DISSERTATION

A CONCURRENT AND PROSPECTIVE EXAMINATION OF THE INCONGRUOUS POSITIVE RELATIONSHIP BETWEEN ALCOHOL USE AND PHYSICAL ACTIVITY

Submitted by

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In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Summer 2012

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ABSTRACT

A CONCURRENT AND PROSPECTIVE EXAMINATION OF THE INCONGRUOUS POSITIVE RELATIONSHIP BETWEEN ALCOHOL USE AND PHYSICAL ACTIVITY

Research has demonstrated an incongruous positive relationship between alcohol consumption and physical activity concurrently among college students (Lisha & Sussman, 2010; Musselman & Rutledge, 2010). A goal of this research was to determine whether this relationship between alcohol use and physical activity exists, and whether different forms of physical activity share this relationship. Another purpose of this dissertation was to examine the potential moderating effects of several individual difference variables.

Results revealed a positive association between alcohol use and moderate physical activity, as well as with two other forms of physical activity (leisure and domestic). In the longitudinal analyses, several factors moderated the relationship between moderate physical activity and alcohol use, with the relationship being stronger for male participants and for individuals who possess high levels of social motives. Opposite of my original hypotheses, several forms of physical activity demonstrated significant negative effects on alcohol use, including overall physical activity, vigorous physical activity, sports, and exercise. Overall, the results suggest the relationship between physical activity and alcohol use in college students is dependent on the type of physical activity being studied (e.g., vigorous versus moderate, sport versus leisure). Age moderated the negative effects of vigorous physical activity on alcohol use, with the

effects being stronger for individuals older than 19 years. Implications for the prevention of alcohol use and abuse, improvement of physical activity behaviors, and studies of college physical activity interventions and alcohol use are discussed.

ACKNOWLEDGMENTS

My deepest gratitude is to Dr. Jennifer Harman, my advisor. I want to extend a special thank you for all the work she put into this manuscript and for the support, encouragement, and excellent advice she gave me throughout my doctoral program. I greatly appreciate all your advice, wisdom, and knowledge over the years.

I would also like to thank my committee members, Dr. Patricia Aloise-Young, Dr. Bryan Dik, and Dr. Andy Merolla, for the advice and knowledge you have provided me. I feel extremely fortunate to have such a wonderful committee, and I genuinely appreciate the assistance, vision, and expertise each of you provided.

Most importantly, none of this would have been possible without my family's love, concern, and support. I would like to express my heartfelt gratitude to my family. To my husband, thank you for always loving me and encouraging me to complete this degree. I greatly appreciate all the love and support you have provided. To my parents, thank you for always being there for me and pushing me – it is hard to believe I have been in college for almost ten years. I thank you for the continued support throughout my life and all the love and encouragement you have provided.

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CHAPTER I

INTRODUCTION

The overall health and wellness of the United States population is impacted by the culture and environment of university campuses. The U.S. Department of Education (2004) reports approximately 16.6 million students are currently enrolled in U.S. colleges and universities, around 29% of young adults have already completed a bachelor degree or higher (National Center for Education Statistics, 2004), and nearly 53% of the US adult population has been enrolled in some form of college based education (Stoops, 2004). Unfortunately, an abundance of research indicates college students are not practicing behaviors that promote personal wellness, with alcohol use and a lack of physical activity ranking among the most pressing health issues faced by these young adults (American College Health Association, 2002; Centers for Disease Control and Prevention [CDC], 1997, 2007, 2008). Researchers and policymakers support the idea of a healthy collegiate lifestyle as one characterized by high levels of physical activity and low levels of alcohol use (American College Health Association, 2010; WHO, 2009). Although there are clear theoretical reasons to believe that physical activity would serve as a protective factor against alcohol use, recent studies indicate higher levels of physical activity is associated with higher levels of alcohol use in college populations (Dunn & Wang, 2003; Moore & Werch, 2008; Musselman & Rutledge, 2010; Vickers et al., 2004).

Alcohol Use

The American College Health Association (2002) identified alcohol use as a Leading Health Indicator in college students. College students are at particular risk for alcohol use, misuse, abuse, and the associated negative consequences, including auto

accidents, unprotected sex, and legal difficulties associated with alcohol use (e.g., DUIs; Glindemann, Geller, Clarke, Chevallier, & Pettinger, 1998). Based off the 2006 National Survey on Drug Use and Health (NSDUH), the Surgeon General reported that alcohol was the most widely used and abused substance among our nation's youth. The NSDUH (2006) showed that 57.8% of students attending college full-time (aged 18 to 20 years) had consumed alcohol in the past month and 40.1% of the students had engaged in binge drinking, with 16.6% reporting heavy drinking. Research reports indicate that around 600,000 college students are annually injured unintentionally while under the influence of alcohol (Hingson, Heeren, Zakocs, Kopsstein, & Weshcler, 2005), about one-half million students are assaulted by other students who have been using alcohol, and around 100,000 students report being victims of alcohol-related sexual assault or date rape (Hingson et al., 2005).

There are a number of other negative consequences of drinking for college students, including hangovers, blackouts, drop in academic performance, aggression and violence, and even death from alcohol poisoning (LaBrie, Pedersen, Earleywine, & Olsen, 2006; Maddock, Laforge, Rossi, & O'Hare, 2001; NIH, 2007). Heavy drinking by college students has been associated with student injuries, sexual risk (e.g., abuse, unprotected sex), and poor academic performance (Reifman & Watson, 2003), and alcohol has been cited as the main cause of death and the leading contributor to death resulting from injuries in the under age 21 category (Galson, 2008). Alcohol use in college populations is a major public health concern because it can and has led to a variety of negative consequences. To understand the nature and consequences of alcohol use on college campuses, researchers need to better understand factors affecting drinking

and the relationship alcohol use shares with other health behaviors of college populations (e.g., physical activity).

Physical Activity

In addition to alcohol use, the 2010 Healthy Campus initiative (American College Health Association, 2002) has identified physical activity as a leading health indicator for college students. As with alcohol use, college is considered a window of high risk for weight gain. In particular, the first year of college is a critical period in which weight and fat gain may occur (Delinsky & Wilson, 2008; Holm-Denoma, Joiner, Vohs, & Heatherton, 2008; Megel, Wade, Hawkins, & Norton, 1994; Levitsky, Halbmaier, & Mrdjenovic, 2004). Although some researchers attribute weight gain during the first year of college to new-found freedom away from family, and accompanying stress associated with transitioning to college, many studies point to a serious reduction in physical activity overall (Cash & Green, 1986; Hesse-Biber, 1989).

There are many health benefits of physical activity for college populations; college students who are regularly physically active or are physically fit report less overall illness, fewer stress-related health issues, and are less susceptible to the damaging effects of stressful life situations (Roth & Holmes, 1985; Brown, 1991; Brown & Siegel, 1988). Unfortunately, studies have consistently found that college students are physically inactive (Anding, Suminski, & Boss, 2001; Bray, 2007; Brevard & Ricketts, 1996; Haberman & Luffey, 1998; Keating, Guan, Pinero, & Bridges, 2005; Leslie, Owen, Salmon, Bauman, Sallis, & Lo, 1999; Pinto & Marcus, 1995). A lack of physical activity can lead to numerous health problems (WHO, 2009, Mayo Foundation for Medical Education and Research, 2007), such as being over-weight or obese (Pate et al., 1995), an

increased risk of diabetes, heart disease, cardiovascular disease, hypertension, a variety of cancers (Brady & Matthews, 2006; National Heart, Lung, and Blood Institute Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, 1998), and a number of diseases including osteoporosis, joint disorders, and arthritis.

More importantly, there is substantial research on the benefits of physical activity (CDC, 1999; Mayo Foundation for Medical Education and Research, 2007; WHO, 2009). Research has shown that regular physical activity can moderate the negative effects of stress and has significant health protective benefits (Owen & Vita, 1997). For example, the American Heart Association (2009) found that physical activity decreases a variety of health risks, including risk of developing type 2 diabetes, high cholesterol, blood pressure, obesity, and risk of coronary heart disease (Bouchard, Shephard, Stephens, Sutton, & McPherson, 1990; Pate, Pratt, Blair, Haskell, Macera, Bouchard et al., 1995; Tuomilehto, Lindstrom, Ericksson, Valle, Hamalainen, Ilanne-Parikka, et al., 2001). Physical activity is associated with improved health habits (McDonald & Hodgdon, 1991), and has been linked to a variety of other positive effects, including improved sleep, improved digestion, improved immune system functioning (Buchner, 1997; Hill, 2004; Woods, 2005), and improvements in mental health (e.g., depression; Craft & Landers, 1998).

Physical Activity and Alcohol Use

Recently, an incongruous positive relationship between physical activity and alcohol use in college student populations has been identified (Dunn & Wang, 2003; Lisha & Sussman, 2010; Moore & Werch, 2008; Musselman & Rutledge, 2010; Vickers,

Patten, Bronars, Lane, Stevens, & Coghan, 2004). Research has shown that college students who engage in more physical activity also report higher levels of alcohol use. Because healthy and unhealthy behaviors tend to cluster together within individuals (De Vries et al., 2007; Mistry, McCarthy, Yancey, Lu, & Patel, 2009; Poortinga, 2007), this positive relationship between physical activity and alcohol use is counterintuitive.

The empirical research on this topic to date has been primarily cross-sectional, and the positive relationship has been identified in men and women across a variety of different physical activities (e.g., vigorous exercise, sports; Dunn & Wang, 2003; Lisha & Sussman, 2010; Moore & Werch, 2008; Musselman & Rutledge, 2010; Vickers et al., 2004). Dunn and Wang (2003) used the 1995 National College Health Risk Behavior Survey (NCHRBS) to show both male and female participants with higher rates of exercise and sports activity also had higher rates of alcohol consumption. Vickers et al. (2004) found evidence of the alcohol-activity association in a sample of women at the binge consumption level, and Moore and Werch (2008) found the positive alcohol-activity association existed for vigorous activity. Unfortunately, all three of these studies are limited in the way in which alcohol or physical activity was assessed. Vickers et al. (2004) only focused on binge consumption, Moore and Werch (2008) only focused on vigorous activity, and Dunn and Wang confounded sports activities with exercise. This relationship among college students needs to be further understood, as it would not be desirable to inadvertently promote alcohol consumption when physical activity is promoted with this population.

Although the causal relationship between alcohol use and physical activity is unknown, all of the studies investigating the association have implied that physical

activity has a positive effect on alcohol use (Dunn & Wang, 2003; Lisha & Sussman, 2010; Moore & Werch, 2008; Musselman & Rutledge, 2010; Vickers et al., 2004). Alcohol is a depressant and likely a de-motivator for physical activity. Alcohol use also is served at a number of physical activities (e.g., sports games). In order to explore these relationships further, the effects of physical activity on alcohol use were examined cross-sectionally and longitudinally in this dissertation. Furthermore, the longitudinal relationship was examined for alcohol use and physical activity measured across six domains (sport, exercise, leisure, domestic, occupation, and transportation). The following hypotheses were made for cross-sectional and longitudinal analyses:

Hypothesis 1 (Cross-Sectional). Research has already exhibited a concurrent positive relationship between overall, vigorous, and moderate physical activity (Dunn & Wang, 2003; Moore & Werch, 2008; Musselman & Rutledge, 2010; Vickers et al., 2004), therefore it was hypothesized that a positive relationship will exist cross-sectionally for alcohol use and overall, vigorous, and moderate physical activity. It was hypothesized the positive relationships will exist between physical activity and both alcohol use and binge drinking.

Hypothesis 1 (Longitudinal). To date there are not any studies that have examined the effect of physical activity on alcohol prospectively, however based on past cross-sectional research, it was hypothesized that similar relationships will be evident; specifically, a positive relationship will exist longitudinally for alcohol use and overall, vigorous, and moderate physical activity.

Hypothesis 1A (Longitudinal). Researchers who have examined the positive effect of physical activity on alcohol cross-sectionally in college students have

identified the relationship for both exercise and sport activities (Lisha & Sussman, 2010; Vickers et al., 2004), therefore, it was also hypothesized that a positive association will exist for alcohol use and sport and exercise activities measured longitudinally.

Research Question 1 (Longitudinal). Several additional forms of physical activities have been identified throughout various literatures; therefore I will examine whether other forms of physical activity demonstrate a positive association with alcohol use. Specifically, exploratory analyses will be conducted to determine whether hobby, domestic, occupational, and transportation activities demonstrate a positive association with alcohol use

Potential Contributing Individual Difference Variables

There is a clear need to understand the positive physical activity-alcohol association and what potential individual difference variables could contribute to the relationship. Musselman and Rutledge (2010) examined several potential third variables that could explain the positive physical activity-alcohol association, but found that the relationship was unaffected by gender, ethnicity, age, GPA, Greek affiliation, and sports participation (Musselman & Rutledge, 2010). More recently, Lisha and colleagues (2011) examined the physical activity-alcohol use relationship and found a moderating effect of age when examining vigorous activity and a moderating effect of gender when examining moderate activity. Several potential behavioral, lifestyle and demographic correlates of physical activity and alcohol use, including, gender, age, sexual orientation, social motives, self-monitoring, and body-mass-index (BMI), were therefore investigated as potential moderators of the physical activity-alcohol use association.

Hypothesis 2 (Cross-Sectional & Longitudinal). The cross-sectional and longitudinal positive association between physical activity and alcohol use will be moderated by several individual difference factors, including age, gender, sexuality, social motives, self-monitoring, and BMI.

Age. Age is suggested as a potential moderator because socio-environmental contexts affecting physical activity and alcohol change across the lifespan (O'Malley & Johnston, 2004). Younger individuals tend to have more social networks, have more social interactions, and are more involved in organized physical activities (e.g., sports and exercise; Hartup & Stevens, 1999). Although some physical activities may decrease with age as a result of restricted range of motion or ability, studies indicate that overall, vigorous, and moderate physical activities all decrease significantly with age (CDC et al., 2004; CDC et al., 2007). In fact, older adults are more likely to engage in physical activities alone, and are less likely to engage in social situations conducive to excessive alcohol consumption (Haraldsdottir & Andersen, 1994). Studies have consistently found a positive association between socio-environmental contexts fostering exercise and alcohol use, thus, socio-environmental contexts conducive to physical activity and alcohol use may be more prevalent in younger adults; especially those in their earliest years of college (O'Malley & Johnston, 2004).

Hypothesis 2A (Cross-Sectional & Longitudinal). The physical activity-alcohol use association will be stronger for younger than older participants.

Gender. Gender is suggested as a potential third-variable because considerable differences between men and women have been found when assessing alcohol consumption and physical activity. In general, women are less physically active than men

at all ages, less likely to engage in vigorous physical activity, and are more likely to be physically inactive (Pate et al., 1995; USDHHS, 1996, 2000). Gender differences in physical activity begin to emerge during the teen years and women continue to lag behind men in achieving the recommended levels (USDHHS, 1996), with women being less active than men at all ages (USDHHS, 2000). Additionally, college women are reportedly less likely to consume alcohol than men (O'Malley & Johnston, 2002) with alcohol being associated with less life satisfaction for women (Murphy, McDevitt-Murphy, & Barnett, 2005). There is evidence that gender differences in the way that alcohol impacts other aspects of life exist (Murphy, Barnett, Goldstein, & Colby, 2007), and gender has already been implicated as a potential moderating factor of the alcohol-activity association by prior researchers (Lisha et al., 2011). The results of these studies suggest that differences in alcohol use and physical activity may exist for men and women, so the following hypothesis was made.

Hypothesis 2B (Cross-Sectional & Longitudinal). The positive association between physical activity and alcohol use will be stronger in male participants than in female participants.

Sexual Orientation. Sexual orientation is suggested as a potential moderator of the physical activity – alcohol use association because differences in both physical activity and alcohol use have been found when examining sexual orientation. A variety of potential differences in physical activity based upon sexual orientation have been reported (Aaron, Markovic, Danielson, Honnold, Janosky, & Schmidt, 2001; Roberts, Dibble, Nussey, & Casey, 2003). Roberts et al. (2003) found that homosexuals were more likely than heterosexuals to exercise, and a higher percentage of homosexuals report

engaging in vigorous physical activity as compared to heterosexuals in the general population (Aaron et al., 2001). Similarly, Case and colleagues (2004) reported that 10% more homosexual than heterosexual women reported strenuous exercise at least once a week. In addition, alcohol consumption has been found to be higher among homosexuals as compared to heterosexuals (Aaron et al., 2001; Case, Austin, Hunter, Manson, Malspeis, & Willett, 2004; Diamant, Wold, Spritzer, & Gelberg, 2000; Moran, 1996; Valanis, Bowen, Bassford, Whitlock, Charney, & Carter, 2000). Most of the research regarding alcohol use and sexual orientation among women has reported that homosexuals have a higher prevalence of alcohol consumption as compared to heterosexual women. Diamante et al. (2000) found that 75% of homosexuals compared to 50% of heterosexuals acknowledged any drinking. Among Canadian women, the percentage of abstainers among homosexuals was 13% vs. 16% found in the overall heterosexual female population but was not statistically significant (Moran, 1996). Higher levels of alcohol use reported by non-heterosexual individuals could be a reflection of the relationship between alcohol and physical activity, therefore sexual orientation was examined as a potential moderator variable.

Research Question 2 (Cross-Sectional & Longitudinal). Will the positive association between physical activity and alcohol use be moderated by sexual orientation?

Social Motives. Alcohol use and physical activity have been implicated as behaviors impacted by social motives, because both behaviors can facilitate social bonding and potentially increase social liking and acceptance by conveying certain images (Kirchner, Sayette, Cohn, Moreland, & Levine, 2006; Martin & Leary, 2001).

The desire to be liked, as well as liking people, can prompt certain behaviors, for example, in male college students, a number of risky behaviors, including alcohol use, can lead to the attainment of social rewards such as being liked by the people they have met in college (Martin & Leary, 2001). Likewise, in exercise settings, men have been shown to do potentially dangerous things in order to increase liking or be seen favorably by members of the opposite sex (Boutcher, Fleischer-Curtian, & Gines, 1988). Thus, alcohol consumption or engagement in physical activity depends partly on the belief that the behavior is tolerated or desired by important or valued reference groups (Leary et al., 1994; Leary, 1995).

Leary (1995) showed that college students want to make impressions described as outgoing, attractive, friendly, and fun, rather than ones that made them appear stupid, boring, superficial, or mean. Accordingly, looking 'cool' and 'fun' are given as the most frequently desired impressions that motivate first year college students to drink (Martin & Leary, 2001). Additionally, individuals with strong social motives are likely to be drawn to other individuals with strong social motives, and who are also socially active. As college students, the social activities that individuals engage in might promote alcohol use or engagement in certain physical activities. It could be argued that students involved in recreational physical activity (e.g., riding bikes with friends) may have increased opportunities for social drinking, more initiation of events involving drinking, and greater peer acceptance of binge drinking (Vickers et al., 2004). Clearly, social motives can play an important role in college students' lives and may play an important role in clarifying the relationship between alcohol use and physical activity.

Hypothesis 2C (Cross-Sectional & Longitudinal). Individuals with high levels of social motives will demonstrate a stronger, positive alcohol-physical activity association than those with lower social motives.

Self Monitoring. People who possess attributes associated with a high level of self-monitoring may be more likely to sacrifice their health and well-being to make impressions on others (Leary & Kowalski's, 1990). The monitoring of how one is being perceived and evaluated by others leads to regulation of behaviors (Leary, 1995). Researchers have shown that individuals who are high self-monitors are worried about social disapproval and anxious about others' perceptions and evaluations (Crowne & Marlowe, 1960; Leary, 1995; Hart, Leary, & Rejeski, 1989; Snyder, 1974), as a result, these individuals are more likely to engage in behaviors in order to make a desirable impression on others. High self-monitors may be highly responsive to interpersonal and social cues regarding what is situationally appropriate (Snyder, 1987). Conversely, low self-monitors do not engage in expressive control, and do not appear to have the same concerns regarding situational appropriateness. Low self-monitoring behavior is thought of as reflective of one's own inner emotions, attitudes, and dispositions (Snyder, 1974). Low self-monitors manage their behaviors less often when compared to high self-monitors, and they are not as sensitive to social cues or to control others' impressions (Leary, 1995; Snyder, 1974).

Research supports the notion that both alcohol use and physical activity can potentially be explained or predicted by motivational factors such as self-monitoring (Leary & Kowalski, 1990). Self-presentation can also be a determinant of physical activity due to its effects on attitudes, thoughts, and behaviors (Leary, Tchividjian, &

Kraxberger, 1999). For example, Hodgins (1992) found that physically active individuals are rated more favorably than those described as sedentary, and in turn these favorable ratings can impact attitudes and the desire to be physically active. Self-monitoring may act as an important factor with respect to both alcohol use and physical activity. Research shows people who report that they have used alcohol in the past score higher on the self-monitoring scale than people who have never reported using alcohol (Sharp & Getz, 1996), and individuals who score higher on the self-monitoring scale report engaging in more frequent and consistent exercise (Fuchs, Goehner, Seelig, 2011). Therefore, individuals with high levels of self-monitoring may have motivation for both alcohol and physical activity, but individuals with low levels of self-monitoring may have varying motivations for physical activity and alcohol. Based on the existing literature the following hypothesis was made.

Hypothesis 2D (Cross-Sectional & Longitudinal). High self-monitors will demonstrate a stronger, positive association between alcohol use and physical activity than low self-monitors.

Body Mass Index. BMI was investigated as a potential moderator of the physical activity-alcohol use association. BMI is a commonly used indicator of body composition and is a ratio of weight to height. In general, body mass index (BMI) is negatively associated with physical activity (Gearhardt & Corbin, 2009; Kleiner, Gold, Frost-Pineda, Lenz-Brunsman, Perri, & Jacobs, 2004; Mack, Anderson, Galuska, Zablotsky, Holtzman, Ahluwalia, 2004; Speck & Harrell, 2003; USDHHS, 1996), and an inverse relationship between BMI and alcohol consumption has been demonstrated by prior researchers (Gearhardt & Corbin, 2009; Kleiner et al., 2004). Additionally, several cross-sectional

studies have consistently reported lower BMI measurements among people with higher levels of physical activity (USDHHS, 1996). Individuals who are physically active also have significantly lower BMIs and body weights than those who are physically inactive (Mack et al., 2004; Speck & Harrell, 2003).

Research Question 3 (Cross-Sectional & Longitudinal). Will the positive association between physical activity and alcohol use be moderated by an individual's BMI?

Other Demographics. An individual's medical condition can have an effect on both physical activity and alcohol use (CDC, 2004; 2007); individuals who are disabled or impaired may have limited activity, and those who are on medication may be limited in their ability to consume alcohol. Therefore, medical condition was included in this study as a potential individual difference variable. In addition, prior studies have identified Greek status as a potential individual difference factor that could impact the alcohol-physical activity association (Mussleman & Rutledge, 2010; Vickers et al., 2004), although these studies did not find significant effects of Greek affiliation it was still included in this study as a potential individual difference variable. No specific hypotheses regarding medical condition or Greek affiliation were made.

The Current Study

In summary, the primary purpose of this dissertation was to examine the physical activity-alcohol association in a sample of college students both concurrently and prospectively. As prior studies are limited in their measurement of physical activity, this study was also designed to measure multiple forms of physical activity in an effort to determine whether the alcohol-activity association is limited to certain types of physical

activity, or physical activity overall. A second purpose of this dissertation was to identify potential individual difference variables that may affect this relationship (age, gender, sexuality, social motives, self-monitoring, BMI, Greek affiliation, & medical condition).

CHAPTER II

METHODS

Participants

A total of 313 undergraduate participants were recruited for the study. Seventy-eight percent of the participants were female, and the age ranged from 16-49 (M=18.6; SD=2.30). Although the legal drinking age at the location of the study was 21, the majority of participants in this study reported drinking alcohol at some point (71%). The majority of participants identified as being White or European/American (77%), with the remaining identifying as being Hispanic or Latino (9.8%), Black or African American (3.8%), Native Hawaiian or Pacific Islander (.6%), American Indian or Alaska Native (.3%), and other (4.4%). Participants rated their sexuality on a scale from entirely heterosexual to entirely homosexual; participants predominantly identified as heterosexual (90%), with 1.3% identifying as homosexual, and 6.3% identifying as not entirely either. Participants were recruited from the Colorado State University PSY100 and PSY250 research participant pool. All PSY100 and PSY250 students at Colorado State University who choose to participate in psychological experiments are required to serve as a research participant for 6 credit hours over the course of the semester. Full participation in this study fulfilled 4 credit hours of that requirement for each participant.

Design and Procedure

Participants reported to a social psychology laboratory on three separate occasions within a three-week time frame to complete several computerized survey measures. Participants came in once at the beginning of the study to fill out consent to participate and to complete the baseline survey (BL), a second time (T2) after one and a half weeks

to complete another survey, and a third/final time (T3) at 3 weeks to complete the final survey and to receive debriefing information.

In-Person, Cross-Sectional Survey

During the baseline meeting, participants first received their consent form; participants were asked to read, understand, and sign the consent form. Participants were then asked to choose a number (five-digits or greater) that would serve as their participant ID. Then, participants were given an information sheet listing all of the information they needed to know regarding the experiment, including directions on how to maintain their daily diary, dates of the T2 and T3 visits, and contact information for the researcher. Participants completed Survey 1 on individual computers using Qualtrics, which consisted of questions regarding past 30-day alcohol behaviors, past 30-day physical activity behaviors, and the moderator variables (demographics, motives, self-monitoring). Participants completed Survey 1 in a group setting with up to 11 total participants present. Participants then left the study with instructions on how to begin the daily diary portion.

At T2, participants completed additional survey items such as perceived behavioral control, sensation seeking, and the body-esteem scale. T2 served as an opportunity to keep the participant involved and to remind them to complete their daily entries and to return for their debriefing during T3. At T3, participants returned to complete the final survey, which included the same measures as in the first survey, with the exception of the demographic questions. Once finished with their T3 survey, participants had their height and weight measured and recorded in a separate room. Participants were then debriefed and thanked for their participation.

In-Person Measures

Physical Activity. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) because reliability and validity analyses for the IPAQ show that questionnaires are a sufficiently accurate method for assessing physical activity (Ainsworth, Leon, Richardson, Jacobs, & Paffenbarger, 1993; Jacobs et al., 1993). The IPAQ is made up of 9 items assessing the number of minutes spent in vigorous and moderate intense activity and low/walking activity during the last 7 days. For all categories, participants reported on how many days and how many minutes they spent in a specific physical activity category. As recommended by Craig et al. (2003) Low, Moderate, and Vigorous time variables exceeding 3 hours or 180 minutes were truncated to be equal to 180 minutes - the rule permits a maximum of 21 hours of activity in a week to be reported in each category. Participants' responses to questions resulted in a measure of weekly metabolic equivalent tasks (MET). For each category the MET/minutes is calculated by multiplying the amount of minutes with 8 (vigorous), 4 (moderate), 3.3 (low), or 1.3 (sitting). Within this sample, the low MET mean was *M*=1250 (*SD*=1087), with a range of 0-4158. The moderate activity MET mean was *M*=1106 (*SD*=1252), with a range of 0-5040. The vigorous activity MET mean was *M*=1536 (*SD*=1769), with a range of 0-10080.

An overall physical activity score was calculated by adding together the METs for the three categories, low, moderate, and vigorous activity. Expenditure was used to categorize participants as either having low, moderate, or high levels of physical activity. The scoring criteria assigns the category of moderate to participants who either 1) engaged in vigorous activity for at least 20 minutes a day for three days a week, 2)

engaged in moderate exercise and walking for at least 30 minutes a day at least five days a week, or 3) had a total MET expenditure of at least 600 METs but not more than 2999 METs. According to IPAQs criteria, participants who are assigned to the high physical activity category either 1) engaged in vigorous activity at least three days a week and had a total MET expenditure each week of 1,500 or 2) engaged in moderate exercise and walking seven days a week and had a total MET expenditure each week of 3,000 METs. 3) All participants who did not fall into the moderate or high categories were to be considered low in physical activity. Within this sample the total MET mean of *M*=3,910 (*SD*=2,767) with a range of 0-14,719, placing the majority of participants within a high level of physical activity, indicating this sample of participants is extremely physically active. Overall, vigorous, moderate, and low physical activities were examined for comparison with other studies. Log-transformations were calculated after adding the constant 5 to each physical variable activity variables (to include respondents reporting 0 min of a specific activity in the log transformation). Log-transformed standardized skewness and kurtosis values were normal (-.34 to 9.84) and (-.31 to 8.78) respectively.

Alcohol Use. Alcohol use was assessed by using measures of frequency, quantity, and heavy drinking (Sher, Walitzer, Wood, & Brent, 1991). Participants were asked "How many times did you drink alcohol in the past 30 days?," and were provided with eight response choices: "*Did NOT drink alcohol in last 30 days*," "*Once in the past 30 days*," "*2-3 times in the past 30 days*," "*Once or twice a week*," "*3-4 times a week*," "*5-6 times a week*," "*Nearly every day*," and "*Every day*." Thirty-three percent of participants indicated they had not drunk alcohol in the last 30 days, 30% of participants indicated they had drunk 1-3 times in the last 30 days, and 37% percent of participants indicated

they drank once a week or more in the last thirty days. In order to assess quantity, participants were asked, "In the past 30 days, when you drank, how many drinks did you usually have on any one occasion?" Drink was defined as: 12 oz. beer, 4 oz. wine, 12 oz. wine cooler or malternative, or a shot of liquor straight or mixed. There were a total of 14 response choices ranging from: "*Did NOT drink alcohol in the past 30 days*," to "*13 or more drinks*." Thirty-three percent indicated they did not consume alcohol in the last 30 days, 39% indicated they consumed between 1 to 4 drinks per occasion, and 28% reported they consumed 5 or more drinks per occasion. Following Sher and colleagues (1991), a measure of alcohol quantity-frequency was calculated as the product of alcohol frequency (coded as the number of times in the last 30 days) and alcohol quantity, providing an overall mean of M=9.82, SD=11.04. This abstinence rate is comparable to national data suggesting that 80% of college students drink alcohol (Hingson et al., 2005), and the quantity-frequency rate is slightly higher than national averages suggesting around 6 drinks per 30 days for the regular college student (Sher et al., 1991).

To assess binge drinking, participants were asked "In the past 30 days how many times have you had five or more drinks in a single setting?" The response items were the same as those for the alcohol frequency measure. Forty-nine percent of participants indicated they had not engaged in binge drinking, 21% indicated they engaged in binge drinking at least once in the last thirty days, and 30% of participants indicated they had engaged in binge drinking 2 or more times in the last thirty days. This binge consumption rate is in-line with national averages showing roughly 30% of college students engage in binge consumption (Hingson et al., 2005).

Motives. Social motives were measured using the stem "How important is it for you…" and includes three items: "*to be popular*," "*to have an active social life*," and "*to date several people*" (Maggs, 1997). Participants were asked to rate each item on a 5 point Likert scale ranging from 1= *not at all important to me*, to 5 = *very important to me*. Reported reliabilities are considered acceptable 0.79-0.81 (Maggs, 1997); within this sample reliability is considered acceptable at α =0.79.

Self-Monitoring. Snyder's (1974; 1987) Self-Monitoring Scale (SMS) was used, which is an 18-item scale (Synder, 1987) consisting of true/false statements (e.g., "In different situation and with different people, I often act like a very different person"). Final scores can range from 0 to 18 with higher scores indicated higher self-monitoring propensities. Within this sample the mean score was *M*=10.57, *SD*=2.24, showing that overall this sample of participants have an average level of self-monitoring. The SMS is considered reliable and valid (Snyder, 1987), and reported reliability for this sample is considered good at α =0.89 (see Appendix A for full scale).

Degree of Health. To measure the participants own degree of health, participant's body mass index (BMI) was calculated (kg/m^2). Quetelet's index (body weight in kilograms divided by height in meters squared) is the most frequently used BMI (ACSM, 2001; USDHHS, 1996, 2000). Other techniques of measuring body composition, such as bioelectrical impedance analysis (BIA), hydrostatic weighing and the sum of skin fold measurements, are more precise than BMI in measuring percent fat, but are more expensive, time consuming, and more difficult to administer in large population-based studies (Brooks, Fahey, & White, 1996). Since BMI has been found to be moderately correlated with percent body fat (r = .80) (Brooks et al., 1996; USDHHS, 1996) and

because height and weight measurements are readily available, BMI is widely used to estimate body composition in epidemiologic studies (USDHHS, 1996). BMI is calculated as weight/height, therefore participants had their weight measured by standing on a digital scale for 10 seconds, and their height measured using a standard height wall ruler. BMI is considered a good indicator of fatness because it is highly correlated with weight but not height (Kraemer, Berkowitz, & Hammer, 1990). Subjects with a BMI between 18.5 and 24.9 are considered normal weight, between 25 and 29.9 are overweight, and 30 or greater are obese. Within this sample the average BMI was *M*=23.22 (*SD*=4.1; Range 18.02 to 36.05), indicating the majority of participants within this study are considered normal weight.

Other Demographics. In addition to the demographics reported in the participant section, participants were asked an open ended question about whether they have any medical conditions affecting their nutrition/health. Participant answers were coded as 0 (no indication of any medical condition) or 1 (indication of any medical condition). A considerable portion of participants (19.5%) reported having a medical condition that affects the state of their nutrition/health; reported conditions varied, ranged from *asthma* to *mitral valve prolapse*. Participants were also asked whether they have any Greek affiliation (e.g., belong to a sorority or fraternity) with answers being coded as 0 (no indication of any Greek affiliation) or 1 (indication of Greek affiliation). Twenty-six percent (*N*=82) of participants indicated they had some sort of Greek affiliation.

Daily-Diary Survey

Additionally, this study employed a longitudinal method utilizing online daily diaries. The daily diary method is considered an effective way of longitudinally capturing

ongoing behaviors and experiences while limiting the amount of time that elapses between when an experience happens and when it is reported (Bolger, Davis, & Rafaeli, 2003; Stone & Shiffman, 2002). For alcohol-related research, daily diaries are an effective method to use when collecting daily data from a large sample of individuals (Armeli, Todd, & Mohr, 2005). The daily diary was kept for 3 weeks, and participants completed the online daily diary once per day using Qualtrics.com. Participants were instructed to complete the diary before 12:00pm each day to report on their physical activity and alcohol use from the day before. As reliability of self-reporting information decreases over time, this cut-off time was chosen because it is best to keep the interval for reporting short (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004).

Daily Diary Measures

Participants were asked to answer a series of questions related to their physical activities and alcohol consumption. First, they were asked to report on their physical activities from the previous 24 hours. In order to do so, they were provided with a list of physical activities across six subcategories representing the six forms of physical activity (Sport, Exercise, Leisure, Domestic, Occupational, and Transportation/Utilitarian). The list of physical activities was based on both the CDC classifications (2007) and a brief university class poll conducted in two introductory psychology courses in the Fall 2010 semester at Colorado State University. During the brief class poll, 273 students were asked to list the forms of physical activity in which they engage. The students provided over 106 different physical activities. These 106 different physical activities were reduced further to create a variety of different activities (as some activities overlapped significantly). For example, students listed "*bike to class*" and "*bike to store*;" these two

items were combined into the transportation category under biking. In addition to indicating which physical activities they participated in, the participant filled in the number of minutes they engaged in each behavior. Participants were also asked to report on their daily total low, moderate, and vigorous activity; these questions were designed from questions on the International Physical Activity Questionnaire (see in-person measures section; Craig et al., 2003).

A physical activity score for each day was calculated for each category, and the final overall physical activity score for each day was calculated as the sum of energy expended in all physical activity categories. Within this sample, the daily low MET mean was *M*=218 (*SD*=168), with a range of 0-594. The moderate activity MET mean was *M*=158 (*SD*=166), with a range of 0-720. The vigorous activity MET mean was *M*=269 (*SD*=323), with a range of 0-1440. The sport activity MET mean was *M*=67 (*SD*=323, range 0-1440), exercise MET mean was *M*=121 (*SD*=323, range 0-1440), leisure MET was *M*= 161 (*SD*=323, range 0-1440), domestic MET was *M*= 292 (*SD*=323, range 0-1440), occupation *M*=169 (*SD*=323, range 0-1440), transportation MET was *M*= 216 (*SD*=323, range 0-1440). Finally, within this sample the total MET mean of *M*=607 (*SD*=439) with a range of 0-2754, indicating the majority of the participants within this sample are highly active every day. Logarithmic-transformations were used to approximate a normal distribution.

Participants were also asked to report on their daily alcoholic consumption in the past 24 hours. They reported on the number of occasions of consumption (*How many times (different occasions) did you drink alcohol in the past 24 hours (since 12PM yesterday)? For example, if I drank in the morning at home and then again in the evening*

when I went out with friends this is two occasions), how many drinks they had on each occasion (*In the past 24 hours (since 12PM yesterday), when you drank, how many drinks did you usually have on any one occasion?*), what type of alcoholic beverages and how many of each type were consumed *(In the past 24 hours (since 12 PM yesterday), when you drank, how many beers did you have total?*), and then participants were asked to list everything they actually consumed. Therefore it was possible to record the type, frequency, and quantity of alcohol use. Participants also answered a question designed to address binge drinking in the last 24 hours (*In the past 24 hours how many times have you had five or more drinks in a single setting?*). Alcohol was consumed during 67% of the total days reported, with an average of .61 (*SD*=1.15) drinks across all days with a mean consumption of 1.08 (*SD*=1.35) drinks during drinking days.

Statistical Analyses

Cross-Sectional Analyses. SPSS 16.0 was used first to analyze the cross-sectional data. Multivariate Analyses of Variance (MANOVAs) were conducted to test cross-sectional differences in all Level-2 variables as a function of gender, age, sexual orientation, social motives, self-monitoring, BMI, Greek affiliation, and medical condition (reported vs. none reported). The MANOVA is the most appropriate statistical technique for this because it reduces the number of analyses. Running this analysis instead of multiple univariate tests offered the benefit of minimizing Type I error as well as accounting for multicollinearity that is often undetected in running multiple univariate analyses. The MANOVA provides an F statistic for each dependent variable to indicate whether there are significant differences across the six groups.

To examine the concurrent portion of Hypothesis 1 (a positive association would exist for overall, vigorous, and moderate physical activity with alcohol use and binge consumption), regression analyses were conducted following the procedures described by Judd and Kenny (2010), beginning with a linear causal relationship in which the variable physical activity is presumed to cause the variable alcohol use. This analysis was performed for each of the 4 variations of physical activity collected at Time 1 (low, moderate, vigorous, and total) predicting overall alcohol use and binge consumption. Following this, potential moderator variables hypothesized to alter the strength of the positive relationship cross-sectionally were tested (Hypotheses 2A-2F). The following multiple regression equation was estimated:

$$Y = i + aX + bM + cXM + E$$

Within this equation, the path *a* measures the main effect of physical activity type when the moderator is zero, the path *b* measures the effect of the moderator when physical activity is zero, and the path *c* measures the moderation effect. Moderator effects are indicated by a significant interaction of X and M in explaining Y.

Multi-level Modeling Analyses. Multilevel modeling analyses were conducted to investigate the longitudinal hypotheses and research questions because daily diary data are multilevel in nature (Armeli, Carney, Tennen, Affleck, & O'Neil, 2000). Multilevel modeling techniques offer advantages over traditional methods of analyzing diary data (e.g., aggregation; see Armeli et al., 2000; Krull & MacKinnon, 2001; Roesch, Aldridge, Stocking, Villodas, Leung, Bartley, & Black, 2010). Specifically, multilevel modeling allows the researcher to simultaneously examine effects at multiple levels of analysis (e.g., within and between levels), resulting in a more accurate model of the multilevel

phenomena (Krull & MacKinnon, 2001; Raudenbush & Bryk, 2002; Roesch et al., 2010). There are several advantages to using multilevel modeling techniques, such as being able to model datasets in which data points are missing, and in which individuals are not measured at exactly the same time points or intervals (Papp, 2004). Using multilevel modeling allows researchers to capture moment-to-moment physical activity and alcohol use and model this within-person (co)variability while at the same time estimating reliable between-person variability. The aggregation of within-person assessments across time reduces error compared to single assessments and provides a more statistically reliable and powerful measure of the constructs.

Physical activity and alcohol use that was collected repeatedly over time (daily diary data) were entered at Level 1. Between subjects factors (e.g., individual differences information collected at the first study session) were added at Level 2. Therefore, it was possible to test both physical activity and individual difference factors that are related to alcohol use, as well as how factors at Level 2 affect relationships at Level 1 (e.g., cross-level interactions or moderators). For example, is the effect of physical activity on alcohol use stronger in men than women?

All analyses were conducted using the Hierarchical Linear Modeling (HLM) software program, Version 7.0 (Raudenbush, Bryk, & Congdon, 2010). The dependent variable in the study, alcohol use (frequency by quantity) is a count variable. Similar to other diary studies examining health risk behaviors such as alcohol use (e.g., Barta, Portnoy, Kiene, Tennen, Abu-Hasaballah, & Ferrer, 2008; Mohr et al, 2001), the count distribution had a large number of zeros (indicated no alcohol consumed), therefore transformations could not be used to normalize the data. Instead, Poisson regression was

used, because it is characterized as the number of events that occur in a particular period and can be used when evaluating distributions that are very positively skewed (Cohen, Cohen, West, & Aiken, 2003). The Poisson option with a log-link function in HLM 7.0 is a non-linear analysis that uses a hierarchical generalized linear model (HGLM; Raudenbush, Bryk, Cheong, & Congdon, 2001). Overdispersion, or systematic variation unaccounted for by the predictors that leads to more variation in residuals, is frequently found in count data (Cohen et al., 2003). Because overdispersion can affect goodness of fit tests and standard errors through inflation, the overdispersion option in HLM was used.

The Poisson model tested whether expected alcohol use is based on predictor variables included in the regression equation (Barta et al., 2008), and the coefficients derived for each predictor variable were expressed as Event Rate Ratios (ERR). ERRs are interpreted relative to the value of 1, and are interpreted as a change in the frequency of events (Barta et al., 2008). For example, an ERR of 1.4 indicates that a one-point increase in a variable increases alcohol use by 40%, and an ERR of .4 would mean that a one-point increase in a predictor variable decreases the alcohol use by 40%. Within this study a one-point increase is representative of a 100 MET increase in that physical activity for the day.

CHAPTER III

RESULTS

Because different analytic techniques were used to test the cross-sectional and longitudinal hypotheses, the analyses within this dissertation are divided into two sections. First, the concurrent/cross-sectional results are presented, including descriptive, MANOVA, and regression analyses. Following, the prospective/longitudinal results using multi-level modeling are presented. See Appendix B for a full list of hypotheses and results.

Cross-Sectional Results

Descriptive statistics and correlations between hypothesized Level-2 variables collected during Time 1 (cross-sectionally) are reported in Table 1. When examining Pearson correlations for physical activity variables, most items correlated as expected; total physical activity [Total METs] was significantly and positively correlated with Low METs, Moderate METs, Vigorous METs, and social motives. These results indicate that overall physical activity is positively associated with low, moderate activity, vigorous activity, and social motives.

Total alcohol use was positively correlated with binge drinking. Alcohol use and binge drinking were positively correlated with only one type of physical activity measured cross-sectionally – moderate physical activity. Additionally, alcohol use and binge drinking were positively related with social motives. Interestingly, BMI was negatively correlated with self-monitoring and social motives. These results indicate that participants with lower BMIs had higher levels of self-monitoring. Additionally, BMI

was negatively correlated with social motives, indicating that individuals who are motivated to be socially accepted have a healthier (lower) BMI.

MANOVA. First, a multivariate analysis of variance (MANOVA) was performed to examine whether all Level-2 variables (e.g., alcohol use measured cross-sectionally at Time 1) differed significantly by gender, age (median split - 18 and below versus 19 and above), sexual orientation (entirely heterosexual versus not entirely heterosexual), social motives (high versus low - median split), self-monitoring (high versus low – median split), BMI (high versus low – median split), Greek affiliation (no affiliation versus affiliation), and medical condition (no condition versus condition). The MANOVA used the independent variables of gender, age, sexual orientation, social motives, self-monitoring, BMI, Greek affiliation, and medical condition, on the dependent variables overall alcohol use, binge consumption, low physical activity, moderate physical activity, vigorous physical activity, and total physical activity. The analyses revealed no significant between-subject effects for Greek status and medical condition on any of the variables examined so Greek status and medical condition were dropped from all further analyses. Although no significant effects for BMI were found, because BMI was of specific interest in this study, BMI was retained for all further cross-sectional and longitudinal analyses. Significant effects were found for gender, age, sexual orientation, social motives, and self-monitoring; see Table 2 for group means and univariate effects.

Preliminary support for hypothesis 2B (cross-sectional): a significant effect of gender on several Level-2 variables was found, including total physical activity, vigorous physical activity, overall alcohol use, and binge drinking, Wilk's lambda = .82, F=4.19, p<.001. Examination of between-subjects effects revealed a significant effect of gender

on vigorous (p<.01) and total physical activity (p=.02), with male participants reporting higher vigorous (M=2128, SD=2,148) and total physical activity (M=4,591, SD=3,227) than female participant's vigorous (M=1,381, SD=1,637) and total (M=3,753, SD=2,613) physical activity. In addition, between-subjects effects revealed a significant effect of gender on both overall alcohol use (p<.01) and binge drinking (p=.02), with men reporting higher scores than women: overall use men (M=11.46, SD=12.37), women (M=6.79, SD=7.77); binge use men (M=2.34, SD=1.37), women (M=1.89, SD=1.12). Additionally, there was a significant effect of sexual orientation on moderate physical activity, Wilk's lambda = .92, F=1.53, p=.05, with individuals not identifying as heterosexual reporting more moderate physical activity (M=1,148, SD=1,283) than heterosexuals (M=751, SD=816). A marginally significant effect of sexual orientation on total physical activity (p=.08) was found, with non-heterosexual participants engaging in more total physical activity (M=4,028, SD=2,773) than heterosexuals (M=2,890, SD=2,500).

When comparing individuals 18-years-and-under with individuals 19-years-and-older, a significant effect of age on vigorous physical activity was found providing preliminary support for hypothesis 2A (cross-sectional), Wilk's lambda = .87, F=2.62, p<.001. Participants in the older category report lower vigorous physical activity (M=1,496, SD=1,514) than participants in the younger category (M=2,117, SD=1,644). This indicates individuals 18 years and younger engage in more vigorous physical activity than individuals 19 years and above. No other effects for age were found.

An examination of between-subjects effects showed preliminary support for hypothesis 2C (cross-sectional), a significant effect of social motives on total physical

activity, vigorous physical activity, and moderate physical activity, Wilk's lambda = .96, F=2.06, p=.05, with individuals who are more socially motivated reporting higher (M=4,480, SD=3,252) total physical activity than individuals with weaker social motives (M=3,376, SD=2,150). A significant effect of social motives on vigorous physical activity (p<.01) shows individuals with stronger social motives report higher (M=1,892, SD=2,116) levels of vigorous physical activity than those with weaker social motives (M=1,214, SD=1,334). Finally, a significant effect of social motives on moderate physical activity (p<.01) shows individuals with stronger social motives report higher (M=1,351, SD=1454) levels of moderate physical activity than individuals with weaker social motives (M=886, SD=1,014). Therefore, individuals with stronger social motives engage in more physical activity across all categories except low, compared to individuals who are not as socially motivated. The results also show a significant effect of self-monitoring on vigorous and moderate physical activity, Wilk's lambda = .95, F=2.84, p=0.01. High self-monitors engage in more vigorous physical activity (M=1,828, SD=2,076) when compared to low self-monitors (M=1,393, SD=1600), and high self monitors also engage in more moderate physical activity (M=1,289, SD=1,357) when compared to low self-monitors (M=1,022, SD=1,214).

Regression. Regression analyses were performed to examine the ability for the physical activity measures to predict alcohol use cross-sectionally and evaluate Hypothesis 1 (cross-sectional). Each form of physical activity as measured by the IPAQ (low, moderate, vigorous, and total) was tested as a predictor of overall alcohol use. The results indicated that within this sample, moderate physical activity was the only significant, positive predictor of alcohol use (t=2.13, p<.05), with moderate physical

activity predicting 12% of the variance in alcohol use. Partial support for Hypothesis 1 (cross-sectional) was found; cross-sectionally, moderate physical activity positively predicted alcohol use. There were no significant effects of overall, vigorous, or low physical activity on alcohol use or binge consumption, and there were no significant effects of moderate physical activity on binge consumption.

Moderation. Next, moderation regression analyses were performed to test hypotheses 2A-2D (cross-sectional) and research questions 2 and 3, and examined whether the proposed moderator variables would alter the strength of the positive relationship between moderate physical activity and alcohol use. Non-significant interactions for all analyses indicated none of the proposed moderator variables had an effect on the relationship (see Table 3 for all moderate physical activity results). No support was found for hypotheses 2A-2D or research questions 2 and 3 within the cross-sectional analyses.

Longitudinal Results

Participants' daily diary information was used to investigate the longitudinal hypotheses. In total, participants provided 5,599 days of data, which indicates that participants completed the daily diary surveys on 85% of the total expected days (total potential days were 6,573). This rate of compliance is consistent with other studies employing the use of daily diaries to measure alcohol use (Armeli et al., 2005; Mohr et al., 2008). As multilevel modeling techniques are efficient at handling missing data, no entries were dropped from the analyses. HLM modeling is considered an especially robust technique compared to other longitudinal analysis procedures, however HLM models assume that data are missing at random (MAR; Little & Rubin, 2002). MAR

indicates the missing data process is independent of the value of the outcome variable (e.g., alcohol use) but can depend on some other observed variable in the study (e.g., gender, age, social motives, sexuality, self-monitoring, and BMI). MAR is considered ignorable as long as the probability of missing does not depend on any unobserved variables in a model, the distribution of missing pattern can be ignored in the estimation process (Little & Rubin, 2002). For example, if the proportions of missing data increase over time while the probability of missing within each time point is not related to values of response variables, it is then treated as ignorable. Analyses were conducted to determine whether the participants who did not complete all diary entries differed from the participants who completed the entire study. Results indicated that participants did not differ on individual differences related to physical activity or alcohol use. See Table 4 for complete *t*-test results.

Alcohol Use. Participants consumed at least one alcoholic beverage during 67% of the total days that were reported across the participants. Participants drank an average of .61 drinks across all days (*SD*=1.15; Mode=0, range=0-8.42). During days when participants did drink, they consumed and average of 1.08 drinks (*SD*=1.35; Mode=.1, range=.1-8.37), and only 5% of participants who reported drinking engaged in binge drinking. Binge consumption was excluded from being a dependent variable in all multi-level analyses because the percentage of participants who binge drank was so low.

Physical Activity. Because of the large range of physical activities possible, participants reported engaging in some form of physical activity during 98% of the total days. Participants had an average daily total physical activity MET of 607 (*SD*=439; Mode=198, range=0-2,754), and engaged in low physical activity 98% of the total days

reported across participants, with an average low daily total MET of 218 (*SD*=168; Mode=198, range=0-594). Participants reported engaging in moderate physical activity 81% of the total days reported across participants with an average moderate daily total of 158 (*SD*=166; Mode=0, range=0-720), and vigorous physical activity 63% of the total days reported across participants with an average vigorous daily total of 269 (*SD*=323; Mode=0, range=0-1,440).

Participants reported engaging in sports 18% and exercise 44% of the total days across participants with an average sport daily total of 67 METs (*SD*=191; Mode=0, range=0-1634) and exercise *M*=121 (*SD*=194; Mode=0, range=0-1278). Hobby and domestic physical activities were reported 53% and 73% of the total days across participants (*M*= 161, *SD*=223; Mode=0, range=0-1839; *M*=292, *SD*=369; Mode=0, range=0-2754; respectively). Reported occupational activity across participants was high at 61%, *M*=169, *SD*=281; Mode=0, range=0-2514). Finally, participants reported engaging in physical activity as transportation 82% of the total days across participants with an average daily total of 216 METs (*SD*=275; Mode=0, range=0-1836).

Multilevel Modeling. All Level 1 and Level 2 variables were group-mean centered. Therefore, at Level 1, an individual's physical activity was understood relative to the average observed in the entire Level 2 group. To longitudinally examine Hypothesis 1, the analysis was first conducted between overall physical activity and alcohol use, and was then repeated for vigorous, and moderate physical activity (binge consumption rates were too low to include in the analyses). To examine Hypothesis 1A, the analysis was then conducted between alcohol use for and sport and exercise activities.

First, an unconditional model with no Level 1 or 2 predictors included in the model was estimated to determine how much variability in alcohol use existed within versus between people. In this model, the outcome measure is not modeled as a function of variables at any level of analysis.

Level 1 (L1): $AlcoholUse_{di} = \beta_{0i} + e_{di}$

Level 2 (L2): $\beta_{0i} = \Upsilon_{00} + U_{0i}$

Here, in the empty longitudinal model, alcohol use is the outcome of day *d* for person *i*. The Level 1 model describes within-person variation in alcohol use as a function of a person-specific intercept (β_{0i}) and a day- and person-specific residual deviation from that intercept (e_{di}). The Level-2 model describes between-person variation in the mean alcohol use across days as a function of a fixed intercept (Υ_{00}), which is the grand mean for the sample, and a person-specific random intercept (U_{0i}), which is the difference between the grand mean and the person *i*'s mean across days.

Next, to investigate the relationship between physical activity and alcohol use, a model with only the Level 1 predictor physical activity was estimated.

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i} (PhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + U_{0i}$

$\beta_{1i} = \Upsilon_{00} + U_{1i}$

Upon doing so, the Level-1 effect of daily physical activity is now specifically the within-person effect of physical activity. Here, alcohol use is person *i*'s alcohol use for day *d*, β_{0i} is the predicted value of alcohol use for person *i* when all predictors are at the sample mean during day *d*, β_{1i} is the within-person regression coefficient for the predictor for person *i*, and e_{di} is the random residual component. Physical activity was group mean

centered; thus β_{0i} can be interpreted as the predicted value for alcohol use adjusting for physical activity. Within the intercept model, Υ_{00} represents the average level of alcohol use (mean intercepts). The final Level 2 regression model predicts the Level-1 within-person associations between physical activity and alcohol use.

Hypothesis 1 (longitudinal), which suggested a positive association would exist between total physical activity and alcohol use, was not supported. The empty longitudinal model for overall physical activity returns a group mean of alcohol use across days (fixed intercept Υ_{00}) of -1.46 with a random intercept variance (τ_0^2) of 2.38 and a residual variance (σ_e^2) of 2.72. These variance components were then used to calculate an intraclass correlation (ICC). The ICC helps determine how much variability in alcohol use can be explained by within-versus between-person differences. The ICC indicated that 46% of the variability in alcohol use was due to differences in between people, while 54% was due to within-person differences. The fixed intercept (Υ_{00}) indicated the mean drinking level was significantly different from zero ($p<.001$). The first conditional model testing the effects of total physical activity indicated that increasing total physical activity is associated with a decrease in the estimated rate of alcohol use, ERR=0.39, $p=.000$. Therefore, a 1-point increase in overall physical activity decreases the amount of alcohol consumed by 39%; an increase in 100 METs of overall physical activity per day will decrease alcohol consumption by 39%. The final model results for all overall physical activity models are presented in Table 5.

The next set of models examined the effects of vigorous physical activity on alcohol use, and provided evidence of an inverse relationship between vigorous physical activity and alcohol use. These results do not support Hypothesis 1 that longitudinally a

positive association between vigorous physical activity and alcohol use would exist (Υ_{00}= -1.41, p<.001, τ_0^2=2.21, σ_e^2=2.80). The conditional model testing the effects of vigorous physical activity indicated that increasing daily vigorous physical activity is associated with a decrease in the estimated rate of alcohol use, ERR=0.41, p<.001. Therefore, a 100 MET per day increase in vigorous physical activity decreased the amount of alcohol consumed by 41%. The final model results for all vigorous physical activity models are presented in Table 6.

The moderate physical activity models revealed support for Hypothesis 1 (longitudinal), with the empty longitudinal model returning a group mean of alcohol use across days (Υ_{00}) of 1.35 with a random intercept variance (τ_0^2) of 2.28 and a residual variance (σ_e^2) of 2.99, the ICC indicated 43% of the variability in alcohol use was due to differences in between people, while 57% was due to within-person differences. The fixed intercept (Υ_{00}) indicated the mean drinking level was significantly different from 0 (p<.001). The conditional model examining the effects of moderate physical activity on alcohol use showed a positive association between moderate physical activity and alcohol use, ERR=1.06, p<.001; a 100 MET daily increase in moderate physical activity increases alcohol use by 6%. Therefore, in contrast to overall and vigorous physical activity, moderate activity was associated with greater alcohol use. All moderate physical activity results are presented in Table 7.

To examine Hypothesis 1A, the next set of models evaluated the longitudinal association between sport and exercise activities with alcohol use. When examining the effects of sports on alcohol use, the empty longitudinal model returned a group mean of alcohol use across days (Υ_{00}) of -1.76 with a random intercept variance (τ_0^2) of 2.68 and a

residual variance (σ_e^2) of 2.37. The ICC indicated that 53% of the variability in alcohol use was due to differences in between people, while 47% was due to within-person differences. The fixed intercept (Υ_{00}) indicated the mean drinking level was significantly different from zero ($p<.001$). The conditional model indicated Hypothesis 1A was not supported, increasing daily sports activities was associated with a decrease in the estimated rate of alcohol use ERR=0.21, $p<.001$. Therefore, a 100 MET daily increase in sports decreases the amount of alcohol consumed by 21%. The final model results for all sport activity models are presented in Table 8.

Finally, the next set of models examined the effects of exercise on alcohol use. The unconditional model ICC indicated that 48% of the variability in alcohol use was due to differences in between people, while 52% was due to within-person differences in exercise (Υ_{00}=-1.59, $p<.001$, τ_0^2=2.62, σ_e^2=2.79). The conditional model indicated Hypothesis 1A was not supported, increasing exercise was associated with a decrease in the estimated rate of alcohol use ERR=0.26, $p<.001$. Contrary to my prediction, results indicate an inverse relationship between exercise and alcohol use exists; a 100 MET daily increase in exercise decreases the amount of alcohol consumed by 26%. The final model results for all exercise activity models are presented in Table 9.

Moderators. Next, to investigate the role of several moderators (e.g., role of age), several models with the possible Level-2 (time-invariant) moderator variables were tested. To differentiate between the time-varying, within-person effect of daily physical activity and the time-invariant between-person effect of person mean physical activity, a new predictor variable was introduced for person mean physical activity. Upon doing so, the Level-1 effect of daily physical activity was now specifically the within-person effect

of physical activity, and the Level-2 effect of person mean physical activity was the contextual effect of person mean physical activity. Next, analyses continued by adding interactions of both effects with the moderator to the model for the means. The role of daily physical activity in the model was also examined for the variances by adding a Level-2 random slope for physical activity. These models allowed for testing the cross-level interactions between the Level-2 and the Level-1 variables. The following equations were modeled to test each potential moderator:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i} (GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01} (Moderator_i) + \Upsilon_{02} (PMPhysicalActivty_i) + \Upsilon_{03}$

$(PMPhysicalActivity_i * Moderator_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11} (Moderator_i) + U_{1i}$

In the model, β_{0i} is the predicted value of alcohol use per person *i*, when physical activity, the moderator, and physical activity x the moderator are equal to the person mean during interaction *i*, β_{1i} is the within-person slope of the physical activity and alcohol use relationship for person *i*, and e_{di} is the random effects residual component. The Level-2 effect of person mean physical activity is the contextual effect of person mean physical activity. These equations were modeled for each suggested moderator, see Appendix C for a full list of the equations modeled for each individual moderator variables.

Hypothesis 2 (longitudinal) was supported; longitudinally, the positive association between moderate physical activity and alcohol use was moderated by several individual difference factors which are described below. See Figures 1-3 for a depiction of the significant interactions.

Gender – Hypothesis 2B. Support for Hypothesis 2B (longitudinal) was found with results revealing a significant moderating effect of gender on the association between moderate physical activity and alcohol use. The Level-1 effect of moderate physical activity (Υ_{10}) in this model is significant increased to 0.05 (SE = 0.01, $p<0.001$), and the Level-2 effect of person-mean moderate physical activity (Υ_{02}) is 0.21 (SE = 0.08, p =0.01) is also significant. The Level-1 within-person effect of daily moderate physical activity indicates that alcohol use is expected to be 5% higher on days when moderate physical activity occurs, holding person mean moderate physical activity constant. The Level-2 contextual effect then indicates the incremental effect of being a "high moderate physical activity person" on mean alcohol use over time, after controlling for today's moderate physical activity. The context effect operates at the global level, affecting the outcome across days; for every unit increase in person mean moderate physical activity, a person's alcohol use is expected to be 21% higher each day on average.

The main effect of gender was not significant; however the Gender X Moderate Physical Activity interaction was significant, and is depicted in Figure 1. As seen in the pattern of results, the effects of moderate physical activity on alcohol use was stronger in male participants. The male and female, low versus high moderate physical activity conditions did not differ significantly ($p>.05$). When examining the overall probabilities associated with the Gender X Moderate Physical Activity interaction, participants who were in the high moderate physical activity condition who were men (.99) had the highest probability of consuming alcohol, men in the low moderate physical activity condition still had a high probability of consuming alcohol (.90) while female participants in the

high moderate physical activity condition had a much lower probability (.49) and female participants in the low moderate physical activity condition had the lowest probability of doing so (.44).

Social Motives – Hypothesis 2C. Support for Hypothesis 2C (longitudinal) was found, the Level-1 effect of moderate activity (Υ_{10}) is significant increased to 0.02 (SE = 0.01, p=0.04), and the Level-2 effect of person-mean moderate physical activity (Υ_{02}) is 0.05 (SE = 0.02, p =0.01) is also significant. There was a significant main effect of person-mean moderate physical activity for social motives. The Level-1 within-person effect of daily moderate physical activity indicates that alcohol use is expected to be 2% higher on days when moderate physical activity occurs, holding person mean moderate physical activity constant. The Level-2 contextual effect then indicates the incremental effect of being a "high moderate physical activity person" on mean alcohol use over time, after controlling for today's moderate physical activity. The context effect operates at the global level, affecting the outcome across days; for every unit increase in person mean moderate physical activity, a person's alcohol use is expected to be 5% higher each day on average. Finally, the cross-level interaction of daily moderate physical activity and person mean moderate physical activity, was significant, indicating social motives have a moderating effect on the positive association between moderate physical activity and alcohol use. This interaction is depicted in Figure 2. As seen in the pattern of results, the positive impact of moderate physical activity on alcohol use was increased in individuals with high social motives.

Follow-up tests were conducted to further investigate the significant interaction by centering the moderator at 1 *SD* above and below the mean, re-running the analyses

and then reinterpreting the main effects after doing so. These follow up tests revealed that when comparing individuals with high levels of social motives, the high and low moderate physical activity conditions did not differ significantly from one another (p>.05). Likewise, when comparing individuals with low levels of social motives, the moderate physical activity conditions did not differ significantly from one another (p>.05). Probabilities were calculated for the conditions that differed significantly; participants who were high socially motivated in the high moderate physical activity condition had a .98 probability of consuming alcohol versus the low moderate physical activity condition had a .86 probability of consuming alcohol, whereas individuals with low social motives in the high moderate physical activity condition only had a .30 probability and those in the low moderate physical activity condition had a .26 probability of doing so.

Hypotheses 2A, 2D, and Research Questions 2 and 3. Longitudinal Hypotheses 2A and 2E were not supported; age and self-monitoring, did not moderate the positive association between moderate physical activity and alcohol use. Research questions 2 and 3 produced no evidence of moderation for sexual orientation or BMI. Additionally Greek affiliation and medical condition were examined as potential moderators and no significant effects were found.

Age. Although there were no specific hypotheses proposed for moderating effects of the negative relationships between overall, vigorous, sports, or exercise activities, the moderator variables were tested against all significant associations. Only the models examining vigorous physical activity revealed a significant effect; Level-1 effect of vigorous physical activity (Υ_{10}) is significant increased to -0.06 (SE = 0.03, p=0.03), and

the Level-2 effect of person-mean vigorous physical activity (Υ_{02}) is -0.15 (*SE* = 0.07, *p* =0.04) is also significant. The Level-1, within-person effect of daily vigorous physical activity indicates that alcohol use is expected to be 6% lower on days when vigorous physical activity occurs, holding person mean vigorous physical activity constant. The Level-2 contextual effect then indicates the incremental effect of being a "high vigorous physical activity person" on mean alcohol use over time, after controlling for the days vigorous physical activity. The context effect operates at the global level, affecting the outcome across days; for every daily 100 MET increase in person mean vigorous physical activity, a person's alcohol use is expected to be 15% lower on average. Although there was no main effect of age, I examined the cross-level interaction of daily vigorous physical activity and person mean vigorous physical activity, and whether this interaction differed by age (represented in the Level-2 equation).

A significant interaction (*p*=0.04; see Figure 3) indicated age has a moderating effect on the negative association between vigorous physical activity and alcohol use. Specifically, older individuals demonstrated a stronger negative effect of vigorous physical activity on alcohol use. Younger participants who were in the high vigorous physical activity category had a .64 probability of consuming alcohol, and younger participants in the low vigorous physical activity category had a .62 probability of consuming alcohol. Overall, participants with the lowest probability of alcohol consumption were those who were older in the high vigorous physical activity category (.46), while those with the highest probability were younger participants in the low vigorous physical activity category (.64).

Exploratory Analyses. Several additional exploratory analyses were performed to examine Research Question 1: do other types of physical activity (low, leisure, domestic, occupation, and transportation) have an effect on alcohol use? The effect of low, occupational, and transportation physical activity was non-significant therefore no further analyses were performed for these variables. There were however, significant positive effects for leisure and domestic physical activity on alcohol use. The empty model demonstrated a group mean of alcohol use across days (Υ_{00}) of 1.69 (p<.001) with a random intercept variance (τ_0^2) of 2.62 and a residual variance (σ_e^2) of 2.42 for leisure activity. The ICC indicated that 51% of the variability in alcohol use was due to differences in between people, while 49% was due to within-person differences. The conditional model tested the effects of leisure activities indicated that increasing leisure physical activity is associated with an increase in the estimated rate of alcohol use, ERR=1.04, p<.001. Therefore a 100 MET daily increase in leisure activity increases alcohol use by 4%. The final model results for all leisure activity models are presented in Table 10.

The final set of exploratory models examined the effects of domestic physical activity on alcohol use revealing a positive association between domestic activities and alcohol use. Results indicated 49% of the variability in alcohol use was due to between-person differences, and 51% was due to within-person differences. The empty longitudinal model returning a group mean of alcohol use across days (Υ_{00}) of 1.61 (p<.001) with a random intercept variance (τ_0^2) of 2.64 and a residual variance (σ_e^2) of 2.67. The conditional model tested the effects of domestic activity indicated that increasing domestic activity is associated with an increase in the estimated rate of alcohol

use, ERR=1.03, $p<.01$. Therefore, increasing domestic activity by 100 METs per day increases alcohol use by 3%. The final model results for all domestic activity models are presented in Table 11.

CHAPTER IV

DISCUSSION

Considering the numerous potential negative consequences of alcohol use (sexual assault, death), with nearly 50% of college students reporting engaging in binge drinking, 82% reporting drinking within the last week (Wechsler & Nelson, 2001; Hingson et al., 2005), and physical inactivity ranking highest among college freshman (Delinsky & Wilson, 2008; Holm-Denoma, Joiner, Vohs, & Heatherton, 2008), alcohol use and physical activity (or lack thereof) for college students is of serious concern. Unfortunately, the inconsistent findings regarding the nature of the relationship between physical activity and alcohol use make it difficult to potentially address either issue individually (French, Popovici, & Maclean, 2008; Musselman & Rutledge, 2010). Additionally, researchers using the Behavioral Risk Factor Surveillance System (BRFSS) data have demonstrated a positive alcohol-activity association in adults aged 21-64 years, indicating the association may extend well beyond the college years. Therefore, it is essential that a clearer understanding of the mechanisms that underlie the relationship between physical activity and alcohol use in college students be obtained.

The main purpose of this dissertation was to examine the physical activity-alcohol use relationship in the college population in greater detail by first testing to see whether physical activity is positively related to alcohol use both concurrently and prospectively. A second aim of this study was to determine whether this positive relationship exists for different types of activities. Because physical activity is a complex, multidimensional behavior which includes numerous components including energy expenditure, frequency, duration, intensity, mode, and weight bearing or non-weight

bearing (LaPorte, Montoye, & Caspersen, 1985), multiple forms of physical activity were also considered within this dissertation. A final goal of this dissertation was to address potential contributing individual difference factors (age, gender, sexuality, social motives, self-monitoring, and BMI) that might moderate the observed relationships between alcohol use and physical activity.

The present study provided strong support for the existence of a positive association between alcohol use and moderate physical activity among college students. This association was identified both cross-sectionally as well as longitudinally; therefore Hypothesis 1 was partially supported. Multilevel analyses revealed that this effect is significant at both the between-person and within-person levels, indicating that the individual college students' moderate physical activity as well as the overall level, or contextual effect of moderate physical activity, has a positive relationship with alcohol use. This paradoxical positive association between moderate physical activity and alcohol use has also been noted in prior studies cross-sectionally (Lisha et al., 2011; Mussleman & Rutledge, 2010; Pate et al., 1996), and appears to hold when investigating the association longitudinally.

Although a positive association between moderate physical activity and alcohol use was identified both cross-sectionally and longitudinally, the positive effect was not found for vigorous or overall physical activity; instead a significant negative association was found for vigorous and overall physical activity. These results contradict what prior researchers have demonstrated concurrently (e.g., cross-sectionally both overall and vigorous physical activity have demonstrated a positive association with alcohol use; Lisha & Sussman, 2010; Vickers et al., 2004), and are an indication that when evaluating

the association between alcohol use and physical activity, different levels and types of physical activity need to be considered depending on whether behavior is being analyzed over time or not. Interestingly, although the current cross-sectional analyses demonstrated that moderate physical activity was the only type of activity to elicit a significant association of any kind, longitudinal analyses show moderate physical activity, as well as domestic and hobby activities demonstrated a positive association with alcohol use, while overall and vigorous physical activity demonstrated a significant negative association.

Additionally, a positive association between alcohol use and leisure and domestic activities was found. One possible explanation is that leisure activities promote more alcohol consumption in college students because college students engage in leisure physical activities with other college students in and around settings that are prone to involve alcohol. For example, college students might ride their bikes on the weekend together for leisure, however their final destination may be a local bar or brewery (which is particularly common in the settling this sample was living). Another potential explanation of the leisure physical activity-alcohol use association is a "work hard-play hard" attitude (Mussleman & Rutledge, 2010); individuals who engage in leisure physical activity may maintain a "play hard" attitude which is more conducive to alcohol consumption. Clearly more research is needed to see whether there is an image of individuals who self-report engaging in leisure physical activities (i.e., "work hard, play hard" image) that could increase alcohol consumption behaviors. Domestic physical activities reported included a variety of behaviors that would occur at or around the home, including sex, cleaning, watching TV, and cooking. Interestingly a positive relationship between housework and alcohol consumption has been identified in the past

(Faird, 1989), and was attributed to marital dissatisfaction, however only 6% of the participants in the current study were married. Furthermore, a wide variety of literature suggests that alcohol use and sexual behaviors have a positive relationship (Cooper, 2002; EMCDDA, 2005; Murphy, 1998), however those previous studies were not investigating sex as a form of domestic physical activity. Because participants reported time involved in all domestic activities and did not specify what type of domestic behavior, there is no way of telling whether participants are drinking while watching sports on television (and are inundated with alcohol advertisements and commercials; Madden & Grube, 1994), or whether participants are drinking at the bar and engaging in sexual activities while intoxicated. Future studies would benefit by addressing this by separating the different types of domestic activities.

Interestingly, the present study provided longitudinal evidence of a more congruous (in terms of health effects) negative association between alcohol use and four types of physical activity (overall, vigorous, sport, and exercise). As healthy behaviors tend to group together across college students (Keller, Maddock, Hannover, Thyrian, & Heinz-Dieter, 2008), these negative associations are more in-line with what research regarding healthy and unhealthy behaviors has revealed (DeVries et al., 2007; Mistry, McCarthy, Yancey, Lu, & Patel, 2009). Empirical findings regarding the clustering of healthy and unhealthy behaviors suggest that, overall; students who are more physically active tend to consume less alcohol and vice versa (Raynor & Levine, 2009). As overall and vigorous physical activity are known to be protective factors against cardiovascular and other chronic diseases (USDHHS, 1996), individuals with higher levels of overall or vigorous physical activity may have lower levels of alcohol use and therefore a decreased

risk for developing certain diseases associated with alcohol use and physical inactivity. Interestingly, age significantly moderated the negative association between vigorous physical activity and alcohol use; a stronger and negative effect of vigorous physical activity on alcohol use was seen for older participants. A recent, cross-sectional analysis of the alcohol-physical activity association also found support of age as a moderator when investigating vigorous physical activity and alcohol use in the past year (Lisha, Martens, & Leventhal, 2011); however the moderating effect was in a positive direction with younger adults. Clearly, age in an important variable to consider when investigating the physical activity-alcohol use association, as age could potentially be related to both positive and negative associations.

Not surprisingly, evidence of a negative relationship between exercise on alcohol use was also found. Support for these results has been provided cross-sectionally by Kulbok and Cox (2002), who used the 1992 Youth Risk Behavior Survey to show that alcohol use was negatively correlated with exercise in a sample of 14 to 21 year-olds, with more alcohol use being associated with less exercise. Conversely, a number of researchers have identified a positive relationship between exercise and alcohol use, therefore the evidence surrounding the relationship between exercise and alcohol use is inconsistent. The sample of college students accessed within this dissertation reported being highly physically active, therefore the majority of participants in the study may be more health conscious than other populations. A person who exercises for the sake of being healthy differs from the exerciser who uses the gym as social time. Kilpatrick and colleagues (2005) have shown that self-reported exercisers are more motivated to exercise for fitness-health related reasons when compared to sport-team players who

were more socially motivated to play team-sports. These results indicate there is a need for a more detailed understanding of college students' exercise behaviors because exercise may serve as a protective factor against alcohol use. Additionally, maintaining an active lifestyle through exercise during college may lead to an active lifestyle later in life (American College Health Association, 2002; Sparling & Snow, 2002). For example, a recent study showed that of the 44% of college students who reported regular exercise during college, 85% were engaging in similar or higher levels of physical activity following graduation (Sparling & Snow, 2002). If exercise is associated with less alcohol use in college, it may be associated with less alcohol use later in life as well; these results indicate exercise is an important variable to focus on in the college population.

The results did not support my hypothesis that a positive association between sport and alcohol use would be found, instead this study found a negative relationship. There are a variety of studies which provide inconsistent results regarding the sports and alcohol use association; some studies of the effects of sports have shown a positive overall association (Eccles & Barber, 1999), while some studies have not (Moulton, Moulton, Whittington, & Cosio, 2000). The negative relationship identified within this dissertation between sport physical activity and alcohol use has been identified when examining other chemical substance use in college students. For example, Lisha and Sussman (2010) found an inverse relationship between athletics participation and cigarette use and a variety of researchers have reported a negative relationship between illicit drug use and sport participation (Anderson, Albrecht, McKeag, Hough, & McGraew, 1991; Pate et al., 1996; Wechsler, Davenport, Dowdall, Grossman, & Zanakos, 1997). Participants recorded their total minutes of sport engagement, but

participants did not report whether they participated in team or university sports, which may explain why the effects in this study were different than prior research. For example, there is a variety of literature that indicates that college students who play sports (varsity or inter-collegiate athletes), are more likely to consume alcohol and to drink in problematic ways than non-athletes (Leichliter, Meilman, Presley, & Cashin, 1998; Martens, Dams-O'Connor, & Beck, 2006). Support for this college sport-team relationship was recently identified when Dunn and Wang (2003) found both male and female college students who had participated in sport-team activities had consumed alcohol in the past 30 days. Perhaps the competitive nature of sport-team physical activity encourages college students to drink, as research has shown that not only do sport-team members drink more, but those who are invested in or involved in the team-sport more consume larger amounts than members who are less involved (Hildebrand, Johnson, & Bogle, 2001). These results illustrate the notion that there may be a protective nature of sport participation; however the nature may depend on sport participation versus sport-team membership.

A partial explanation of the mixed findings regarding the relationship between physical activity and alcohol use is dependent on certain individual difference characteristics that tend to vary across samples. The present study also extends prior research on the physical activity-alcohol use association by examining the potential moderating effects of age, gender, sexuality, social motives, self-monitoring, and BMI. By demonstrating the positive association between moderate physical activity and alcohol use both concurrently and prospectively, this study provides strong support for

Hypothesis 1; however the longitudinal association varies when gender and social motives are added to the equation, providing support for Hypothesis 2.

Gender was hypothesized to moderate the physical activity-alcohol association because gender has been identified by prior researchers as a potential moderator of the cross-sectional physical activity-alcohol use association (Hoffmann, 2006; Mays & Thompson, 2009; Pate et al., 1996). Within this study, gender did not have a significant main effect, however it significantly moderated the association between *moderate* physical activity and alcohol use, and specifically the effects of moderate physical activity on alcohol use were stronger in male participants. Lisha and colleagues (2011) have also shown that gender moderates the cross-sectional association between past year's moderate physical activity and alcohol use, with male participants showing a stronger association than female participants. This same moderation was found by Buscemi and colleagues (2011) when examining potential moderators of both moderate and vigorous physical activity on alcohol use. As moderate physical activities often involve behaviors that are considered recreational or for leisure, a possible explanation for this gender moderation may be that men are more likely than women to engage in leisure or recreational sports and activities which promote alcohol use. For example, men might be more likely to engage in recreational sports such as fishing that encourage drinking behavior among men, while women are more likely to engage in exercise as part of a substance-free physical activity (Murphy, Barnett, Goldstein, & Colby, 2007). Because a variety of studies have shown gender differences in types of activities exist (e.g., exercise versus sports; Murphy et al., 2007), it is important to note there were not

significant differences between males and females when examining exercise and sport activities.

Within this study there was also support for Hypothesis 2C, in that a significant moderating effect of social motives was found. Specifically, individuals with a higher level of social motives demonstrated a stronger association between moderate physical activity and alcohol use. Prior research has established social motives as an important predictor of alcohol use (Corbin, Iwamoto, & Fromme, 2011) and physical activities (Martens et al., 2006). If one strongly values engagement in social activities, the potential for alcohol consumption or physical activity to improve social interaction should be particularly attractive. This effect of social motives is not surprising, physically active college students may enjoy positions of higher social status or privilege than non physically active students (Martens et al., 2006; Sussman et al., 2007), yet this increased social status may come with a potential increase in alcohol use.

As discussed above, gender and social motives moderated the positive effects of moderate physical activity on alcohol use, and age moderated the negative effects of vigorous physical activity on alcohol use. Although sexuality, self-monitoring, and BMI had no moderating effects within this study, prior research indicates these individual difference variables have significant relationships with both physical activity and alcohol use and should still be considered in future studies examining the physical activity-alcohol use association.

Although research examining the relationship between physical activity and alcohol use has expanded, few have examined sexual orientation. To date there have not been any studies outside of this dissertation known to have examined the effects of an

individuals' sexual orientation on the association between physical activity and alcohol use. Differences in alcohol use and vigorous physical activity have been found when comparing heterosexual individuals to non-heterosexual individuals (Aaron et al., 2001, Moran, 1996; Case et al., 2004), with non-heterosexuals reporting greater levels of both behaviors. Within this study only around 10% of the population identified as not-entirely-heterosexual, with over half of those individuals indicating they were not entirely homosexual either. To address the large gaps in the literature regarding homosexual health (Solarz, 1999), ideally future studies would acquire a sample with a larger percentage of individuals identifying as homosexual. Because a variety of health behaviors are shown to be affected by sexual orientation (Solarz, 1999), it is recommended that future studies investigating the physical activity-alcohol use association also include sexual orientation as an individual difference variable.

Interestingly BMI had no effect on the physical activity-alcohol use association. Consistent with my results, Randell and Wells (1998) have shown that BMI is not a significant predictor of leisure time physical activity; however the majority of research shows that BMI is a strong negative predictor of physical activity (Ingledew, Hardy, & De Sousa, 1995; Pajari, Pietilainen, Kaprio, Rose, & Saarni, 2010; Shoenborn & Stommel, 2011). Recently, Shoenborn and Stommel (2011) provided evidence of a negative relationship between BMI and aerobic activity as well as aerobic activity and alcohol use. Consistent with these results, Pajari and colleagues (2010) examined the relationship between BMI and alcohol use from adolescence to adulthood and found that BMI and alcohol use were inversely related, and vigorous physical activity was inversely related to alcohol use. Although BMI had no significant moderating effects within this

study, the potential for BMI to contribute to this relationship is there, as evidenced by prior research.

Limitations

While this study provides the first longitudinal examination of the physical activity-alcohol use relationship, there are some important limitations. The first limitation involves the use a convenience sample of college students; sampling issues can occur if the sample is not representative of the population it intends to study (Gall, Gall, & Borg, 1999). However, as the population of interest within this dissertation was college students, utilizing the PSY100 participant pool at CSU was appropriate. Self-selection could also have been a problem. The participants had a basic knowledge of the issues being investigated (physical activity), and therefore individuals who selected to participate in this study may be inherently different than individuals who did not. For example, the mean level of overall physical activity was extremely high – roughly 900 METs over what the IPAQ creators consider highly physically active – indicating this sample of college students is extremely physically active overall. Persons who did not respond may have had different experiences than those captured by the present study. Additionally, this study was conducted in Colorado which is considered the leanest state in the nation (Sealover, 2012) and where outdoor activities are abundant; as indicated by the high average of total physical activity reported both cross-sectionally and longitudinally the sample used for this study may not reflect the same activity levels as individuals not living in Colorado or similar regions.

Another limitation of the present study involves the self-report nature of the data collection. Self-report data is subject to distortion and omission of important information

(Gall et al., 1999). Participants may have inflated certain information, or may not have disclosed certain information in order to impress the experimenter favorably. In order to increase the accuracy of the data collected, the interviewer took time to build rapport during the T1 and T2 meetings, and to provide reassurance in regards to the confidentiality of the study. Additionally, a limitation regarding the reporting of physical activity is the participants' ability to remember details of recent physical activity; therefore participants reported their behaviors every twenty-four hours because short-term questionnaires are less affected by forgetfulness. Unfortunately, this type of reporting may not reflect seasonal variation in physical activity and may not take into account the individual's typical, regular, or usual activity over a year long period (Washburn & Montoye, 1986).

An additional limitation is that no information was collected about whether participants in this study were actively involved with collegiate sports. It has been argued that team membership rather than the physical activity (sport) is an important feature in determining alcohol use, perhaps because televised sports events publish more commercials for alcoholic products than for any other beverage (Madden & Grube, 1994), and alcohol advertising can be found at sporting events through stadium signs and on-site promotionals. This could help explain why other researchers have found a positive relationship with sports and alcohol use and the current study did not. Furthermore, the low daily sport activities reported might be a reflection of having an over-representation of female participants. There were only 69 male participants within this study, and although gender acted as a moderator this moderating effect could potentially be stronger with a more adequate male sample.

Finally, this study was correlational in nature therefore the temporal nature of the relationship between physical activity and alcohol use is still unknown. For example, it could be that alcohol use increases physical activity; as alcohol is a depressant the relationship examined within this dissertation is considered more probable. A lack of causal relationships can be limiting in suggesting future implications because it remains unknown if moderate physical activity causes the increases in alcohol use that were found in the present study, or if there are other potential causal factors unexplored herein. Although causal relationships cannot be inferred, this study was longitudinal in nature; the relationship was captured over a three-week period of time.

Conclusions and Implications

These results confirm the notion that some healthy behaviors should be clustered with other healthy behaviors; college students that are engaging in vigorous physical activities, including sports and exercise (healthy behaviors), are *less* likely to consume alcohol (healthy behavior). The present study provides some support for the existence of an incongruous positive relationship between moderate physical activity and alcohol use in college students. Although this association has been noted in prior studies, those studies were limited in terms of the participants studied and the definitions of alcohol use and/or physical activity utilized. Because the present study examined the relationship cross-sectionally as well as longitudinally, defined physical activity broadly, assessed physical activity using a reliable and valid instrument, assessed alcohol use in a variety of ways, and examined several potential individual difference variables as they relate to the alcohol-activity association, replicating the positive association cross-sectionally and

longitudinally within this study serves to more firmly establish the existence of this surprising relationship for moderate physical activity.

Further understanding of the physical activity-alcohol use relationship among college students and the variables that affect that relationship has several implications for increasing physical activity and decreasing alcohol consumption in college populations. Estimates of the total overall costs of substance abuse in the United States, including losses in productivity, as well as crime and health-related costs exceed one-half trillion dollars annually, and this figure includes $185 billion for alcohol alone (Harwood, 2000). As staggering as these numbers seem, they reflect only a minor portion of the overall public health and safety implications (e.g., family disintegration, school failure, homelessness, employment loss, domestic violence, child abuse, and other crimes). As a result, to provide a cost-effective strategy at reducing the burden of the overall cost of disease treatment, many organizations and government systems are promoting exercise programs as a form of prevention initiative (WHO, 2009; CDC, 1999). However, these results indicate that any intervention messages which are too simplistic, such as, "Be healthy, drink less and exercise more," may not be as effective as messages which consider the role of individual difference variables. Understanding which individual difference variables (e.g., gender, social motives) affect the physical activity-alcohol use relationship will allow researchers and specialists to potentially formulate a more adequate intervention message. One intervention message might be proffered for all college students who have social image concerns, and another intervention might be tailored specifically for men.

Next, the present findings suggest that programs need to consider the specific type of physical activity, in particular moderate physical activity. These findings are supported by several other researchers (Lisha et al., 2011; Mussleman & Rutledge, 2010) who have cross-sectionally identified the association with moderate physical activity and alcohol use. Finally, these findings suggest that interventions designed to decrease alcohol use should also address moderate physical activity and similarly, programs that aim to increase moderate physical activity should also address alcohol consumption. Prior research provides some evidence of support for the efficacy of intervening in the areas of alcohol use and physical activity simultaneously (Werch, Moore, DiClemente, Owen, Jobli, & Bledso, 2003; Werch, Moore, DiClemente, Bledsoe, & Jobli, 2005), and a similar approach may be just as effective with college populations. For example, college programs designed to increase moderate physical activity may promote physical activities that involve socializing with friends (i.e., riding bikes) while simultaneously addressing the potential to engage in non-alcoholic events post physical activity (i.e., instead of riding your bikes to a brewery, ride them to the library or movies).

Table 1.

Correlation matrix and descriptive statistics for Cross-Sectional (Level-2) Variables

	M	*SD*	1	2	3	4	5	6	7	8	9
1. Physical Activity (Total METS)	3910	2767	1	693	785	972	255	255	419	607	-842
2. Physical Activity (Low METS)	1250	1087	.44**	1	384	518	-10.3	42	37	-145	190
3. Physical Activity (Moderate METS)	1536	1769	.81**	0.04	1	875	176	143	127	319	-339
4. Physical Activity (Vigorous METS)	1106	1252	.68**	0.04	.34**	1	89	69	254	433	-693
5. Alcohol Use (Overall)	9.83	11.04	0.06	-0.01	0.12*	0.03	1	1.85	0.35	0.21	-0.08
6. Alcohol Use (Binge)	2.01	1.2	0.09	0.02	0.14*	0.05	.85**	1	0.24	0.18	-0.18
7. Social Motives	3.05	0.7	.21**	0.03	.17**	.21**	.28**	.29**	1	0.13	-0.52
8. Self-Monitoring	10.57	2.24	0.10	-0.05	0.09	.11*	0.03	0.05	0.06	1	-1.49
9. BMI	23.21	4.1	-0.07	0.05	-0.06	-0.09	0.02	-0.03	-.16**	-.16**	1

Note: Upper diagonal reflects covariances, lower diagonal reflects correlations; (*) denotes a significant correlation at the .05 level; (**) denotes a significant correlation at the .001 level

Table 2.

Group means, standard deviations, and univariate effects of all moderator variables on cross-sectional (Level 2) data.

	Male	Female			Hetero	Not Hetero			Young	Old			Low BSM	High BSM			Low SM	High SM			Low BMI	High BMI		
	M (SD)	*M* (SD)	*F*	*p*	*M* (SD)	*M* (SD)	*F*	*p*	*M* (SD)	*M* (SD)	*F*	*p*	*M* (SD)	*M* (SD)	*F*	*p*	*M* (SD)	*M* (SD)	*F*	*p*	*M* (SD)	*M* (SD)	*F*	*p*
Total PA	**4591 (3227)**	**3753 (2613)**	**5.48**	**.02**	2890 (2500)	4028 (2773)	2.97	.08	4029 (2630)	3758 (3174)	0.87	.55	**3376 (2150)**	**4480 (3252)**	**11.39**	**.00**	3712 (2628)	4317 (3071)	3.22	.07	4179 (2850)	3488 (2525)	0.82	.72
Low PA	1167 (1029)	1284 (1089)	0.95	.33	959 (1067)	1293 (1087)	1.62	.20	1295 (1083)	1182 (1077)	0.79	.63	1251 (1006)	1251 (1161)	0.06	.80	1298 (1143)	1167 (962)	1.32	.25	1262 (1075)	1331 (1150)	0.55	.93
Moderate PA	1330 (1463)	1067 (1201)	1.78	.18	**751 (816)**	**1148 (1283)**	**3.03**	**.05**	1155 (1257)	1055 (1315)	1.11	.35	**886 (1014)**	**1351 (1454)**	**8.75**	**.00**	**1022 (1214)**	**1289 (1357)**	**3.71**	**.05**	1155 (1263)	985 (1209)	0.82	.71
Vigorous PA	**2128 (2148)**	**1381 (1637)**	**10.95**	**.00**	1180 (2160)	1576 (1738)	0.45	.50	**2117 (1644)**	**1496 (1514)**	**3.07**	**.05**	**1214 (1334)**	**1892 (2116)**	**11.18**	**.00**	**1393 (1600)**	**1828 (2076)**	**4.66**	**.03**	1734 (1891)	1171 (1466)	0.78	.75
Alcohol Use	**11.46 (12.37)**	**6.79 (7.77)**	**11.56**	**.00**	7.75 (9.09)	9.14 (9.95)	0.44	.50	8.61 (9.20)	7.31 (9.17)	0.62	.79	8.03 (9.40)	7.44 (8.78)	1.21	.27	7.25 (8.54)	8.44 (9.79)	1.49	.22	7.54 (9.37)	8.04 (8.77)	0.85	.68
Binge Drinking	**2.34 (1.37)**	**1.89 (1.12)**	**5.45**	**.02**	2.25 (1.22)	1.99 (1.20)	0.34	.56	1.98 (1.21)	2.03 (1.17)	0.74	.68	2.03 (1.27)	1.91 (1.11)	1.29	.26	1.95 (1.18)	2.06 (1.20)	0.92	.34	2.01 (1.19)	1.95 (1.19)	0.41	.99

Table 3.
Interactive effects of moderate physical activity, age, gender, sexuality, social motives, self-monitoring, and BMI on alcohol use, and simple effects analysis.

	β	***p***
Moderate Physical Activity	0.13	.03*
Age	0.02	.69
MPA x Age	-0.05	.41
Gender	-0.17	.00*
MPA x Gender	-0.01	.83
Sexual Orienation	-0.13	.03*
MPA x SO	-0.03	.57
Social Motives	0.07	.15
MPA x BSM	0.05	.39
Self Monitoring	0.01	.92
MPA x SM	-0.05	.36
BMI	0.01	.86
MPA x BMI	-0.05	.41

Note. N=313. *p<.05

Table 4.
Means for individual difference variables for participants who completed the entire study versus those who did not.

	Fully Completed (*N*=269)	Partially Completed (*N*=44)	
Variable	*Mean*	*Mean*	*t-value*
Overall METS	607.23	606.89	-0.66
Low METS	218.87	216.12	0.10
Moderate METS	156.27	158.43	0.51
Vigorous METS	269.02	267.18	-0.02
Sport	67.24	62.58	-1.10
Exercise	121.03	118.95	-1.21
Domestic	291.08	292.22	0.21
Hobby	162.11	161.85	0.15
Occupation	168.37	170.49	0.23
Transportation	216.63	218.02	-0.34
Alcohol Use (Overall)	1.18	1.02	-0.06

Table 5

Final Model results for multilevel modeling testing total physical activity

Variables	ERR (95% CI)	*t*	*p*
Hypothesis 1			
Intercept	0.23 (0.18,0.29)	-11.62	.000***
Total Physical Activity	0.39 (0.10,1.00)	-1.23	.01**
Hypothesis 2A			
Intercept	0.38 (0.01,14.57)	-0.51	.60
Age	0.98 (0.81,1.19)	-0.12	.90
Total PM	0.99 (0.98,1.00)	-1.65	.10
Age x TotPM	1.00 (1.00,1.00)	1.52	.13
Hypothesis 2B			
Intercept	0.73 (0.19,4.95)	-0.32	.75
Gender	0.63 (0.22,1.82)	-0.87	.39
Total PM	0.98 (0.98,1.00)	-0.35	.73
Gender x TotPM	0.99 (0.99,1.00)	-0.04	.97
RQ #2			
Intercept	0.24 (0.01,1.47)	-0.51	.61
Sexuality	1.05 (0.41,2.70)	0.12	.91
Total PM	0.99 (0.98,1.01)	-0.09	.93
Sexuality x TotPM	0.99 (0.99,1.00)	-0.02	.98
Hypothesis 2C			
Intercept	0.03 (0.01,0.30)	-3.00	.00**
BSM	2.13 (1.04,4.37)	1.98	.06
Total PM	1.00 (0.99,1.00)	0.32	.75
BSM x TotPM	0.99 (0.99,1.00)	-0.68	.49
Hypothesis 2D			
Intercept	0.06 (0.01,0.52)	-2.57	.01*
SM	1.17 (0.96,1.43)	1.61	.11
Total PM	1.00 (0.99,1.01)	0.74	.46
SM x TotPM	0.99 (0.99,1.00)	-1.12	.26
RQ #3			
Intercept	0.49 (0.03,9.89)	-0.46	.64
BMI	0.98 (0.86,1.11)	-0.28	.78
Total PM	0.99 (0.99,1.00)	-0.02	.98
BMI x TotPM	0.99 (1.00,1.00)	-0.20	.84

*p<.05; **p<.01; ***p<.001

Table 6

Final Model results for multilevel modeling testing vigorous physical activity

Variables	ERR (95% CI)	*t*	*P*
Hypothesis 1			
Intercept	0.24 (0.19,0.30)	-12.11	.000***
Vigorous Physical Activity	0.41 (0.09,0.99)	-5.57	.000***
Hypothesis 2A			
Intercept	0.15 (0.01,1.60)	-1.57	.12
Age	1.02 (0.91,1.16)	0.45	.65
Vigorous PM	0.28 (0.97,1.00)	-2.03	.04*
Age x VPM	1.01 (1.00,1.01)	2.01	.04*
Hypothesis 2B			
Intercept	0.79 (0.21,2.98)	-0.34	.74
Gender	0.56 (0.27,1.18)	-1.52	.13
Vigorous PM	0.99 (0.99,1.18)	-0.05	.96
Gender x VPM	0.99 (0.99,1.00)	-1.41	.66
RQ #2			
Intercept	0.98 (0.07,14.47)	-0.01	.99
Sexuality	0.80 (0.51,1.27)	-0.93	.35
Vigorous PM	0.98 (0.96,1.01)	-1.03	.30
Sexuality x VPM	1.00 (0.99,1.00)	1.01	.32
Hypothesis 2C			
Intercept	0.09 (0.02,0.39)	-3.23	.00
BSM	1.45 (0.92,2.30)	1.62	.11
Vigorous PM	0.99 (0.99,1.00)	-0.94	.35
BSM x VPM	1.00 (0.99,1.00)	0.73	.46
Hypothesis 2D			
Intercept	0.07 (0.02,0.30)	-3.67	.00***
SM	1.13 (0.99,1.29)	1.92	.06
Vigorous PM	1.00 (0.99,1.00)	1.38	.17
SM x VPM	0.99 (0.99,1.00)	-1.71	.08
RQ #3			
Intercept	0.64 (0.09,4.61)	-0.43	.66
BMI	0.96 (0.88,1.05)	-0.84	.39
Vigorous PM	0.99 (0.99,1.00)	-0.42	.68
BMI x VPM	1.00 (1.00,1.01)	0.31	.75

*p<.05; **p<.01; ***p<.001

Table 7
Final Model results for multilevel modeling testing moderate physical activity

Variables	ERR (95% CI)	*t*	*p*
Hypothesis 1			
Intercept	1.26 (0.20,0.32)	11.97	.000***
Moderate Physical Activity	1.06 (1.01,1.10)	4.88	.000***
Hypothesis 2A			
Intercept	1.36 (0.08,1.62)	1.34	.18
Age	0.94 (0.41,2.16)	-0.13	.90
Moderate PM	0.99 (0.99,1.01)	1.11	.26
Age x MPM	0.99 (0.99,1.00)	-1.51	.13
Hypothesis 2B			
Intercept	1.39 (0.01,10.64)	2.86	.00**
Gender	1.09 (0.83,1.18)	1.70	.09
Moderate PM	1.21 (0.06,1.40)	2.42	.01**
Gender x MPM	1.01 (1.00,1.01)	2.24	.02*
RQ #2			
Intercept	1.44 (0.04,8.53)	0.19	.84
Sexuality	0.78 (0.42,1.47)	-0.74	.45
Moderate PM	0.97 (0.93,1.01)	-1.50	.13
Sexuality x MPM	1.00 (0.99,1.01)	1.41	.16
Hypothesis 2C			
Intercept	1.01 (0.00,0.06)	5.79	.00***
BSM	1.69 (1.71,4.22)	4.34	.00***
Moderate PM	1.01 (1.00,1.01)	2.46	.01**
BSM x MPM	1.01 (0.99,1.01)	2.83	.00**
Hypothesis 2D			
Intercept	0.07 (0.01,0.44)	0.56	.57
SM	1.15 (0.97,1.35)	0.08	.93
Moderate PM	1.00 (0.99,1.01)	0.59	.55
SM x MPM	0.99 (0.99,1.00)	-0.94	.35
RQ #3			
Intercept	0.51 (0.06,4.36)	-0.62	.54
BMI	0.98 (0.89,1.07)	-0.41	.68
Moderate PM	0.99 (0.98,1.01)	-0.61	.54
BMI x MPM	1.00 (1.00,1.01)	0.36	.72

*p<.05; **p<.01; ***p<.001

Table 8
Final Model results for multilevel modeling testing sport activity

Variables	ERR (95% CI)	*t*	*p*
Hypothesis 1A			
Intercept	0.17 (0.11,0.25)	-8.35	.000***
Sport Physical Activity	0.21 (0.08,0.99)	-3.99	.000***
Hypothesis 2A			
Intercept	0.09 (0.01,1.16)	-1.86	.06
Age	1.01 (0.89,1.16)	0.30	.76
Sport PM	0.96 (0.91,1.02)	-1.38	.16
Age x SPM	1.00 (0.99,1.01)	1.47	.14
Hypothesis 2B			
Intercept	0.18 (0.02,1.63)	-1.53	.12
Gender	0.82 (0.25,2.68)	-0.32	.74
Sport PM	0.99 (0.99,1.01)	0.89	.37
Gender x SPM	0.99 (0.99,1.00)	-0.36	.72
RQ #2			
Intercept	0.20 (0,00,8.22)	-0.37	.71
Sexuality	0.93 (0.22,3.85)	-0.09	.93
Sport PM	1.00 (0.89,1.13)	0.09	.92
Sexuality x SPM	0.99 (0.98,1.01)	-0.05	.95
Hypothesis 2C			
Intercept	0.03 (0.00,0.21)	-3.61	.00***
BSM	1.65 (0.90,3.03)	1.64	.10
Sport PM	1.00 (0.98,1.01)	0.28	.77
BSM x SPM	0.99 (0.99,1.00)	-0.01	.99
Hypothesis 2D			
Intercept	0.03 (0.00,0.38)	-2.74	.00**
SM	1.14 (0.91,1.43)	1.19	.24
Sport PM	1.00 (0.98,1.02)	0.47	.64
SM x SPM	0.99 (0.99,1.00)	-0.21	.83
RQ #3			
Intercept	0.28 (0.01,8.01)	-0.74	.45
BMI	0.96 (0.84,1.11)	-0.51	.61
Sport PM	1.00 (0.99,1.02)	0.89	.37
BMI x SPM	0.99 (0.99,1.00)	-0.59	.55

*p<.05; **p<.01; ***p<.001

Table 9

Final Model results for multilevel modeling testing exercise activity

Variables	ERR (95% CI)	*t*	*p*
Hypothesis 1A			
Intercept	0.20 (0.13,0.31)	-7.42	.000***
Exercise Physical Activity	0.26 (0.01,0.99)	-3.34	.000***
Hypothesis 2A			
Intercept	0.22 (0.01,4.32)	-1.00	.32
Age	0.98 (0.85,1.14)	-0.16	.87
Exercise PM	0.97 (0.94,1.02)	-1.34	.18
Age x EPM	1.00 (0.99,1.00)	1.38	.16
Hypothesis 2B			
Intercept	0.57 (0.03,1.35)	-0.38	.70
Gender	0.52 (0.11,2.54)	-0.81	.42
Exercise PM	0.99 (0.97, 1.01)	-0.65	.52
Gender x EPM	0.99 (0.99,1.01)	0.63	.53
RQ #2			
Intercept	2.61 (0.02,6.01)	0.37	.71
Sexuality	0.64 (0.27,1.54)	-0.99	.32
Exercise PM	0.88 (0.72,1.08)	-1.20	.23
Sexuality x EPM	1.02 (0.98,1.05)	1.21	.23
Hypothesis 2C			
Intercept	0.02 (0.00,0.24)	-3.33	.00***
BSM	2.00 (1.01,3.94)	2.04	.04*
Exercise PM	1.00 (0.99,1.01)	0.38	.70
BSM x EPM	0.99 (0.99,1.00)	-0.59	.55
Hypothesis 2D			
Intercept	0.11 (0.00,4.34)	-1.18	.24
SM	1.04 (0.75,1.46)	0.27	.79
Exercise PM	0.99 (0.97,1.01)	-0.59	.56
SM x EPM	1.00 (0.99,1.00)	0.59	.55
RQ #3			
Intercept	1.93 (0.02,1.79)	0.28	.78
BMI	0.90 (0.74,1.11)	-0.99	.32
Exercise PM	0.99 (0.96,1.01)	-0.69	.49
BMI x EPM	1.00 (0.99,1.00)	0.72	.47

*p<.05; **p<.01; ***p<.001

Table 10

Final Model results for multilevel modeling testing leisure activity

Variables	ERR (95% CI)	*t*	*p*
Research Question 1			
Intercept	1.18 (0.12,1.27)	7.98	.000***
Leisure Physical Activity	1.04 (1.00,1.01)	5.27	.000***
Hypothesis 2A			
Intercept	0.86 (0.08,8.54)	0.12	.90
Age	0.46 (0.13,1.67)	-1.18	.24
Leisure PM	0.98 (0.96,1.01)	-1.01	.31
Age x LPM	0.99 (0.99,1.02)	0.87	.39
Hypothesis 2B			
Intercept	0.45 (0.02,6.96)	0.57	.56
Gender	0.96 (0.84,1.11)	-0.44	.66
Leisure PM	0.96 (0.93,1.00)	-1.85	.06
Gender x LPM	1.00 (1.00,1.00)	1.76	.08
RQ #2			
Intercept	1.20 (0.00,8.03)	0.04	.96
Sexuality	0.76 (0.17,3.30)	-0.36	.71
Leisure PM	0.97 (0.89,1.06)	-0.47	.64
Sexuality x LPM	1.00 (0.98,1.01)	0.42	.67
Hypothesis 2C			
Intercept	0.14 (0.01,1.42)	1.68	.09
BSM	1.18 (0.56,2.46)	0.45	.65
Leisure PM	0.99 (0.97,1.00)	-1.52	.13
BSM x LPM	1.00 (0.99,1.01)	1.29	.20
Hypothesis 2D			
Intercept	0.08 (0.00,1.78)	-1.61	.11
SM	1.10 (0.83,1.46)	0.71	.48
Leisure PM	0.99 (0.97,1.01)	-0.65	.51
SM x LPM	1.00 (0.99,1.00)	0.40	.68
RQ #3			
Intercept	0.37 (0.01,7.16)	0.45	.64
BMI	0.96 (0.80,1.15)	-0.41	.67
Leisure PM	0.99 (0.97,1.02)	-0.03	.97
BMI x LPM	0.99 (0.99,1.00)	-0.22	.82

*p<.05; **p<.01; ***p<.001

Table 11
Final Model results for multilevel modeling testing domestic activity

Variables	ERR (95% CI)	*t*	*p*
Research Question 1			
Intercept	1.19 (0.12,1.30)	7.55	.000***
Domestic Physical Activity	1.03 (1.00,1.01)	2.71	.007**
Hypothesis 2A			
Intercept	0.17 (0.01,2.60)	1.28	.20
Age	1.00 (0.87,1.14)	0.01	.98
Domestic PM	0.99 (0.99,1.00)	-0.80	.42
Age x DPM	1.00 (1.00,1.00)	0.89	.37
Hypothesis 2B			
Intercept	0.10 (0.02,1.18)	1.84	.07
Gender	0.35 (0.34,5.30)	0.43	.66
Domestic PM	0.99 (0.99,1.00)	1.58	.12
Gender x DPM	0.99 (0.99,1.00)	-1.45	.15
RQ #2			
Intercept	2.08 (0.00,2.35)	0.26	.79
Sexuality	0.66 (0.25,1.73)	-0.86	.39
Domestic PM	0.95 (0.86,1.06)	-0.80	.42
Sexuality x DPM	1.00 (0.99,1.02)	0.80	.42
Hypothesis 2C			
Intercept	0.06 (0.00,0.62)	-2.39	.02*
BSM	1.38 (0.68,2.82)	0.92	.36
Domestic PM	0.99 (0.99,1.00)	-1.23	.22
BSM x DPM	1.00 (1.00,1.01)	1.39	.17
Hypothesis 2D			
Intercept	0.01 (0.00,0.27)	-2.86	.00**
SM	1.25 (0.96,1.64)	1.71	.09
Domestic PM	1.00 (0.99,1.00)	1.40	.16
SM x DPM	0.99 (0.99,1.00)	-1.31	.19
RQ #3			
Intercept	1.87 (0.04,3.84)	0.33	.74
BMI	0.90 (0.77,1.05)	-1.27	.21
Domestic PM	0.99 (0.99,1.00)	-0.95	.34
BMI x DPM	1.00 (1.00,1.01)	1.06	.28

*p<.05; **p<.01; ***p<.001

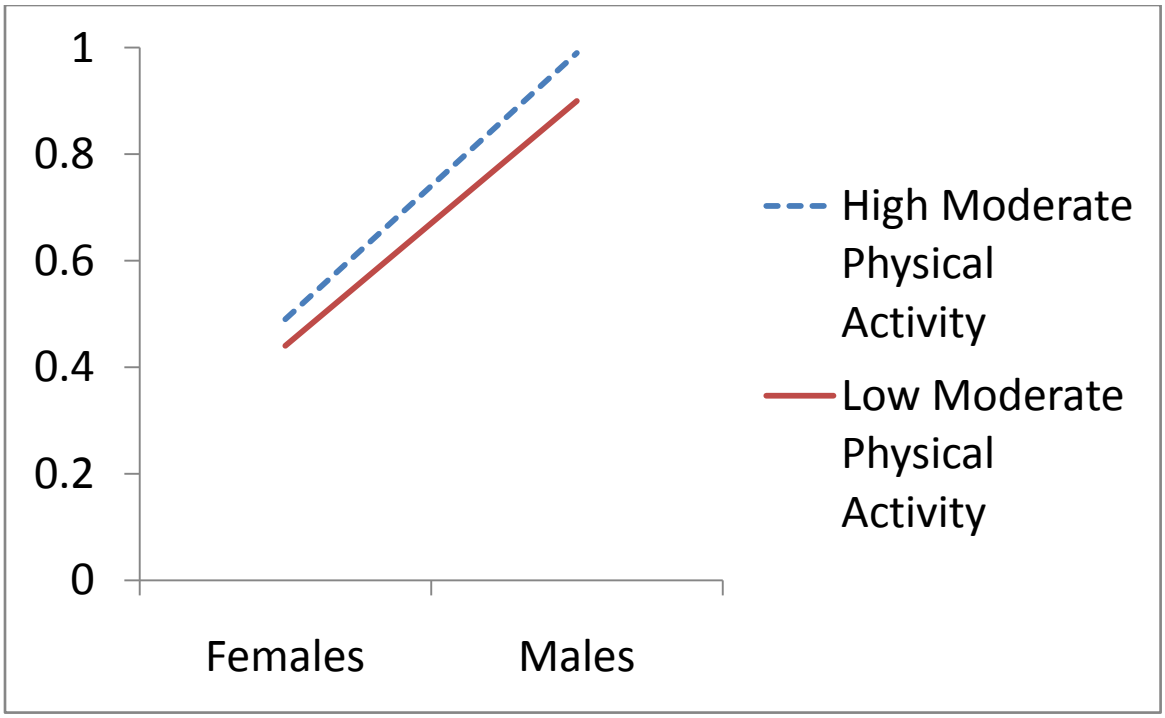

Figure 1. Gender as a moderator of the association between moderate physical activity and alcohol use.

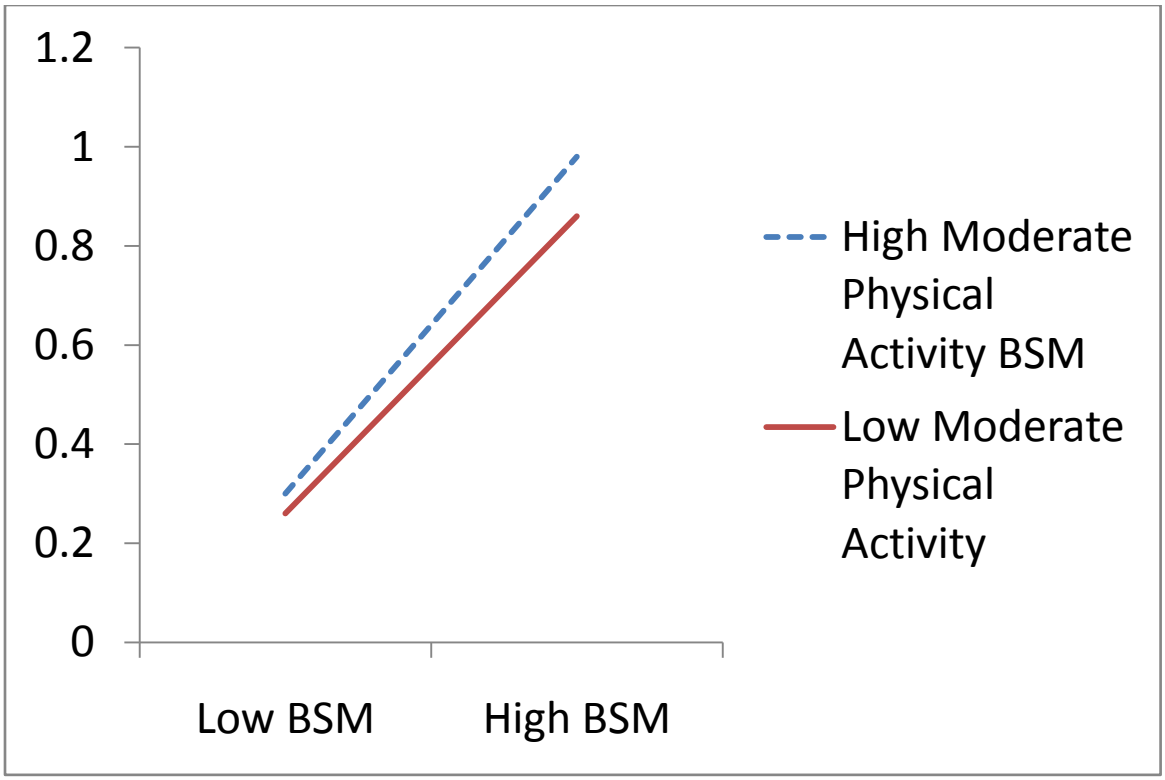

Figure 2. Social motives as a moderator of the association between moderate physical activity and alcohol use.

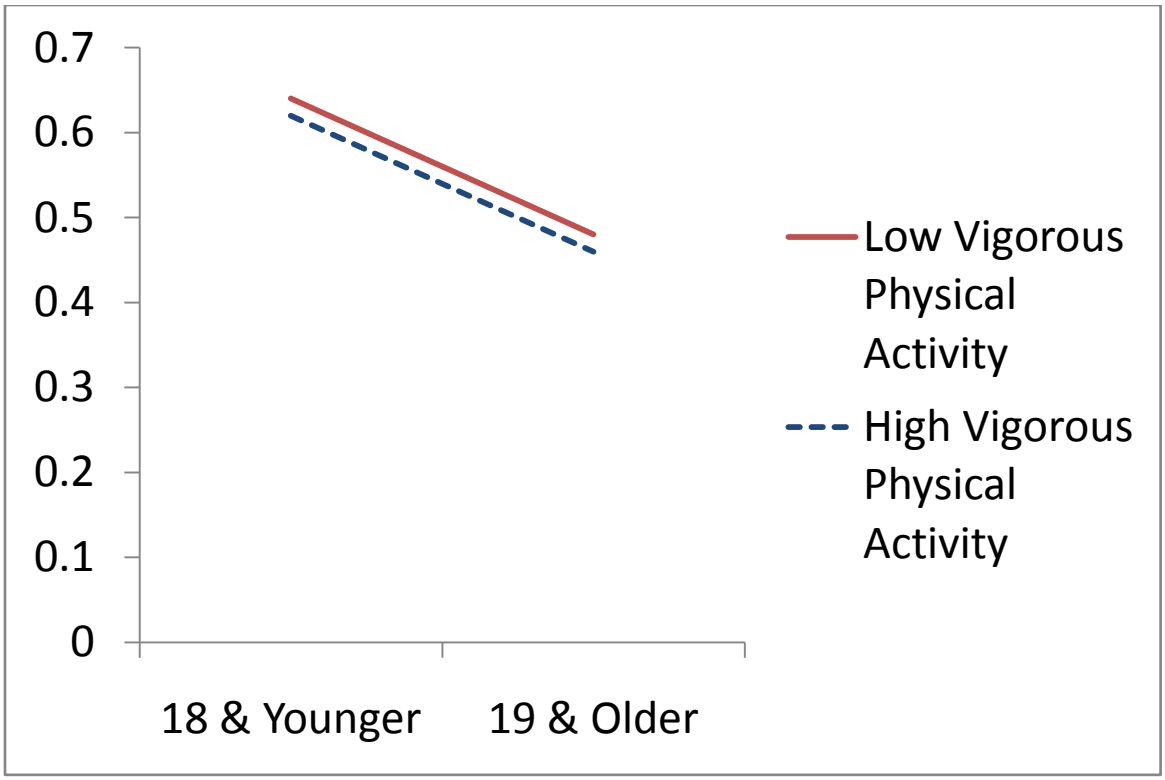

Figure 3. Age as a moderator of the association between vigorous physical activity and alcohol use.

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Appendix A

Self-Monitoring Scale (Snyder, 1987)

1. I find it hard to imitate the behavior of other people.
2. At parties and social gatherings, I do not attempt to do or say things that others will like.
3. I can only argue for ideas that I already believe
4. I can make impromptu speeches even on topics that I have almost no information
5. I guess I put on a show to impress or entertain others.
6. I would probably make a good actor.
7. In a group of people I am rarely the center of attention
8. In different situation and with different people, I often act like very different persons.
9. I am not particularly good at making other people like me.
10. I'm not always the person I appear to be.
11. I would not change my opinions (or the way I do things) in order to please someone or win their favor
12. I have considered being an entertainer.
13. I have never been good at games like charades or improvisational acting.
14. I have trouble changing my behavior to suit different people and different situations.
15. At a party, I let other keep the jokes and stories going.
16. I feel a bit awkward in public and do not show up quite as well as I should
17. I can look anyone in the eye and tell a lie with a straight face (if for a right end).
18. I may deceive people by being friendly when I really dislike them.

Appendix B

Hypotheses	Cross-Sectional Support	Longitudinal Support
Hypothesis 1. A positive relationship will exist cross-sectionally for alcohol use and overall, vigorous, and moderate physical activity. It was hypothesized the positive relationships will exist between physical activity and both alcohol use and binge drinking.	Yes *(Moderate Physical Activity)*	Yes *(Moderate Physical Activity)*
Hypothesis 1A. A positive association will exist for alcohol use and sport and exercise activities measured longitudinally.	Not Tested	No
Hypothesis 2. The positive association between physical activity and alcohol use will be moderated by several individual difference factors, including age, gender, sexuality, social motives, self-monitoring, and BMI.	Yes	Yes
Hypothesis 2A. The physical activity-alcohol use association will be stronger for younger than older college students.	No	No
Hypothesis 2B. The positive association between physical activity and alcohol use will be stronger in men than in women.	No	Yes
Research Question 2. will the positive association between physical activity and alcohol use be moderated by sexual orientation?	No	No
Hypothesis 2C. Individuals with high levels of social motives will demonstrate a stronger, positive alcohol-physical activity association than those with lower social motives.	No	Yes
Hypothesis 2D. High self-monitors will demonstrate a stronger, positive association between alcohol use and physical activity than low self-monitors.	No	No
Research Question 3. The positive association between physical activity and alcohol use will be stronger for individuals with a low BMI compared to individuals with a high BMI.	No	No
Research Question 1. Do hobby, domestic, occupational, and transportation activities demonstrate the positive association with alcohol use?	Not Tested	Yes *(Hobby & Domestic)*

Appendix C

Multi-level modeling equations designed to examine Hypotheses 2A-2F:

Hypothesis 2A - Age:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(Age_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*Age_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(Age_i) + U_{1i}$

Hypothesis 2B - Gender:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(Gender_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*Gender_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(Gender_i) + U_{1i}$

Research Question 1 - Sexuality:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(Sexuality_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*Sexuality_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(Sexuality_i) + U_{1i}$

Hypothesis 2C – Social Motives

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(BSM_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*BSM_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(BSM_i) + U_{1i}$

Hypothesis 2D – Self-Monitoring:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(SM_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*SM_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(SM_i) + U_{1i}$

Research Question 2 – BMI:

L1: $AlcoholUse_{di} = \beta_{0i} + \beta_{1i}(GMPhysicalActivity_{di}) + e_{di}$

L2: $\beta_{0i} = \Upsilon_{00} + \Upsilon_{01}(BMI_i) + \Upsilon_{02}(PMPhysicalActivty_i) + \Upsilon_{03}(PMPhysicalActivity_i*BMI_i) + U_{0i}$

$\beta_{1i} = \Upsilon_{10} + \Upsilon_{11}(BMI_i) + U_{1i}$