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Sedentary College Student Drinkers Can Start Exercising and Reduce Drinking after Intervention

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Abstract

Heavy drinking by college students is exceedingly harmful to the individuals and to the overall college environment. Current interventions to reduce drinking and negative consequences are infrequently utilized. This randomized clinical trial examined an alternative approach that sought to increase exercise behavior, a substance free activity, in sedentary heavy drinking college students. Participants ($N = 70$) were randomized to an 8-week exercise intervention: (1) motivational interviewing plus weekly exercise contracting (MI+EC) or (2) motivational interviewing and weekly contingency management for exercise (MI+CM). Follow-up evaluations occurred at post-treatment (2 months) and 6 months post baseline. Participants in both interventions significantly increased exercise frequency initially, and the MI+CM participants exercised significantly more than the MI+EC intervention participants during the intervention period ($d = 1.70$). Exercise behavior decreased during the follow-up period in both groups. Significant reductions in drinking behaviors and consequences were noted over time, but were not related to changes in exercise or the interventions ($ds \leq 0.01$). This study underscores the complex nature of promoting one specific health behavior change with the goal of changing another.

Keywords

motivational interviewing; contingency management; alcohol; physical activity

Approximately 45% of college students engage in heavy drinking in the past month, defined as drinking five or more drinks for men and four or more drinks for women (5/4 criterion; Hingson, 2010). Heavy drinking in college students is strongly associated with negative consequences, such as injuries, blackouts, and interpersonal problems. In addition, heavy drinking college students engage in other risky behaviors such as unprotected sex and driving while intoxicated (White & Hingson, 2013). Although brief interventions, such as those based upon motivational interviewing (MI), have been shown to significantly reduce heavy drinking in college students (Carey, Scott-Sheldon, Carey, & DeMartini, 2007), few college students recognize it as a problem and infrequently voluntarily seek help (~2%; Wu, Pilowsky, Schlenger, & Hasin, 2007). Stigma, combined with a desire to handle a problem

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on one's own, is a primary reason why college students do not seek mental health services (Jennings et al., 2015). Alternative non-stigmatizing interventions are therefore needed to increase the number of individuals who access treatment. This study examined exercise as a potentially non-stigmatizing intervention for heavy drinking college students who also met criteria for hazardous drinking.

Substance use, including drinking, can be conceptualized as a goal-directed behavior that is governed by the principles of reinforcement. Both animal and human studies repeatedly demonstrate that rates of alcohol and drug self-administration vary inversely with the availability of and participation in substance-free reinforcers (Ahmed, 2005; Van Etten, Higgins, Budney, & Badger, 1998). Within heavy drinking college students, Correia and colleagues (2003) found lower frequency and enjoyment in certain substance-free activities (e.g., hiking, art projects, pleasure reading) in comparison to non-heavy drinkers, suggesting increases in these activities as a potential intervention target.

Exercise, a substance free activity, has been proposed as having both potential preventive and treatment effects for alcohol use disorders (Linke & Ussher, 2015) in part because exercise has been shown to decrease urges to drink alcohol (Ussher, Sampuran, Doshi, West, & Drummond, 2004) and has substantial mental and physical health benefits, including reducing symptoms of depression and anxiety (Penedo & Dahn, 2005). Benefits of exercise can occur acutely (e.g., positive mood induction; Killingsworth & Gilbert, 2010) while others require weeks of consistent exercise before emerging (e.g., cardiovascular benefits; Wilson, Ellison, & Cable, 2015). Another mechanism by which exercise may alter drinking is through self-regulation. Oaten and Cheng (2006) found a two-month exercise intervention in college students generated significant improvements in self-regulation, which had broad impacts upon a variety of self-regulatory behaviors including alcohol consumption. Alcohol consumption decreased by about 5 drinks per week during the intervention - without directly targeting of the behavior. Conversely, being sedentary and engaging in heavy drinking frequently co-occur in college students (Luo, Agley, Hendryx, Gassman, & Lohrmann, 2015; Quintiliani, Allen, Marino, Kelly-Weeder, & Li, 2010).

Interventions aimed at increasing engagement in substance-free activities, such as exercise, in heavy drinking college students have an inverse relationship to problematic substance use in some studies (Correia, Benson, & Carey, 2005; Murphy et al., 2012; Murphy, Pagano, & Marlatt, 1986), albeit some data are mixed (Weinstock, Capizzi, Weber, Pescatello, & Petry, 2014). For example, Murphy and colleagues (1986) in randomized clinical trial of 60 heavy drinking college students found that a supervised exercise intervention in comparison to a no-treatment and meditation conditions not only showed an increase in physical fitness but also had the greatest reductions in alcohol consumption during the 8-week intervention and 6-week follow-up. Reductions were significantly greater than the assessment-only control group (*d*s = 0.97 to 1.19) and moderate in size in comparison to the meditation group (*d*s = 0.56 to 0.71); however, individuals who dropped out of the study were not included in the analyses ($n = 29$). Correia and colleagues (2005) used brief advice to increase exercise behavior in college students and found significant reductions in drinking over a one month intervention period; however, the study included a brief advice to reduce drinking condition which had greater reductions in drinking. Finally, a control condition showed no changes in drinking over time. The study did not include any long-term follow-up. Meanwhile, Weinstock and colleagues (2014) in an 8-week pilot study (n = 31) with no follow-up found two different MI exercise interventions did not result in any significant reductions in drinking behavior in heavy drinking college students. Type II error is likely in that study as it was underpowered, and effect size estimates found small to medium effect sizes for drinking outcomes (ds = 0.15–0.48). Unfortunately, these studies did not examine directly whether changes in drinking were attributable to changes in exercise. Therefore, while these types of interventions have shown promise, more work is needed to fully examine the efficacy of exercise as an intervention for heavy drinking. Incorporating long-term follow-up assessments that yield information about adherence to exercise and stability of changes in drinking behaviors are needed.

Research on interventions for engaging in exercise highlight the difficulty of initiating and maintaining this behavior (O'Brien et al., 2015). Within college students, a majority are sedentary (Dinger, Brittain, & Hutchinson, 2014) and those who start an exercise program exercise sporadically or completely stop exercising prior to realizing its many potential benefits (~ 30%; e.g., Dishman, Jackson, & Bray, 2014; Mailey et al., 2010; Martens, Buscemi, Smith, & Murphy, 2012). Several factors have been identified that are associated with successful initiation and maintenance of an exercise program. These factors include social support, self-efficacy, motivation, having physical activity choices, goal setting and behavioral contracts, positive reinforcement, intervention duration, and feedback (Plotnikoff et al., 2015). More broadly, studies have found that while extrinsic motivation may be important for initiating exercise, intrinsic motivation is an important component for sustaining it (Buckworth, Lee, Regan, Schneider, & DiClemente, 2007), and interventions that are designed to enhance intrinsic and/or extrinsic motivation to start and maintain an exercise program demonstrate a range of positive effect sizes (Martins & McNeil, 2009; O'Halloran et al., 2014; Webb & Sheeran, 2006). With these factors in mind, a combination of MI and prize-based contingency management (CM) to increase exercise in sedentary heavy drinking college students was created for this study.

The combined intervention sought to address difficulties associated with initiating and sustaining an exercise program. MI is defined as a client-centered, directive method for enhancing intrinsic motivation to change by exploring and resolving ambivalence (Miller & Rollnick, 2013). MI is efficacious as a stand-alone intervention or as a module of a larger intervention for exercise across a variety of populations, including healthy adults, with small to moderate effect sizes in comparison to no-treatment or placebo control groups (Lundahl et al., 2013; O'Halloran et al., 2014). Therefore, MI appears to be an appropriate and efficacious intervention for exercise and was used as the control condition and platform therapy for CM.

Prize-based CM is a behavioral treatment in which tangible reinforcement (e.g., retail goods and services) is provided to individuals when target behaviors are completed and objectively verified (e.g., drug abstinence verified via urine samples). The use of CM to reinforce drug abstinence in substance use disorders treatment is empirically supported (Benishek et al., 2014; Prendergast, Podus, Finney, Greenwell, & Roll, 2006). Successful CM interventions are designed around three central tenets: (1) the environment is arranged such that target behaviors are frequently and easily monitored, (2) tangible reinforcers are provided whenever the target behavior is demonstrated, and (3) when the target behavior does not occur, rewards are systematically withheld (and sometimes a slight punisher may also be delivered). Immediacy and magnitude of rewards are significant moderators of CM interventions' effect sizes with more immediate access to large reinforcement increasing the effect size (Lussier, Heil, Mongeon, Badger, & Higgins, 2006).

Although CM can alter a variety of behaviors (e.g., drug abstinence, medication adherence, group therapy attendance; Benishek et al., 2014; Mbuagbaw et al., 2015; Petry, Weinstock, & Alessi, 2011), few studies have utilized CM procedures for exercise. Several exercise interventions utilizing contingent incentives have shown effects, while others have been ineffective. These differences in outcome appear to be related to the implementation of the interventions and adherence to CM principles. Small magnitude and delayed provision of reinforcement (e.g., ≥ monthly basis) appears to limit the efficacy of CM exercise interventions (e.g., DeVahl, King, & Williamson, 2005; Jeffery, Wing, Thorson, & Burton, 1998). Conversely, studies showing more pronounced effects for incentives on exercise are those that adhere to the central tenets of CM (e.g., Irons, Pope, Pierce, Van Patten, & Jarvis, 2013; Patel et al., 2016; Petry, Andrade, Barry, & Byrne, 2013). Thus, exercise behavior changes in response to CM interventions when it is monitored frequently, immediate and desirable rewards are offered, and reinforcement is withheld for non-adherence.

In this study, we evaluated a combined MI+CM intervention for exercise in comparison to MI plus weekly exercise activity contracting (MI+EC) in sedentary heavy drinking college students who were not seeking treatment for alcohol-related problems. The comparison condition (MI+EC) was constructed to control for attention and self-monitoring of exercise behavior without providing reinforcement for exercise. Prior work suggested a MI for exercise only condition would potentially suffer from poor exercise adherence (Weinstock et al., 2014). First, we examined exercise outcomes, with the hypothesis that the combined MI +CM intervention would lead to greater exercise engagement during the 8 week intervention and 4 month follow-up period. Second, we hypothesized that engagement in exercise would predict reductions in alcohol consumption and alcohol-related negative consequences.

Methods

Participants

Participants ($N = 70$) in this study were enrolled in a randomized clinical trial (Clinical Trials Identifier: NCT01057979). Data were collected from January 2010 to September 2011. Individuals were included in the study if they were between the ages of 18–25 years, sedentary as indicated by exercising less than 2 days per week within the last 2 months, enrolled in more than 6 credit hours in the current semester, reported ≥ 4 heavy drinking episodes (4/5 standard drink criterion) in the past 2 months, and met criteria related to hazardous drinking (Alcohol Use Disorders Identification Test scores ≥ 8; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The definition for sedentary has been used previously in exercise clinical trials (e.g., Brown et al., 2010) and is of an intensity that is unlikely to yield lasting benefits (American College of Sports Medicine [ACSM], 2013). Individuals were excluded if they indicated they were currently receiving or expressed a desire to receive treatment for alcohol-related problems, disclosed acute psychiatric problems requiring immediate treatment, had medical contra-indications for exercise as assessed by the Physical Activity Readiness Questionnaire (Shepard, Thomas, & Weller, 1991), or a Body Mass Index (BMI) ≥ 35.0 kg/m^2. Participants were recruited via flyers posted on campus, email announcements, and direct screening of the student body. All participants provided written informed consent, and the study was approved by the university's Institutional Review Board. As shown in Figure 1, 70 individuals were randomized to an exercise intervention condition for 8 weeks. Two participants were withdrawn from the study after randomization due to medical problems that arose.

We conducted a power analysis for a latent growth curve model (see Data Analysis below) simulated in Mplus (Version 7.1; Muthén & Muthén, 2002). Previous studies of prize-based CM have found large effect sizes for substance use outcomes (Benishek et al., 2014), and a pilot study testing the combination of MI+CM implemented in the current study resulted in a large effect size for exercise outcomes and a moderate effect size for alcohol use (Weinstock et al., 2014). We conducted power simulations using parameter estimates from Weinstock et al. (2014) and a moderate effect size ($d = .50$). Assuming a Type I error rate of $\alpha = .05$, optimal power of .80 (Type II error rate of $\beta = .20$), and a sample size of 70 resulted in power of .83, indicating the sample size was sufficient to detect medium effect sizes.

Randomized participants had a mean age of 20.0 years ($SD = 1.47$; age range 18–25). The sample was comprised of 31 men and 39 women (55.7% female). With regard to race/ethnicity, 86.8% of individuals identified themselves as Caucasian/White, 5.9% as Hispanic, 2.9% as Asian, 2.9% as Other, and 1.5% as African American, which is reflective of the larger student body at the university. Participants ranged from freshmen to fifth-year seniors with 34.7% reporting to be in their first year of college, 20.6% in their second year, 14.7% in their third year, 25.0% were in their fourth year of college, and 4.4% reporting five years or more of college education. Participants' BMI ranged from 17.5 to 34.2 with a mean BMI of 24.7 ($SD = 3.3$).

Measures

Demographic Questionnaire—It assessed age, gender, ethnicity, and year in school.

BMI—BMI was assessed from height (assessed in stocking feet and measured to the nearest 0.10cm) and weight (with excessive clothing and materials such as keys and wallet removed and measured to the nearest 0.10 kg) with a Health-o-meter® Professional scale 597 KL with height rod (Pelstar, Bridgeville, IL). BMI is weight in kg/height in m^2.

YMCA Submaximal Bicycle Ergometer Test (YSET)—The YSET is a standardized submaximal assessment of predicted VO_2 maximum, a criterion of cardiorespiratory fitness (Poldermans et al., 1993; ACSM, 2013) A regression plot of heart rate versus work load estimates VO_2 maximum.

Timeline Followback (TLFB)—The TLFB is the gold standard for self-reported retrospective assessment of drug and alcohol use (Donovan et al., 2012). It demonstrates good psychometric properties for assessing exercise as well (Panza, Weinstock, Ash, &

Pescatello, 2012). Two separate TLFBs assessed: (1) frequency, duration, and intensity of exercise and (2) alcohol, marijuana and other drug use in the 60-days prior to baseline and throughout the follow-up. Using the *Compendium of Physical Activities* (Ainsworth et al., 2011), exercise behavior on the TLFB was then coded into metabolic equivalents (METs) hours per week, a measure of overall exercise volume that reflects the frequency, intensity, and time of exercise.

Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ)—The BYAACQ is a 24-item comprehensive self-report measure of negative consequences due to drinking alcohol with good reliability and validity while being sensitive to changes in drinking over time (Kahler, Hustad, Barnett, Strong, & Borsari, 2008; Kahler, Strong, & Read, 2005). It assesses a range of consequences with minimal gender bias. Cronbach's alpha internal consistency in this sample ranged from 0.81 to 0.90.

Treatment Services Review (TSR)—The TSR assessed receipt of medical and mental health services (McLellan et al., 1992), including alcohol treatment, in the 2-months prior to intake and throughout the study. It assessed exclusion criteria and monitored serious adverse events.

Client Satisfaction Questionnaire—An investigator derived questionnaire administered at the post-treatment evaluation only and assessed participants' satisfaction with the intervention they received. Using a 5-point Likert-scale questions asked about overall intervention satisfaction (1 = very satisfied; 5 = very dissatisfied), how participants' condition changed since the start of the intervention (1 = I'm much better; 5 = I'm much worse), and whether the changes were related to the intervention (1 = definitely related; 5 = definitely not related).

Procedures

In a private research office, trained research assistants obtained written informed consent and completed the baseline evaluation with participants, which included the questionnaires and the submaximal cardiorespiratory assessment. At subsequent evaluations, post-treatment (2-months post-baseline) and follow-up (6-months after baseline), the same assessment was completed by participants. Participants were compensated $65 for the baseline and post-treatment evaluations and $45 for the 6-month follow-up. Follow-up rates exceeded 85% at each post-baseline evaluation (see Figure 1).

Upon completion of the baseline assessment, participants were randomized to one of two study intervention conditions using a computerized urn-randomization procedure (Stout, Wirtz, Carbonari, & Del Boca, 1994) balancing groups on baseline heavy drinking episodes (≤ 5 episodes versus > 5 episodes per month) and BMI (≤ 30.0 versus >30.0). Six different therapists (1 clinical psychologist, 5 ACSM certified exercise specialists who trained and supervised by the first and third author) delivered the interventions. All therapists underwent an initial two-day workshop on motivational interviewing lead by an outside expert and a one-day workshop on contingency management followed by annual one-day refresher trainings. Ongoing supervision consisted of regular review of intervention binders, audiotapes, and case discussion.

Interventions

The study had two intervention conditions: (1) motivational interviewing plus exercise contracting (MI+EC) and (2) motivational interviewing plus contingency management (MI +CM). The interventions were alike in that participants received two 50-minute MI sessions, plus 8 weekly individually-delivered exercise contracting sessions. The difference between the conditions was that the MI+EC intervention reinforced participants for attending the exercise contracting sessions (regardless of exercise activity completion) while the MI+CM intervention reinforced participants only for completion of verified exercise activities. Specific components of the interventions are described below.

MI Sessions—The first MI session was provided immediately after completion of the baseline assessment to ensure delivery of at least part of the intervention. The second MI session was scheduled 4 weeks later. The MI sessions were framed as a “wellness intervention” for increasing exercise and adhered to the principles of MI (Miller & Rollnick, 2013). As the focus of the intervention was to promote exercise, motivation to reduce heavy drinking was not discussed unless first raised by participants within the context of starting and maintaining an exercise routine. The second MI session occurred 4 weeks later and served as a booster session.

EC Sessions—The exercise contracting sessions were held over 8 consecutive weeks, with the first exercise contract completed at the end of the first MI session. These sessions were approximately 10–15 minutes in length. Collaboratively, the therapist and participant completed an exercise contract. The contract contained at least three specific exercise activities to be completed within the upcoming week. Exercise activities were selected by the participants to ensure the activities were of interest. Activities ranged widely and included jogging on a treadmill, attending an exercise class, and swimming. Each activity was explicitly defined in terms of intensity and duration (minutes), as well as objective verification needed for proving completion. Objective verification included pedometers, cellphone videos of instructors verifying attendance at an exercise class, and digital pictures for team sports participation.

In the subsequent weeks, the therapist met briefly with participants to review the prior week’s exercise contract and verification, problem-solve any issues with exercising, and create a new exercise contract for the upcoming week. As participants were sedentary at the baseline evaluation, the goal of the intervention via the exercise contracting was to increase over time and maintain a level of moderate to vigorous intensity exercise consistent with public health guidelines of at least 150 minutes per week of moderate intensity or at least 75 minutes per week of vigorous intensity exercise (ACSM, 2013). Participants assigned to the MI+EC intervention received $5 in gift certificates for attending the EC sessions for a possible total of $40.

CM—Participants in the MI+CM were reinforced for completion and verification of exercise activities specified on the weekly exercise contract. Participants earned one draw from a prize bowl for each exercise activity completed. For each week in which at least three activities were completed, participants received bonus draws, and bonus draws started at 3 and escalated over time by 1 draw per week to a maximum of 10 bonus draws per week. In total, participants could earn up to 79 draws from the prize bowl if they completed the 24 exercise activities. If participants did not complete three exercise activities in a week, they earned a draw for each activity completed (if any) but forfeited the bonus draws. In addition, the bonus draws were reset back to 3 on the next week's contract.

The prize bowl for drawings contained 80 slips of paper. Half (40) of them stated “Good job!” and were not associated with a prize. The other half were winning slips: 34 state “small prize”, 5 state “large prize”, and 1 states “jumbo prize”. Small prizes were worth $1, large prizes were worth $20, and the jumbo was worth $100. When participants drew a winning slip, they chose amongst the available gift certificates in that category: small, large, and jumbo. A large selection of gift certificates consistent with a healthy lifestyle was available, and participants were solicited for suggestions of types of gift certificates they wanted at each CM session. Average maximal reinforcement of CM was estimated at $230 per participant.

Treatment Fidelity—Using a modification of the Yale Adherence and Competence Scale (Carroll et al., 2000) and the Contingency Management Competency Scale (Petry, Alessi, Ledgerwood, & Sierra, 2010) six independent raters assessed 127 randomly selected audiotapes (about 20% of all sessions). MI, EC, and CM items were rated on a seven point Likert scale (1 = none/poor, 3 = some/adequate, 7 = extensive/excellent). One of the MI items was: “To what extent were the therapist's questions open-ended and reflective?” One of the exercise contracting items was: “To what extent did the therapist develop a new exercise contract for the upcoming week with specific exercise activities outlining duration and intensity, potential barriers, means of verification?” One of the CM items was: “To what extent did the therapist state how many draws would be earned at the next session if the client were to complete all three exercise activities?” Inter-rater reliability ranged from 0.90 to .99 across the items rated.

For the MI sessions, mean and standard deviation of the MI items was 4.67 (1.31) (reflecting average rankings of ‘good/quite a bit’) with no significant difference in the ratings of the MI sessions between the MI+EC and the MI+CM conditions, $p = .75$. Meanwhile, in the EC sessions the rating of the MI items was 1.02 (0.10), which was significantly different from the MI sessions, $p < .001$. For the EC sessions, which was an aspect of every session rated, mean and standard deviation of the EC items was 5.02 (1.03) with no significant differences between the two intervention conditions, $p = .51$. Lastly, for the CM sessions, mean and standard deviation of the CM items was 5.21 (1.30), which was significantly different from the MI+EC sessions' means and standard deviations: 1.46 (0.64), $p < .001$. Thus, the interventions were distinguishable and rated as having ‘good’ therapist adherence and competence.

Data Analysis

Analysis of variance and chi-square tests examined group differences at baseline. Because distributions of the METs expended with exercise and standard drinks per week substantially deviated from normality, we applied log transformations, which were successful in bringing skewness within acceptable levels (<± 2; Gravetter & Wallnau, 2014). Whereas skewness values ranged between 1.34 and 3.44 for untransformed drinks per week values, log transformed values ranged between −0.34 and 0.78. Likewise, untransformed values for METs ranged from 1.24 to 2.94 and transformed values ranged from −0.32 and −0.03.

Using intent-to-treat analyses, which includes all randomized participants regardless of their participation, the primary analytical strategy was latent growth curve (LGC; Curran & Hussong, 2003) to analyze individual client change in exercise behavior. The primary outcomes were selected *a priori* and included: weekly exercise frequency, METs hours per week, and estimated cardiorespiratory fitness. Secondary outcomes consisted of alcohol use outcomes, specifically binge drinking episodes, frequency of alcohol use (measured in standard drinks per week), and consequences associated with alcohol use. Missing data were handled with full information maximum likelihood (FIML) estimation, under the assumption that the data were missing at random (MAR; Little & Rubin, 1989). LGC modeling was conducted using Mplus (Version 7; Muthén & Muthén, 1998–2014) and proceeded in two stages. First, we tested a series of growth curve models representing possible forms of growth (e.g., no change, linear change, discontinuous change) to determine the overall shape of the individual change trajectories. Because several of the outcomes we examined yielded count data, we also compared the fit of negative-binomial models to conventional models assuming continuous data using Bayesian Information Criterion (BIC) statistics. With the exception of one outcome, exercise frequency, the conventional models indicated better fit. Second, we added intervention condition and gender as covariates to the models to test the impact of intervention type and gender on initial status and change over time (i.e., intercept, slope growth parameters). Gender was included as covariate due to potential differences by gender in terms of drinking behaviors and alcohol-related consequences (e.g., Cranford, Eisenberg, & Serras, 2009). Intervention effects were demonstrated by a statistically significant slope parameter, as tested by the pseudo-z test associated with treatment condition. In addition to the transformations mentioned above, the robust maximum likelihood estimator was used to minimize the impact of non-normality on the results. Both effect sizes (Cohen's *d*), calculated using Feingold's (2009) method for growth curve modeling, and significance tests associated with intervention effects are reported.

As part of the interventions, all participants completed weekly exercise contracts, which required verification of exercise and serves as an objective and reliable source of information regarding exercise behavior during the intervention period. TLFB data were used rather than data from the exercise contracts in the analyses because the TLFB data allow for examining adherence/change over time (i.e., 2 months prior to study enrollment through the 6 month follow-up). The prospective contracts were only available for the 8 week intervention period. Pearson *r* correlations between the TLFB and exercise contracts for the intervention time period demonstrated excellent convergence (*r*'s = .55 – .80).

Results

Baseline Indices—Baseline data appear in Tables 1 and 2. In the two months prior to enrolling in the study, MI+EC participants reported exercising significantly more frequently than the MI+CM participants, $F(1,69) = 4.33$, $p < .05$. Therefore, we adjusted for baseline exercise frequency in LGC models examining treatment differences in outcomes. In models examining change in outcomes other than exercise frequency, this was accomplished by including baseline frequency as a covariate. However, this produced a convergence problem in the model for exercise frequency; therefore, the adjustment was accomplished by regressing slope parameters on the intercept (which estimates baseline functioning). No other baseline or demographic variables differed significantly between the groups, *ps* >.05.

Treatment Participation and Satisfaction—As shown in Table 3, attendance at the MI and exercise contracting sessions did not differ between the intervention groups, *ps* > .05, with all participants completing at least one MI session and 91.4% of participants completing both MI sessions. Approximately 89% of participants in both intervention groups attended all 8 exercise contracting sessions. In terms of number of exercise activities selected and completed with verification, again there were no significant differences between the intervention groups, with an overall average of 30.4 activities selected (out of a total possible 32; $SD = 4.9$) and 17.9 activities completed with verification ($SD = 7.0$), *ps* > .05. Costs of reinforcement for the interventions totaled an average of $37.1 ($SD = 9.1$) for the MI+EC and $166.5 ($SD = 118.4$) for the MI+CM. As also shown in Table 3, no differences were noted between groups on treatment satisfaction, $p > .05$, with both groups rating their satisfaction in the moderately to very satisfied range. Lastly, all participants endorsed improvement and attributed it to the intervention they received with no differences in ratings between the intervention groups, *ps* > .05.

Effects on Exercise—See Table 2 for means and standard deviations for each outcome measure at each assessment point. Table 4 displays model fit indices for the best-fitting models for each outcome. Best-fitting LGC models for exercise volume and standard drinks per week showed unacceptable fit to the data and therefore will not be considered further. A comparison of likelihood ratio difference tests revealed that growth in exercise frequency was best depicted by piecewise models (Crawford, Pentz, Chou, Li, & Dwyer, 2003) with two distinct phases of growth representing change during the intervention period (between baseline and 2-month follow-up) and the post-intervention period (between 2- and 6-month follow-up). Coefficients for the assessment points were coded as 0, 1, 1, 1 for the first piece and 0, 0, 1, 2 for the second, and the variance of the first piece was fixed to 0 to permit model identification. As hypothesized, college students in both treatments significantly increased their exercise frequency during the intervention period (Mean Slope = 1.04, standard error [*SE*] = 0.71, *pseudo-z* = 14.63, $p < .001$) followed by a significant decrease over the following 4 months (Mean Slope = −0.49, $SE = 0.11$, *pseudo-z* = −4.29, $p < .001$). Although participants as a whole showed a decrease in exercise frequency between 2- and 6-month follow-up, they were still exercising at greater frequency than baseline. Although exercise frequency increased, participants showed no change in cardiorespiratory fitness, as the linear slope model showed no improvement in fit over an intercept-only (i.e., no change) model.

Comparing the intervention conditions, participants who received the MI+CM condition increased their exercise frequency during the intervention period to a greater extent than those who received MI+EC (treatment slope = 0.23, *SE* = 0.09, *pseudo-z* = 2.51, *p* = .012, *d* = 1.70). There was also a marginal effect favoring the MI+CM condition for changes in exercise frequency between 2- and 6-month follow-ups (treatment slope = 0.15, *SE* = 0.09, *pseudo-z* = 1.73, *p* = .083, *d* = 0.58). There were no gender differences, *p*s > .05. During the last two weeks of the intervention, 60.0% of the sample was exercising according to ACSM guidelines, with no differences between the groups, $\chi^2(1) = 2.14$, *p* = .143.

Effects on Drinking—First, examining change over time, participants significantly decreased the number of binge episodes (Mean Slope = −0.07, *SE* = 0.02, *pseudo z* = −2.72, *p* = .007) and consequences associated with alcohol use (Mean Slope = −0.29, *SE* = 0.09, *pseudo z* = −3.29, *p* = .001). Yet, there were no differences in change when the treatment conditions were compared (Binge Episodes: treatment slope = −0.01, *SE* = 0.03, *pseudo z* = −0.34, *ns, d* = 0.01; Consequences: treatment slope = 0.01, *SE* = 0.18, *pseudo z* = 0.06, *ns, d* = 0.00). There were also no gender differences in treatment outcomes, *p*s > .05.

Finally, we examined parallel process LGC models examining associations between change in exercise and change in alcohol use. In general, these models did not provide adequate fit to the data, and in no case did change in exercise predict change in alcohol use.

Serious Adverse Events—One participant broke her hand while exercising as part of this study. No other study related adverse events were noted, and no participant reported receiving any alcohol-related treatment throughout the 6 month study and follow-up period.

Discussion

This study found that sedentary heavy drinking college students not only actively engaged in an 8 week motivational intervention to help start and maintain a regular exercise routine, but that they significantly increased their exercise behavior in comparison to baseline (when they were exercising approximately once per week). Differences were noted between the intervention conditions in that individuals in the MI+CM condition exercised significantly more often than the individuals randomized to MI+EC condition, with 3.1 episodes per week versus 2.7 episodes per week, respectively, during the 8 week intervention. In comparison to prior studies with sedentary heavy drinkers, our results are similar to the MI+CM condition in Weinstock et al. (2014) in which individuals exercised 2.5 times per week. Results are also similar to Murphy et al.’s (1986) supervised exercise intervention in which individuals exercised 3.4 times per week; however, this is likely an overestimate as they did not account for attrition, in which over a third of the sample randomized to the exercise condition dropped out.

It is not surprising that the interventions increased engagement in exercise, as a meta-analyses find MI yields small to moderate effect sizes in facilitating behavior change (Huh et al., 2015; O'Halloran et al., 2014). Both exercise interventions incorporated other effective components that likely impacted adherence to exercise such as weekly contracting. However, we expected and found that the combination of MI+CM enhanced outcomes over MI+EC. This expectation is rooted in prior research that found a large effect size of prize-based CM interventions (Benishek et al., 2014) and the success of CM in increasing exercise behavior in previous research (e.g., Petry et al., 2013; Weinstock et al., 2014). Thus, despite a strong comparison condition, reinforcing the identified behavior target (i.e., exercise) yielded a moderate to large effect size for exercise outcomes during the intervention period in comparison to reinforcing attendance to the exercise contracting sessions.

In addition to positive changes in exercise behavior, significant reductions in drinking behavior and drinking consequences during the intervention and follow-up periods occurred, with no differences noted between the intervention conditions. Although statistically significant, the differences do not appear to be clinically significant with reductions of less than one binge episode per week and endorsement of one to two fewer consequences over time. These reductions in drinking were consistent with prior studies (Correia et al., 2005; Murphy et al., 1986). However, contrary to our hypothesis, changes in exercise were not predictive of changes in drinking. More research is needed to substantiate these findings.

There are several possible explanations for the failure to find any correspondence between the two behaviors. First, change in drinking outcomes could be a reactivity effect from general study assessments, such that change in drinking is associated with the study procedures. Prior research has shown that completion of an assessment regarding drinking and its negative consequences leads to reductions in college students' drinking behavior (Walters, Vader, Harris, & Jouriles, 2009). Second, the benefits of exercise can vary across individuals such that these benefits may have differential impact upon drinking; therefore, muddling the relationship between exercise and drinking. For example, in some women exercise may be a compensatory strategy for calories consumed while drinking (e.g., "I can drink tonight since I burned 350 calories running this morning"). In fact, Buchholz and Crowther (2014) found that women who exercised as a compensatory strategy drank at a greater intensity than their peers who were not using exercise as a compensatory strategy. On the other hand, exercise may lead to reductions in drinking via improvements in self-regulation or reductions in impulsivity. Impulsivity is associated with heavy drinking (Coskunpinar, Dir, & Cyders, 2013), and exercise has been shown to reduce impulsivity (Cerrillo-Urbina et al., 2015). To compound matters, drinking consequences can also influence future drinking behavior, such that it can lead to reductions in drinking (Read, Wardell, & Bachrach, 2013). It is possible that our exercise intervention highlighted specific negative consequences that spurred changes in drinking. These examples highlight the many possible divergent effects of exercise upon drinking within college students.

Another reason why exercise may not have been related to drinking outcomes is that the interventions did not directly link the two behaviors with each other. Prior work suggested targeting exercise without addressing drinking would be successful (e.g., Correia et al., 2005; Murphy et al., 1986). However, results from a recent health behavior change meta-analysis find interventions that directly target and link two health behaviors have greater effects than interventions that target only one health behavior with the goal of changing an additional health behavior (Wilson et al., 2015). Going forward, reframing and linking exercise with reductions in heavy drinking under the guise of a health and wellness intervention may be an appropriate means to link and address both behaviors simultaneously, as approximately 33% of college students are sedentary and drink heavily (Luo et al., 2015; Quintiliani et al., 2010).

Long-term exercise outcomes of the study were less robust. Over a four month post-treatment follow-up period engagement in exercise decreased significantly over time with participants averaging slightly less than two episodes per week, which is below current exercise guidelines. Unfortunately, the falloff in exercise behavior over time is common (e.g., Dishman et al., 2014; Murphy et al., 1986; Patel et al., 2016). As there were no differences on outcomes between intervention conditions during the follow-up period, reductions in exercise behavior are not likely due to the removal of incentives specifically for exercise. More likely, other factors contributed to this decline, such as discontinuation of weekly meetings and exercise contracts (i.e., attention, accountability), changes in the environment requiring new behavioral patterns (i.e., going home for breaks), or a failure to develop sufficient intrinsic motivation to sustain exercise over time. Adding a third motivational interview at the completion of the 8-week intervention may enhance intrinsic motivation to sustain the behavioral changes over time.

Limitations of this study inform future research in this area. While objective verification of exercise was required for the weekly exercise contracts, the study did not have an objective measure of physical activity (e.g., accelerometers) and relied on participant self-report. The self-reporting of exercise allowed for assessment over longer periods of time (i.e., months) than would be feasible for objective monitoring, and self-reports converged with the weekly prospective exercise contracts completed during the intervention. Related, changes in exercise behavior did not translate into significant changes in objective markers of cardiorespiratory fitness. The exercise intervention in this study only prescribed and monitored exercise behavior for 8 weeks. A longer, more intensive, supervised exercise program with specific heart rate reserve targets would likely improve cardiorespiratory fitness. Another limitation is that the study was conducted at one university and drinking and other health behaviors differ by college campus (Seo & Li, 2009). Specific attributes of the campus may enhance or diminish engagement in these behaviors (e.g., spring festival weekend, snowy winter climate). Another limitation is that MI intervention did not explicitly address heavy drinking. A few students discussed the relationship between exercise and heavy drinking in their MI sessions; sadly, this information was not systematically tracked which prevents us for examining its impact. Finally, model fit statistics suggested that the models for the exercise volume measure (METs per week) and drinks per week fit the data poorly, although model comparisons suggested the piecewise model provided the best fit of the models we examined. Strengths of the study include the long-term follow-up and the fidelity with which the interventions were delivered.

Overall, exercise interventions devised for this study engaged sedentary heavy drinking college students and facilitated adoption of a consistent exercise routine during the 8-week intervention. Once the intervention was completed exercise behavior diminished over time. Significant reductions in drinking and drinking consequences were found over time, but were not associated with engagement in exercise. This study contributes to a line of literature examining exercise as an intervention for addictive behaviors, and highlights the many complexities in promoting one specific health behavior change with the goal of changing another.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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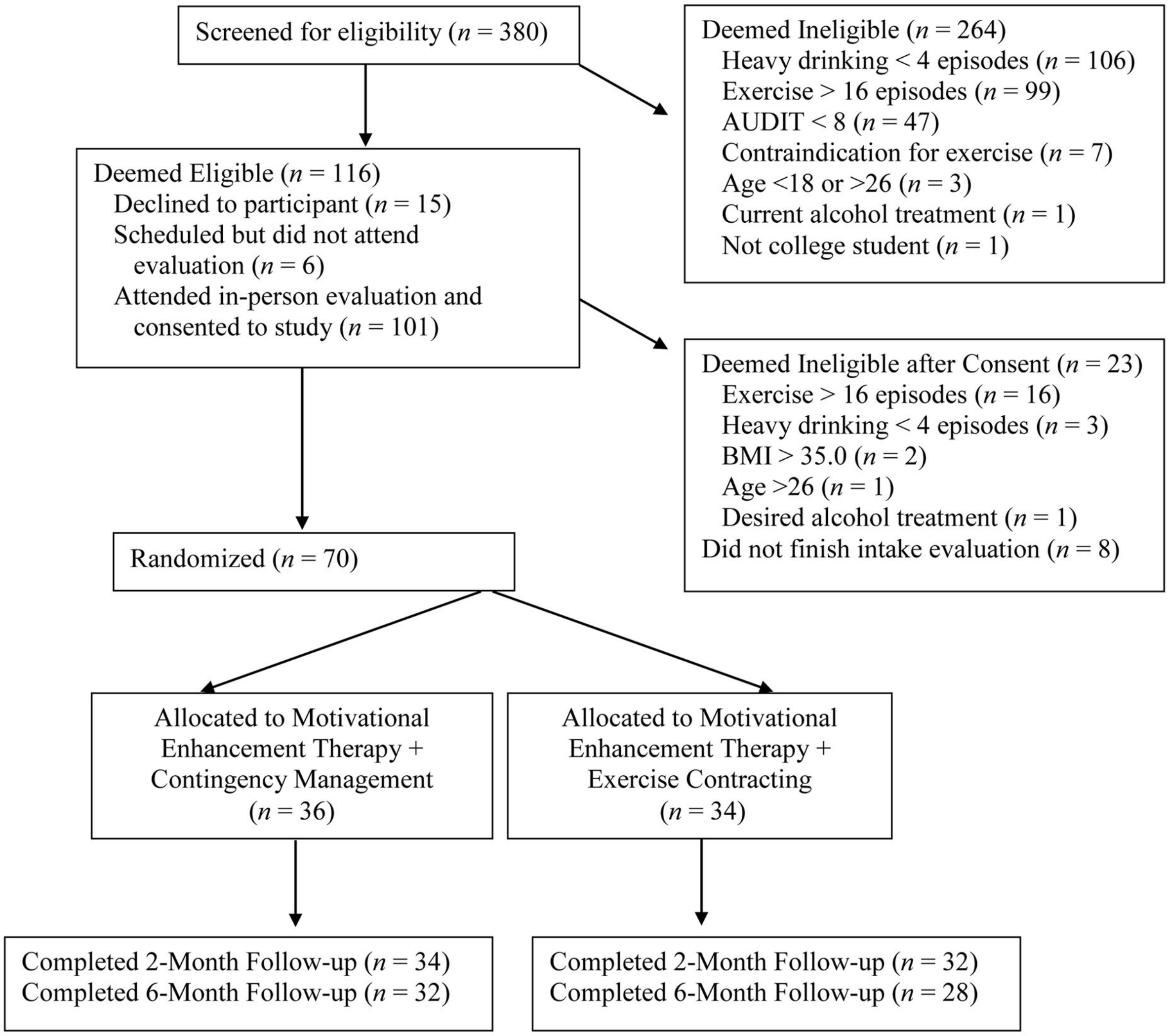

Figure 1.
Flowchart of participants through the study

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Table 1

Demographics and baseline characteristics.

	MI+EC (*n* =34)	MI+CM (*n* =36)	Statistic (*df*)	*p*-value
Age	19.9 (1.3)	20.1 (1.6)	$F(1,69) = 0.44$	.512
Male, no. (%)	13 (37.1)	18 (51.4)	$\chi^2(1) = 1.45$	.229
Ethnicity, no. (%)			$\chi^2(2) = 1.67$	.439
African American	1 (2.9)	0 (0.0)		
Caucasian	29 (82.9)	32. (91.4)		
Other	5 (14.3)	3 (8.6)		
Years of Education	14.2 (1.5)	14.3 (1.7)	$F(1,69) = 0.02$	.880
Cumulative Grade Point Average	3.2 (0.5)	3.3 (0.5)	$F(1,69) = 0.64$	.428
AUDIT Score, past year	13.9 (5.9)	13.7 (4.9)	$F(1,69) = 0.03$	.859
Body Mass Index (kg^2/m)	24.1 (3.2)	25.1 (3.3)	$F(1,69) = 1.60$	.210

Note. AUDIT = Alcohol Use Disorders Identification Test; MI+EC = motivational interviewing plus exercise contracting; MI+CM = motivational interviewing plus contingency management.

Table 2

Mean and standard deviation of exercise and drinking behavior and consequences at baseline, post-treatment, and follow-up

	Baseline		Post-Treatment		Follow-up	
	MI+EC	**MI+CM**	**MI+EC**	**MI+CM**	**MI+EC**	**MI+CM**
Cardiorespiratory Fitness	35.9 (6.1)[a]	37.8 (6.8)[a]	38.3 (7.7)[a]	37.5 (5.9)[a]	37.6 (9.5)[a]	38.1 (7.2)[a]
Weekly Exercise Frequency	1.2 (0.5)[a]	0.9 (0.5)[b]	2.7 (1.0)[c]	3.1 (0.9)[d]	1.7 (1.4)[e]	1.7 (1.2)[e]
Weekly Exercise MET Hours	7.1 (5.6)[a]	5.6 (5.8)[a]	17.7 (12.3)[b]	17.8 (9.6)[b]	7.9 (9.2)[c]	6.7 (6.2)[c]
Weekly Total Standard Drinks	15.7 (12.9)[a]	14.0 (12.8)[a]	14.2 (10.8)[b]	14.2 (9.3)[b]	11.2 (8.2)[b]	12.8 (15.5)[b]
Weekly Binge Drinking Episodes	1.8 (1.1)[a]	1.5 (0.7)[a]	1.6 (1.0)[b]	1.6 (0.9)[b]	1.2 (0.9)[c]	1.3 (1.0)[c]
BYAACQ Score	10.6 (4.4)[a]	9.9 (4.6)[a]	9.0 (5.2)[b]	9.5 (5.1)[b]	9.2 (5.7)[c]	8.0 (5.5)[c]

Note. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire; MI+EC = motivational interviewing plus exercise contracting; MI+CM = motivational interviewing plus contingency management; MET = Metabolic Equivalent. Like letter superscripts within a row denote no significant differences. Unlike superscripts within a row denote significant differences.

Table 3

Treatment participation and satisfaction by intervention group.

	MI+EC (***n*** **=34)**	**MI+CM** (***n*** **=36)**	**Statistic (*df*)**	***p*-value**
MI Sessions Attended	1.91 (0.3)	1.91 (0.3)	$F(1,69) = 0.00$	1.00
EC Sessions Attended	7.46 (1.6)	7.71 (0.7)	$F(1,69) = 1.16$	.387
Exercise Activities Selected	29.74 (6.3)	31.00 (2.8)	$F(1,69) = 1.24$	.293
Exercise Activities Completed	16.43 (6.7)	19.37 (7.1)	$F(1,69) = 3.18$	.079
CSQ Overall Satisfaction	1.64 (0.8)	1.30 (0.5)	$F(1,64) = 3.83$	.055
CSQ Change During Intervention	1.67 (0.5)	1.72 (0.6)	$F(1,64) = 0.20$	.660
CSQ Changes Attributed to Intervention	1.39 (0.7)	1.45 (0.7)	$F(1,64) = 1.32$	.254

Note. MI+EC = motivational interviewing plus exercise contracting; MI+CM = motivational interviewing plus contingency management; CSQ = Client Satisfaction Questionnaire.

Table 4

Chi-square, CFI, and RMSEA Model Fit Indices for Best-Fitting Models for Exercise and Drinking Outcomes

Variable	$\chi^2(df)$	CFI[a]	RMSEA[b]	TLI[a]	SRMR[b]
Exercise Volume	33.88 (7)*	0.54	.236	−.17	.102
Binge Drinking Episodes	14.68 (11)	0.97	.069	.95	.042
Drinks per Week	12.80 (7)	0.91	.109	.77	.104
Drinking Consequences	2.21 (4)	>0.99	<.001	1.08	.025

Note. CFI = Comparative Fit Index. RMSEA = Root Mean Square Error of Approximation. SRMR = Standardized Root Mean Square Residual. TLI = Tucker-Lewis Index.

Cardiorespiratory fitness model fit indices are not depicted because this variable showed no change over time. Exercise frequency model fit indices are not depicted because negative binomial models produced in Mplus do not yield fit indices. Variations in degrees of freedom between models are due to differences in model specification (i.e., linear vs. piecewise) and number of assessment points.

[a]CFI and TLI values of .95 and larger indicate good model fit and values of .90 and larger indicate adequate fit.

[b]RMSEA and SRMR values of .05 and lower indicate good model fit and values of .08 and lower indicate adequate fit.

* $p < .05$