dependence score between the patients and the controls, 2. are there associations between exercise dependence score, amount of physical activity, and ED symptoms in the patients and the controls, 3. which variables may explain variance in exercise dependence score	female inpatients from the Department of Eating Disorders at Modem Bad Psychiatric Centre (n=59), and age-matched women (controls) randomly selected from a pooled sample of representatives for the Norwegian female population aged 18-55 years (n=53)	Norway	exercise dependence	Results indicated higher exercise dependence scores in patients than controls. Vigorous physical activity and exercise for regulation of negative affect were the main explanatory variables for exercise dependence scores in both groups. Eating disorder symptoms were positively associated with weekly amounts of vigorous physical activity in patients, whereas these factors were negatively associated in controls. Exercise for weight and appearance related concerns were excluded as an explanatory variable for exercise dependence."

Chalk, Miller, Roach, & Schultheis (2011)	examine predictors of obligatory exercise in college undergraduates	college undergraduates (n=172)	USA	obligatory exercise	"Results suggest that women who internalize the thin ideals of the Western media are more likely to experience over commitment to exercise and exercise-related negative effect, both of which have been correlated with psychological maladjustment and increased risk factors for disordered eating in college students. Male students that feel pressure from dating partners to be toned are more likely to feel overly committed to exercise. Results suggest that perceived pressure from others, rather than internalization of cultural attitudes, is a more critical target for screening and intervention with men."
Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan (2013)	The purpose of the study was to explore the prevalence, and the role of mood, exercise frequency, age, and gender differences on exercise dependence	regular exercisers (n=409)	Italy	exercise dependence	"Age, mood, exercise frequency, and gender predicted exercise dependence. The two youngest groups reported higher exercise dependence scores than the oldest groups, and women reported lower exercise dependence scores than men. 4.4% of the sample was labeled at-risk."
Dalle Grave, Calugi, & Marchesini (2008)	the study was aimed at assessing the prevalence of compulsive exercising to control shape and weight in eating disorders (Eds) and its relationship with treatment outcome	n=165 consecutive ED inpatients	Italy	compulsive exercise	"Compulsive exercise is more common in RAN (anorexia with restrictive eating, no purging, and no bingeing) than any other eating disorder subtype and is associated with the eating disorder restraint score."

Elbourne & Chen (2007)	The aim of this study was to carry out a preliminary study of the proposed continuum model of obligatory exercise, which states that obligatory exercise lies on a continuum	female triathletes (n=61)	Australia	obligatory exercise	"The model provides a framework for examining the relationship between obligatory exercise and eating disorders. A relationship was found between eating disorder behavior and obligatory exercise, but the SEM does not suggest a direct causal relationship between these two variables. The correlation between obligatory exercise and eating disorder inventory scores is a consequence of shared common causes, like weight and shape preoccupation. Preoccupation with weight and shape was found to be a predictor of obligatory exercise, while overall energy expenditure (duration of exercise) was not found to be a predictor of obligatory exercise."
Gapin, Etnier, & Tucker (2009)	This study explores the hypothesized relationship between exercise addiction and the level of baseline frontal activity asymmetry, as measured by EEG	regularly active women (n=28)	USA	exercise addiction	The hypothesis was that greater right frontal activity would be associated with exercise addiction, but the study revealed that greater left frontal activity was associated with exercise addiction, revealing that addicts might use exercise as a coping mechanism and therefore produce positive affect. This study showed that exercise frequency and intensity was a predictor of exercise addiction. Perceived intensity of exercise was a stronger predictor than volume of exercise."

Gonzalez-Cutre & Sicilia (2013)	use self-determination theory to analyze the relationships of several motivational variables with exercise dependence	n=531 Spanish exercisers	Spain	exercise dependence	"Results revealed that an ego-involving climate (a climate in which comparison between exercisers positively predicted exercise dependence) was both directly affected by and mediated by introjected regulation (the person is motivated by thedesire to avoid feelings of guilt, shame, and anxiety and needs to exercise for self-approval and to improve self-esteem) and external regulation (the individual exercises to obtain some external incentive). Perceived competence (developing ability or physical condition) positively predicted exercise dependence both directly and mediated through integrated exercise (exercise is integrated into the individual's lifestyle)."

Goodwin, Haycraft, & Meyer (2011b)	the study aims to identify whether sociocultural factors are related to compulsive exercise in an adolescent sample, after controlling for disordered eating attitudes; hypothesis: sociocultural factors will be significantly and positively associated with compulsive exercise; also aimed to identify which is the best cross-sectional predictor of compulsive exercise	adolescents (n=828)	UK	compulsive exercise	"Results suggest that compulsive exercise is aligned more with a drive to be thin than with bulimic attitudes. Messages that adolescents receive from different sociocultural sources are associated with their compulsive exercise. For boys, it appears that messages from significant others to become more muscular could lead to a greater compulsivity toward exercise. Boys perceiving general media messages about having a thinner body and losing weight, as well as reporting their own drive to be thinner, could be at an increased risk of compulsive exercise cognitions. Girls reported that a pressure to be thin from the media, as well as their own drive for thinness, contributed to a compulsivity toward exercise."

Goodwin, Haycraft, & Meyer (2012)	The current study aims to determine whether compulsive exercise is linked with emotion regulation strategies among a community sample of adolescents; hypothesis: CE will be significantly associated with emotion regulation strategies and that CE will be most closely associated with the dysfunctional emotion regulation strategies	adolescents (n=1630)	UK	compulsive exercise	"Compulsive exercise could be used as a way of managing emotions. External functional emotion regulation was the largest unique predictor of compulsive exercise for boys, and internal functional emotion was the strongest predictor for girls. There was a link between compulsive exercise and internal dysfunctional emotion regulation in girls and boys, suggesting that those with compulsive exercise attitudes could be trying to deal with their emotions on their own and in a dysfunctional manner. This study demonstrated a link between drive for thinness and compulsive exercise."
Goodwin, Haycraft, & Meyer (2014)	study aims to identify whether these is a specific longitudinal association between emotion regulation styles and compulsive exercise	n=572 adolescents	UK	compulsive exercise	"Results demonstrated that emotion regulation styles did longitudinally predict compulsive exercise in boys and girls, even after controlling for initial levels of CET. Specifically, the internal dysfunctional emotion regulation style was the only significant unique predictor of compulsive exercise (management of emotion using behaviors such as self-harm and is conducted without support)."

Goodwin, Haycraft, & Meyer (2014b)	This study aimed to replicate previous cross-sectional work by considering psychological characteristics as longitudinal predictors of compulsive exercise	adolescents (n=369)	UK	compulsive exercise	"Results for boys demonstrated that obsessive-compulsiveness and self-perfectionism predicted compulsive exercise, even after controlling for baseline levels of compulsive exercise, suggesting these variables lead to increased compulsive exercise over a two-year period. Anxiety was also a significant predictor but in the opposite direction to hypothesis, with lower anxiety predicting more compulsive exercise. Psychological predictors did not predict compulsive exercise among girls. Only baseline compulsive exercise and schools were predictors indicating there could be an environment-specific variables and that compulsive exercise might be stable for this age group."
Goodwin, Haycraft, & Meyer (2014c)	This study aims to explore longitudinal sociocultural risk factors for compulsive exercise, using a 12-month prospective design	adolescents (n=332)	UK	compulsive exercise	"Results among boys were in accordance with cross sectional findings, as messages to become more muscular from parents and peers significantly predicted compulsive exercise. Results for girls identified perceived pressures from the media to be thin as a significant predictor of compulsive exercise."

Goodwin, Haycraft, Willis, & Meyer (2011)	This study aimed to provide a first step in identifying potential cross-sectional predictors of compulsive exercise	n=1488 adolescents	UK	compulsive exercise	"Results indicate that for girls and boys a drive for thinness was the best predictor of compulsive exercise, along with self-perfectionism, and then obsessive-compulsiveness. Social perfectionism was a predictor for boys only, although it did not explain as much variance as the other predictors."
Grandi, Clementi, Guidi, Benassi, & Tossani (2011)	the aim of this study was to assess personality characteristics and psychological distress associated with primary exercise dependence in a mixed gender sample	adult habitual physical exercisers (n=79)	Italy	exercise dependence	"Females showed greater involvement in exercise for weight control than males and were more likely to present with disordered eating patterns compared to males. Primary exercise dependence differed in personality in both temperament and character dimensions."

Gulker, Laskis, & Kuba (2001)	To address the relationship between excessive exercise, obsessive compulsive symptomology, and eating disordered behavior	n=172 exercisers from Central California	USA	excessive exercise	"The results of this study found that excessive exercisers scored significantly higher on obsessive compulsiveness and on subscales drive for thinness, perfectionism, and body dissatisfaction than non-excessive exercisers."
Hall, Kerr, Kozub, & Finnie (2007)	The purpose of the present investigation was to determine the relationship between athletes' goal orientations, elements of perfectionism, perceived ability, and obligatory exercise	British middle-distance runners (n=246)	UK	obligatory exercise	"Although the MANOVA found no gender differences in obligatory exercise scores, exploratory regression analyses revealed different models for males and females. Ego and task goals, the pursuit of high personal standards, and concern about mistakes explained 27% of variance in obligatory exercise for males. Concern about mistakes, perceived ability, and the pursuit of high personal standards that combined to predict 49% of female variance in obligatory exercise behavior. Perfectionistic striving appears to be the critical motivational antecedent of obligatory exercise in females. In addition to fear of failure, there is a salient appetitive source of motivation underpinning obligatory exercise in men, characterized by over striving (intense desire to succeed and avoid failure)."

Hausenblas & Downs (2002)	The purposes of this study were to examine sex differences and the predictive ability of exercise imagery for exercise dependence symptoms	university students enrolled in sport and fitness classes (n=408)	USA	exercise dependence	"Males reported more exercise dependence than females. The only subscale that did not have gender differences was withdrawal effects. Energy imagery predicted exercise dependence for men and women, while appearance imagery was only a predictor for females. No differences were evidenced for technique and appearance imagery."
Homan (2010)	to explore the relationship between athletic-ideal internalization and three outcome variables that have been linked to disordered eating and attitudes: body dissatisfaction, dieting, and compulsive exercise	n=231 women from a liberal arts college	USA	compulsive exercise	Initial athletic-deal internalization predicted subsequent increases in CET, but not body dissatisfaction or dieting. Initial thin-ideal internalization predicted body dissatisfaction, dieting, and compulsive exercise
Karr, Zunker, Thompson, Sherman, Erickson, Cao, Crosby, & Mitchell	the purpose of the current study was to further examine the association between exercise identity and obligatory exercise within a large sample of individuals who participated in an athletic event; hypothesis: exercise identity, internalization of the thin-ideal body shape, and internalization of the athletic-ideal body shape would be positively related to obligatory exercise among all participants	participants in a running event (n=2,421 full marathon, half marathon, and shorter distance runners)	USA	obligatory exercise	"After controlling for the effects of BMI, age, and distance group, the three-way interaction of exercise identity, gender, and internalization of the athletic ideal body shape predicted obligatory exercise. The exercise identity-obligatory exercise relationship was stronger for women who reported high internalization of an athletic physique, which is different than typical thin-ideal."

Lu, Hsu, Wang, Huang, Chang, & Wang (2012)	The purpose of this study was to examine the associations of exercise identity, exercise commitment, exercise dependence, and the mediating effects of exercise commitment on the relationship between identity and dependence; first goal: examine the associations of exercise identity, exercise dependence, and the two types of commitment; the second: examine whether exercise commitment mediates the relationship between identity and dependence	Taiwanese regular exercisers (n=253)	Taiwan	exercise dependence	"SEM results indicated that the relationship between exercise identity and exercise dependence was partially mediated by "have to" commitment, implying maladaptive commitment is associated with dependence. People with high exercise identity and high "have to" commitment have a tendency toward exercise dependency. The mediating effect only existed in a vigorous exercise condition."
Mathers & Walker (2010)	examine whether exercise addicts are more extraverted than those who engage in frequent exercise and those who do not exercise; hypothesis: commitment and addiction to PA are associated with higher levels of extraversion	students from University of Sydney (n=24)	Australia	exercise addiction	"The claim that people who are addicted to activity are more extraverted than those who are not so addicted received little support. There was not a relationship between psychological dependence on exercise and extraversion, but rather the desire to exercise regularly and extraversion."

McLaren & Best (2007)	The purpose of this study was to examine the relationship between weekly exercise habits and scores on the Exercise Dependence Questionnaire	undergraduate students (n=292)	Canada	exercise dependence	"The High Activity Group scored higher than the Low Activity group on Interference with Social, Family, or Work Life, Positive Reward, Withdrawal Symptoms, Exercise for Social Reasons, Exercise for Health Reasons, and Stereotyped Behavior. The High Activity Group had higher Exercise Dependence Total Scores, but did not differ on Exercise for Weight Control Subscales (both groups exercised for weight control). Men scored higher on Interference subscale than women. Women scored higher on the Exercise for Weight Control subscale than men."
Modolo, Antunes, Borba de Gimenez, Santiago, Tufik, & Tulio de Mello (2011)	The objective of the present study was to assess if there are differences in the answers to the "Negative Addiction Scale" questionnaire between male and female athletes and if those differences could affect the sleep and mood of that population	amateur athletes (n=300)	Brazil	exercise addiction	"Similar percentages of men and women may suffer negative addiction symptoms. Negative addiction symptoms can lead to lower quality of life and can cause changes in general mood and changes in sleep patterns. Motivation to exercise seems to have different origins in each gender because women have a great motivation to be thin and may add excessive exercise to diets and other strategies to achieve weight loss."

Murray, McKenzie, Newman, & Brown (2013)	The aim of this study was to explore the relationship between exercise identity and exercise dependence. Hypothesis: stronger exercise identities would be associated with greater odds of experiencing exercise dependence symptoms	adults recruited from websites for sports clubs and sport and exercise networking sites; n=101	UK	exercise dependence	“The hypothesis was partially met because only one of the two factors from the exercise identity scale was associated with dependence."
Nuzzo, Schindler, & Ryan (2013)	The purpose of this study was to compare exercise dependence symptoms between ES (exercise science) and non-ES students in the US; hypothesis: ES students in the US would exhibit more symptoms of exercise dependence than non-ES students	undergraduate students (n=396; n=132 ES students, n=264 non-ES students)	USA	exercise dependence	"Exercise science students did exhibit more symptoms of exercise symptoms than non-exercise science students, but are less likely to be classified as at-risk."

Paradis, Cooke, Martin, & Hall (2013)	To examine the relationship between passion for exercise and exercise dependence symptoms	kinesiology students (n=480)	Canada	exercise dependence	"The hypothesis stated that harmonious passions would be negatively associated with EDS, and obsessive passions would be positively associated. The hypothesis was not supported because two positive relationships were found between harmonious passion and time and tolerance. Obsessive passions met the hypothesis that it would be positively associated with exercise dependence. Those that participate in physical activity because of harmonious passion are likely to want to spend more time and to improve (tolerance) their craft, they also are not likely to engage in physical activity to reduce negative withdrawal symptoms, do not continue when injured, do not feel lack of control as to when to stop, do not exercise more than intended, and do not forgo other activities in their life to exercise. Obsessive passion exercisers increase their time exercising but also decrease their time doing other things. Those who are obsessively passionate are likely to experience various exercise dependence symptoms and side effects."

Penas-Lledo, Vaz Leal, & Waller (2001)	examined the presence of excessive exercise in different women with eating disorders, and its psychopathological differences	n=124 female outpatients	Spain	excessive exercise	"Across both groups, excessive exercise was associated with higher weight for height (BMI) and greater levels of depression. Excessive exercise was associated with more unhealthy general and bulimic eating attitudes, and with higher levels of somatization and anxiety, but only among the anorexic patients."
Phelan, Bond, Lang, Jordan, & Wing (2011)	To compare physical activity and exercise dependence in weight loss maintainers and normal weight control	weight loss maintainers (n=267) and normal weight controls (n=213)	USA	exercise dependence	"Weight loss maintainers scored higher on exercise dependence than normal weight exercisers. The exercise dependence variable that best discriminated weight-loss maintainers from normal weight controls was their motivation to exercise for weight control. Level of physical activity was more strongly related to exercise dependence than weight loss maintenance status."
Pritchard & Beaver (2012)	To expand on previous research in factors that may be predictive of obligatory exercise, specifically in the relation between obligatory exercise and reasons for exercising	n=306 students from general psych classes		obligatory exercise	"Results found no gender differences in obligatory exercise, but there were gender differences in reasons for exercise and in the magnitude of the relation between reasons for exercise and obligatory exercise. Women were more likely to exercise for weight control, to improve mood, and to tone their bodies than men. Exercising for weight control was not a predictor in women, but exercising for tone was."

Rodgers, Hall, Blanchard, & Munroe (2001)	the purpose of this study was to examine exercise imagery as a means of inferring the ideation around obligatory exercise; hypothesis: if obligatory exercise is associated with maladaptive thought similar to that associated with eating disorders, it would be predicted by appearance motives, which would be reflected by appearance-related imagery	adult exercisers (n=243)	Canada	obligatory exercise	"The hypothesis that obligatory exercise is associated with a strong appearance motive was not supported. Although participants reported using appearance imagery more than the two other imagery types, it did not predict obligatory exercise. Imagery accounted for about 20% of the variance in obligatory exercise, with energy and technique energy displaying statistically significant and meaningful predictive relationship in men and women. Results suggest motives for obligatory exercise and eating disorders might be different."
Slay, Hayaki, Napolitano, & Brownell (1996)	The purpose of this study was to compare the motivations for running and the level of eating concerns in male and female obligatory and nonobligatory runners; hypothesis: obligatory runners are more motivated by negative factors such as feelings of guilt for not continuing, while nonobligatory runners are more motivated by positive factors such as well-being and physical health	runners registered for the New Year's Resolution Run (n=347)	USA	obligatory runners	"Obligatory runners scored higher on negative subscales of the motivation measure (addiction and escape) regardless of sex. Obligatory runners scored higher on positive motivation factors (challenge, health, social, and well-being), and women scored higher on these dimensions than men. This study provides evidence of eating disturbance among obligatory runners, with female obligatory runners at higher risk."

Szabo, La Vega, Ruiz-Barquin, & Rivera (2013)	Investigate moderators contributing to the variability in susceptibility to exercise addiction; explore gender differences in EA; explore the risk of EA in a social context, in terms of individual or group exercisers	Spanish sport science (n=57) and non-sport orientation (n=90) university athletes and a group of elite ultra-marathon runners (n=95); a total of n=242 athletes	Spain	exercise addiction	"Proneness to exercise addiction varies among athletes. There were higher exercise addiction scores in the runners group regardless of time spent training. Athletes on team sports scored higher on exercise addiction than individual sports athletes."
Taranis & Meyer (2010)	the aim of the present study was to determine the relationship of the high personal standards and self-criticism dimensions of perfectionism with compulsive exercise	female exercisers from a UK University (n=97)	UK	compulsive exercise	"Compulsive exercise was found to be associated with the high personal standards dimension of perfectionism. Self-criticism was associated with avoidance and rule-driven behavior, weight and shape exercise, and exercise rigidity suggesting that the self-critical component of perfectionism may be a more significant factor in compulsive exercise. The association between perfectionism and compulsive exercise may be largely accounted for by the self-critical dimension."

White & Halliwell (2010)	examine a mediational model with a latent variable for perceived sociocultural pressure (comprising of pressure to lose weight, pressure to build muscle, and modeling of behavior change techniques) showing a direct relationship with observed variables for focus on exercise and a compulsive need for exercise and a mediated relationship through an observed variable measure of appearance investment and a latent variable for body image disturbance	n=421 boys and girls	UK	excessive exercise	"The relationship between sociocultural pressures and need for exercise was fully mediated by appearance investment and body image suggesting the sociocultural model can be extended to incorporate excessive exercise. There was no support for an association between sociocultural pressures, or body image disturbance, on focus on exercise. The model accounted for a greater proportion of variance in boys' compulsive need to exercise than girls. Body image disturbance was a stronger mediator of sociocultural pressure in girls."

Zmijewski & Howard (2003)	Extend findings from Ogden et al. (1997) to a sample of undergraduate college students; assess problematic involvement with exercise to establish the existence of primary and secondary exercise-dependence subtypes; examine the prevalence of exercise-dependence symptoms to atypical and disordered attitudes toward eating	college undergraduates (n=237)	USA	exercise dependence	"Symptoms of exercise dependence were common and women were found to have significantly higher scores on the Exercise for Weight Control and Exercise for Health Reasons subscales of the Exercise Dependence Questionnaire than men. High correlations between these subscales and food preoccupation suggest college women may be exercising in association with a formal subclinical eating disorder. This study found a high correlation between exercise dependence and food preoccupation/bulimia and a substantially higher prevalence of exercise dependence withdrawal symptoms among college women than men. There were clear positive relationships between measures of disordered eating attitudes and exercise dependence measures."

APPENDIX B

Review Matrix of studies using SNA to investigate the health of college-aged adults

Author and Date	Research Question	Type of Network	Sample	Network Characteristics Measured	Key Findings
Wister & Avison, 1982	To test social network impact on marijuana use among college students	Ego network	n=332 students enrolled in sociology classes in Canada	degree, density, composition	"Results indicate that normative expectations (tested through the creation of four normative congruence scores) of one's friends are important influences on the individual. Chi square tests showed men were more likely to use marijuana, and a differences of means test revealed men use more frequently. People's networks mirror their behavior choices."
Fondacaro & Heller, 1983	Investigation focused on social support and social competence among male college freshmen and the relation of these variables to alcohol use and psychological adjustment	Ego network	n=137 male college freshmen	network size, density, amount of social contact	"Alcohol use was positively related to social network characteristics that reflect high levels of social interaction (density, social contact) and measures of social competence. Psychological symptomology was negatively related to measures of perceived support, social competence, and network density. Social context provides frequent opportunities for alcohol use and abuse in a college community."

Dorsey, Scherer, & Real, 1999	Examined to whom students are talking, with whom they are affiliated, and how frequently they are discussing potential effects of risky behaviors on the excessive use of alcohol	Ego network	n=239 undergraduate students	composition; frequency of communication with connections; cohesion	"Membership in Greek organizations on campus, the range of one's network, and the frequency of talking about drinking and potential consequences were all significantly related to drinking in excess."
Duncan, Boisjoly, Kremer, Levy, & Eccles, 2005	Test for analogous peer effects in the drug use and sexual behavior of male and female college students using data on the characteristics of first-year roommates to whom they are randomly assigned	Ego network	n=279 males and n=435 females first year students	homophily	"Males who report binge drinking in high school drink much more in college if assigned to a roommate who also binge drank in high school than if assigned to a non-binge-drinking roommate. Students who did not engage in these behaviors in high school do not appear to be affected by their roommates' high school behaviors."
Reifman, Watson, & McCourt, 2006	Investigating students' social networks by testing social influence and selection	Ego network	n=119 freshmen	composition; key network members	"A greater presence of drinking buddies in personal networks was predictive or one's own later drinking. Those the respondent felt closest to or spent the most time with did not improve prediction of drinking behavior. Having a high percentage of Greek members in one's network, having a low percentage of family in one's network, and associating with people one had known for a long time predicted heavier drinking behaviors."

Phua, 2011	The aim of the study was to examine whether popularity within the fraternity network had a causal influence on smoking and drinking, and whether conformity to peer norms mediated this relationship.	whole network	Greek fraternity, n=34; 76.5% Caucasian, half of the network smokers; all members drank alcohol; 100% participation rate	Clustering; centrality	"Results indicated that popularity significantly predicted both smoking and drinking behaviors. Strong homophily existed for smoking, but not for the number of drinks consumed per day. Smoking and drinking were significantly correlated, and diffusion of both behaviors occurred in the network over a period of time. Conforming to peer norms also mediated the effect of popularity on smoking and drinking within the peer social network. Popular members both smoked and drank more, but this occurred due to their greater likelihood of conforming to their peer group's smoking and drinking norms."
Hendrickson, Rosen, & Aune, 2011	Looks to explore the overall composition of international students' personal networks but also the varying strengths of friendships	Ego network	n=84 international students from University of Hawaii	network composition; tie strength	ANOVA, correlations; intl students did not report having a high ration of individuals from their home country in their networks; intl students with a higher ration of individuals from host country in their network claimed to be more satisfied, content, and less homesick; participants who reported more friendship variability with host country individuals described themselves as more satisfied, content, and more socially connected."

Korneinko, Clemans, Out, & Granger, 2013	Explore how position and relationships within a friendship network structure are related to individual differences in salivary cortisol levels; examine whether degree and density-related indices of an individual's position within a network are uniquely associated with differences in HPA axis activity	whole network	students enrolled in an accelerated cohort at Johns Hopkins (n=130); 56% of cohort participated	density, degree	"Results revealed that (1) individuals with lower gregariousness status (i.e., lowest number of outgoing ties) had higher cortisol levels, and (2) individuals with higher popularity status (i.e., higher numbers of incoming ties) had higher cortisol levels. Popularity and gregariousness-based network status is significantly associated with hypothalamic–pituitary– adrenal axis activity."
Swartout, 2013	To test model of sexual aggression with the addition of attitudinal and structural variables of participants' peer groups	ego network	n=341 college-aged men	Density; perceived peer attitudes;	"Perceived peer rape-supportive attitudes significantly influence individual members' hostile attitudes toward women. Peer network density negatively predicted hostile attitudes. Individuals with tightly knit peer groups tend to have less hostile attitudes toward women. Interaction between peer group density and perceived peer-rape supportive attitudes in predicting individuals' hostile attitudes toward women while individuals in high density, low hostility peer groups had the lowest average levels of hostility toward women."

Dumas, Wells, Flynn, Lange, & Graham, 2014	To understand if within-group status affects drinking behaviors among college-aged adults	ego network	n=104 same sex adult drinking groups	Within-group status; likeability; network structure	"Higher-status members engaged in the most alcohol consumption but in heavier drinking groups only. Higher-status members also encouraged the most alcohol consumed by others, regardless of levels of group drinking. Though being liked by one's peers was positively related to intoxication that night, it did not account for the relationship between within-group status and drinking."
Holloway, Rice, & Kipke, 2014	To understand the extent to which young men who have sex with men social spaces are connected by the YMSM who share those social contexts in order to inform the delivery of venue-based HIV prevention programs and services for this population	whole network (created venueXvenue matrix)	n=484 men; 110 venues included in final analysis (network of venues, not people)	popularity; connectivity; core-periphery; degree	"Degree of person sharing between venues was used to demonstrate interconnectivity between venues classified as low-risk (coffee shops) and high risk (bars and clubs). 65% of venues nominated were bars and clubs. Nearly all men were connected by a single venue and over 87% connected by the six most central venue. A handful of highly connected low-risk venues was central to the venue network and connected to popular high-risk venues."

Dumas, Graham, Bernards, & Wells, 2014	To examine associations between young adults' drinking patterns and social status within their natural drinking groups and assesse gender differences in these relationships	ego network	n=293 men and women	status; likeability	"Men who engaged in more frequent heavy drinking and women who drank more frequently were nominated as occupying higher-status positions within their natural drinking groups compared to their peers who drank less. Drinking more than one's peers during one's heaviest drinking occasion in the past year was associated with higher within-NDG status for men and women. Higher social status is associated with riskier drinking patterns and have important implications for prevention programming,"
Lorant & Nicaise, 2014	To investigate whether university students' social positions within their networks are related to their drinking behavior	whole network	n=253 psychology students (60%) and 234 engineering (66%)	ego centrality, cross-gender relationships; social capital; indegree centrality, closeness	"Ego drinking is positively and moderately related to alter drinking behavior. Moran's I was higher for friendship than for dorm-sharing, leisure, or working relationships. Moran I was greater among students in Engineering than in Psychology for dorm sharing, while the reverse was true for leisure relationships. Centrality was associated with increased binge drinking frequency (for each in-degree, binge drinking frequency increased by 26%). Having a higher effect size decreased risk of binge drinking. Cross-gender relationships were protective from binge drinking."

Lamkin, Campbell, vanDellen, & Miller, 2015	To examine the characteristics of individuals who date grandiosely or vulnerably narcissistic individuals	ego network	n=104 undergraduate couples	homophily; duration of relationship	"Actor-Partner Interdependence Models (APIM) indicated that negative relationship adjustment was found when both partners had higher entitlement traits and had been together for a longer period of time. There was some evidence of homophily related to grandiose narcissism in relationships."
Dumas, Graham, Maxwell-Smith, & Wells, 2014	To assess the relationship between within-group status and aggression	ego network	n=116 first year university male students that are bar-goers	Within-group status	"The higher participants'' within-group-peer status, the more likely they were to report that they would respond to provocation at a bar with physical aggression."

APPENDIX C

Survey Instrument

Your Name: _____

Thank you so much for participating in this study! Your participation will help me investigate how the relationships in our lives interact with our health, specifically concerning exercise and body image. There are three parts to this survey. Please answer every question in all three parts, and answer as honestly as possible. **All of the information you provide will remain confidential.** Once data is entered, any identifying information (e.g., the roster) will be destroyed, leaving only numbers linking to data.

Part 1: Attribute Data. In this section, please answer each question about yourself.

1. What is your date of birth? Please fill in the blanks provided. MM _____ DD _____ YYYY _____

2. What is your classification? Please select one.
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
   e. Graduate Student
   f. Seminary Student
   g. Law Student

3. How would you describe your race/ethnicity? Please select one.
   a. White Non-Hispanic
   b. Black Non-Hispanic
   c. Hispanic or Latino
   d. Asian or Pacific Islander
   e. Native American or Alaskan Native or Native Hawaiian
   f. Biracial or Multiracial
   g. Other, please specify _____
   h. I would prefer not to answer.

4. Do you hold a leadership position within your sorority?
   a. No
   b. Yes. If so, which one? _____

5. When you are not in school, where is home? Please write the name of the state or country: _____

6. To the best of your knowledge, what is your height and weight?
   a. height: _____ ft. _____ in.
   b. weight: _____ lbs.
   c. I would prefer not to answer.

During a typical **7-Day period** (a week), how many times on average do you do the following kinds of exercise for **more than 15 minutes** during your free time (write on each line the appropriate **number**)? If you do not participate in any or all of the following categories, please write in a 0.

a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY) _____ times per week
(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling, spin cycling, boot camp, etc.)

b) MODERATE EXERCISE (NOT EXHAUSTING) _____ times per week
(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, dancing)

c) MILD EXERCISE (MINIMAL EFFORT) _____ times per week
(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, easy walking, house cleaning)

During a typical **7-Day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heart beats rapidly)? Please select one of the following:

a. Often b. Sometimes c. Rarely

Listed in the table below are a series of statements regarding exercise. Please read each statement carefully and circle the number that best indicates how true each statement is of you. Please answer all the questions as honestly as you can.

Never True 0	**Rarely True 1**	**Sometimes True 2**	**Often True 3**	**Usually True 4**	**Always True 5**
I feel happier and/or more positive after I exercise.	0	1	2	3	4	5
I exercise to improve my appearance.	0	1	2	3	4	5
I like my days to be organized and structured, of which, exercise is just one part.	0	1	2	3	4	5
I feel less anxious after I exercise.	0	1	2	3	4	5
I find exercise a chore.	0	1	2	3	4	5
If I feel I have eaten too much, I will do more exercise.	0	1	2	3	4	5
My weekly pattern of exercise is repetitive.	0	1	2	3	4	5
I do not exercise to be slim.	0	1	2	3	4	5
If I cannot exercise, I feel low or depressed.	0	1	2	3	4	5
I feel extremely guilty if I miss an exercise session.	0	1	2	3	4	5
I usually continue to exercise despite injury, unless I am very ill or too injured.	0	1	2	3	4	5
I enjoy exercising.	0	1	2	3	4	5
I exercise to burn calories and lose weight.	0	1	2	3	4	5
I feel less stressed and/or tense after I exercise.	0	1	2	3	4	5
If I miss an exercise session, I will try and make up for it when I next exercise.	0	1	2	3	4	5
If I cannot exercise, I feel agitated and/or irritable.	0	1	2	3	4	5
Exercise improves my mood.	0	1	2	3	4	5
If I cannot exercise, I worry that I will gain weight.	0	1	2	3	4	5
I follow a set routine for my exercise sessions (e.g., walk or run the same route, particular exercises, same amount of time, and so on).	0	1	2	3	4	5
If I cannot exercise, I feel angry and/or frustrated.	0	1	2	3	4	5
I do not enjoy exercising.	0	1	2	3	4	5
I feel like I've let myself down if I miss an exercise session.	0	1	2	3	4	5
If I cannot exercise, I feel anxious.	0	1	2	3	4	5

I feel less depressed or low after I exercise.	0	1	2	3	4	5

Below are questions regarding your body-satisfaction. Please answer as truthfully as possible.

Over the past **FOUR WEEKS**:	**Never 1**	**Rarely 2**	**Sometimes 3**	**Often 4**	**Very Often 5**	**Always 6**
Has feeling bored made you worry about your shape?	1	2	3	4	5	6
Have you thought that certain parts of your body (i.e., thighs, arms, etc.) are too large for the rest of you?	1	2	3	4	5	6
Have you worried about your flesh not being firm enough?	1	2	3	4	5	6
Have you felt so bad about your shape that you have cried?	1	2	3	4	5	6
Have you avoided running because your flesh might wobble?	1	2	3	4	5	6
Has being with thin women made you feel self-conscious about your shape?	1	2	3	4	5	6
Have you worried about your thighs spreading out when sitting down?	1	2	3	4	5	6
Has even a small amount of food made you feel fat?	1	2	3	4	5	6
Have you avoided wearing clothes which make you particularly aware of the shape of your body?	1	2	3	4	5	6
Has eating sweets, cakes, or other high calorie food made you feel fat?	1	2	3	4	5	6
Have you felt ashamed of your body?	1	2	3	4	5	6
Has worry about your shape made you diet?	1	2	3	4	5	6
Have you felt happiest about your shape when your stomach has been empty (e.g., in the morning)?	1	2	3	4	5	6
Have you felt that it is not fair that other women are thinner than you?	1	2	3	4	5	6
Have you worried about your flesh being dimply?	1	2	3	4	5	6
Has worry about your shape made you feel you ought to exercise?	1	2	3	4	5	6

Part 2. Egocentric Data. In this section, you will fill out two tables. In the first, please provide the **five people you correspond with most in your life** (five people you communicate with most often, in some

way). This can be anyone – relatives, friends, sorority sisters, etc. Put the initials of each of your five persons in the top row of table provided below. Then, answer the questions in the table for each person you identified. ***This question is not asking you who you feel closest to, but who you communicate with most often.**

Please provide the initials of five people you <u>communicate</u> with most often in your life.					
Initials	**Person 1** _____	**Person 2** _____	**Person 3** _____	**Person 4** _____	**Person 5** _____
How do you know _____? Circle all that apply.	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____
Is _____ male or female?	Male Female	Male Female	Male Female	Male Female	Male Female
How often do you communicate with ____? Circle one.	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year
How long have you known ____?	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos
How often does ____ exercise? Circle one.	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know
Does ___ make you feel good about how you look? Circle one.	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always

Does ___ make you feel guilty about your exercise habits? Circle one.	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always

In the second table, indicate the **five people you feel closest to in your life**. It is okay if some or all of the people in your first table are identified in your second table. Put the initials of each of the five people in the top row of the table, and then fill out the rest of the table for each person you identified.

Please provide the initials of five people you feel <u>closest</u> to in your life.					
Initials	**Person 1** _____	**Person 2** _____	**Person 3** _____	**Person 4** _____	**Person 5** _____
How do you know _____? Circle all that apply.	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____	-parent -sibling -family member -significant other -friend -roommate -neighbor -professional -sorority member -classmate -other _____
Is _____ male or female?	Male Female	Male Female	Male Female	Male Female	Male Female
How often do you communicate with ____? Circle one.	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year - less than once/year
How long have you known ____?	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos	___ yrs ___ mos
How often does ____ exercise? Circle one.	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know	-everyday -3-6x/week -1-2x/week -1-2x/month -1-2x/year -never -I don't know
Does ___ make you feel good about how you look? Circle one.	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always

Does ___ make you feel guilty about your exercise habits? Circle one.	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always	-Never -Rarely -Sometimes -Usually -Always

Part 3: Census Data. In this section, you are **only considering women currently in your sorority**.

Who are the five people you feel <u>closest</u> to in your sorority?					
	Person's First and Last Name	**From 1-4, how strong do you feel your relationship is with this person?**			
1		Very Strong 1	Strong 2	Average 3	Not Strong 4
2		Very Strong 1	Strong 2	Average 3	Not Strong 4
3		Very Strong 1	Strong 2	Average 3	Not Strong 4
4		Very Strong 1	Strong 2	Average 3	Not Strong 4
5		Very Strong 1	Strong 2	Average 3	Not Strong 4

Who are the five people you <u>spend the most time</u> with in your sorority?					
	Person's First and Last Name	**From 1-4, how often you are you with this person?**			
1		Daily 1	Every Other Day 2	Once/Twice per Week 3	Less than Once per Week 4
2		Daily 1	Every Other Day 2	Once/Twice per Week 3	Less than Once per Week 4
3		Daily 1	Every Other Day 2	Once/Twice per Week 3	Less than Once per Week 4
4		Daily 1	Every Other Day 2	Once/Twice per Week 3	Less than Once per Week 4
5		Daily 1	Every Other Day 2	Once/Twice per Week 3	Less than Once per Week 4

You have completed the survey! I truly appreciate your participation.

Please review and make sure you **answered all questions** and provided your **roster number** on the front page of this survey. Thank you!