Feasibility of a Motion-Activated Videogame for Substance Use Disorder Relapse Prevention in Youth: A Pilot Randomized Trial

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Conflicts of Interest: DG is the President of Media Rez LLC. Media Rez is planning to sell ‘‘Recovery Warrior’’ as a commercial venture. LCA has the potential to benefit financially from

the sale of ‘‘Recovery Warrior.’’ MF is the Medical Director of Mountain Manor Treatment Center(MMTC), where patients were enrolled in this study, and a part-time faculty member of the Johns Hopkins University. He is a beneficiary of the trust that owns MMTC. MF also serves on the governing board of the trust and the Board of Directors of MMTC. This arrangement has been reviewed and approved by the Johns Hopkins University in accordance with its conflict of interest policies. SCC, LR, MR, VS, HV declare no conflicts of interest.

Abstract
Background: Body motion-activated video games are a promising strategy for promoting addiction treatment engagement and adherence among youth.

Objective: This pilot randomized trial (N=80) investigated the feasibility of a body-motion activated video game prototype, Recovery Warrior 2.0, targeting relapse prevention in the context of a community inpatient care program for youth.

Materials and Methods: Participants ages 15-25 were recruited from an inpatient drug treatment program and randomized to treatment as usual (TAU) or to game play + TAU. Assessments were conducted at baseline, prior to discharge, and at 4-and 8-weeks post discharge.

Results: The provision of the game play intervention was found to be feasible in the inpatient setting. On average, participants in the intervention group played for 36.6 minutes and played on 3.6 different days. Participants in the intervention group mostly agreed that they would use the refusal skills taught by the game. Those in the intervention group reported attending more outpatient counseling sessions than the control group (10.8 versus 4.8, respectively), but differences were not significant. The game had no effect on drug use at 4-weeks or 8-weeks post discharge, with the exception of a benefit reported at 4-week follow up to participants in treatment for marijuana addiction ($p<.05$).

Conclusions: Preliminary evidence indicates that a motion activated video game for addiction recovery appears to be feasible and acceptable for youth within the context of inpatient treatment. With further development, such games hold promise as a tool for youth substance use disorder treatment.

I. INTRODUCTION

Drug use is recognized as a serious public health problem among adolescents and young adults. In 2015 in the US, 37.5% of young adults, aged 18-25 years, and 17.5% of adolescents, aged 12-17 years, reported the use of any illicit drugs that year [1]. Adolescent and young adult substance use disorders (SUDs) are associated with numerous negative outcomes including overdose, HIV transmission, school failure, criminal behavior and other social problems.

The standard of care for youth with SUDs includes detoxification as needed, followed by traditional psychosocial treatments [2-4]. Psychosocial treatments typically consist of individual and group counseling and may focus on developing skills related to abstinence such as problem solving, coping, and refusal skills [5]. While such programs are associated with positive outcomes for youth [5], dropout from treatment remains a major barrier to success [6]. There is a need to develop innovative strategies to improve retention among youth and increase rates of abstinence.

One promising strategy to promote treatment engagement and adherence is to create models of treatment that offer therapeutic content in game-based formats. Games, including video games, have been explored as therapeutic tools for alleviating a variety of psychological and physical conditions such as stress, anxiety, and mood disorders [7], as well as in treating addiction [8-12]. For addiction, video games have been used to change knowledge and risk perception surrounding drugs and alcohol, develop refusal skills, and to help people quit smoking [10-13]. Such games have involved role-play (e.g. Klisch et al.) and virtual reality exploration (e.g. Girard et al.). Not well explored is how experiential games, such as motion-activated games using platforms such as the Nintendo Wii and Microsoft Kinect, can be used in addiction treatment.

The current study builds on an earlier pilot [14] and examines how a game that runs on an off-the-shelf gaming system, the Microsoft Kinect, can be used in SUD treatment by helping patients develop negative associations with drugs and build drug refusal skills [15]. This study is a pilot randomized trial (N=80) of a revised body-motion activated game, Recovery Warrior 2.0, targeting relapse prevention in the context of a community treatment program for youth SUD. Of interest was the feasibility of the game in the inpatient and outpatient setting, participant ratings of the game, the effect of the game on the mediators of relapse, treatment adherence and retention, and drug use outcomes.

II. MATERIALS AND METHODS

Study Procedures

The study was approved by the MaGil Institutional Review Board (IRB). Participants were recruited from the short term inpatient program at the Mountain Manor Treatment Center (MMTC) in Baltimore, Maryland between 02/05/16 and 06/21/16.

Patients were approached about participating in the study by MMTC research staff within their first few days of inpatient admission, allowing some time for adjustment to the environment and resolution of the most acute phase of withdrawal distress. Interested individuals were assessed for eligibility and, if eligible, consented by research staff using a written consent form. For patients under the age of 18, assent and parental consent were obtained.

Inclusion criteria were: ages 15 to 25 years, attending the MMTC inpatient program for primarily opioid or marijuana use disorder treatment; an English speaker; without a co-morbid psychiatric condition that

would make participation unsafe (e.g. acute suicidality, unstable psychosis); and not pregnant (because of the physical exertion required to play the game).

Once consented, participants were given a baseline survey and randomized to Recovery Warrior (RW) game play with treatment as usual (TAU) or to TAU alone. In addition to the baseline survey, all participants were given an in-person survey prior to inpatient discharge (discharge survey), and by phone at 4 weeks and 8 weeks after discharge from inpatient treatment. Participants were given a $20 gift card for each survey, plus a bonus gift card of $10 at 4 weeks and $20 at 8 weeks. This resulted in a maximum incentive for assessments of $110. Phone calls, text messages, Facebook messages, and subject interception at MMTC outpatient treatment were used to remind participants of their upcoming follow-up surveys. For the 4 and 8 week surveys, up to 15 contact attempts were made per survey before being considered a missed follow-up.

RW Game Play + TAU

In addition to their usual care, those randomized to game play were given the opportunity to participate in a game play session 3 times/week for the length of their stay in the residential (inpatient) program. Typical inpatient stays at MMTC are for 9 days, and thus it was expected that participants would have 4 game play sessions over the course of their inpatient stay. Among those in the intervention group who transitioned to outpatient care at MMTC, participants were given additional weekly opportunity to play the game for 4 weeks. The goal was for each game play session to last 1 hour and include 3-5 participants, with each participant playing at least 10 minutes and no more than 15 minutes per session. Players would take turns with each player playing one at a time, and the others watching and encouraging him/her on. Each 1-hour session included an introduction to the game by the counselor (2 min), game play, and then an informal debriefing by the counselor about lessons learned in the game (8-10 mins). Sessions were offered in a dedicated room at MMTC.

Recovery Warrior 2.0 was developed for use with Microsoft's Kinect running on a Windows PC. Recovery Warrior 2.0 was improved from an initial version that was previously pilot tested [16], and consisted of a suite of several games All games made use of whole body motion detection and the same voice recognition feature. Body motions included a variety of arm, leg and whole body movements to physically enact the motions of destroying or evading images of drugs and drug paraphernalia. Voice features consisted of recognition of the refusal phrase, "I'm Clean!"; Players could say or shout "I'm Clean!" in order to gain additional strength for their game play avatar. All game art was created in a hyper-realistic, idealized and heroic style, the preferred style choice as determined by focus group in earlier work [16]. Across games, players were given a choice of several distinct hyper-realistic avatars from which to select. The counselor set up the game so that the drug images would correspond to the drug being treated for (e.g. opioid patients would see syringes, spoons, pill bottles and pills as part of game play, while the marijuana patients were exposed to marijuana cigarettes, baggies of marijuana, and bongs). Players could choose whether to play in a mode where they destroyed drugs, avoided drugs, or discerned pro-social "goodies" from drugs while avoiding drugs and collecting "goodies". Goodies included images of items such as graduation caps, car keys, and footballs.

The following games were tested: Recovery Ninja (destroy drugs); Recovery Ninja + Goodies (destroy and discern); Recovery Climber (avoid drugs); Recovery Racer (destroy drugs); Recovery Racer +

Goodies (destroy and discern); Recovery Runner (avoid drugs); and Recovery Runner + Goodies (avoid and discern). For example, the goal of Recovery Ninja is to destroy drugs that fly at the player's avatar. The player must make chopping, punching and hitting gestures in order to destroy the drugs that fly across the screen in order to win the game while periodically shouting "I'm Clean!" to power up. Another example is Recovery Runner. In this game, the player runs through a dark city, which progressively brightens as the player succeeds in staying away from drugs. Instead of destroying drugs (as in Recovery Ninja), the player must avoid them by physically ducking, dodging and jumping to control the avatar's movements and avoid touching the drugs. As with other games, the player periodically shouts "I'm Clean!" to gain additional power. See Appendix 1 for more details and screenshots for the games.

Theoretical Mechanism of Recovery Warrior

The development of the game was based on the Social Cognitive Theory (SCT), repetition priming, and the Reinforcement Theory of Motivation (RTM) [16,17]. Based on SCT, it is hypothesized that by repeatedly role-playing destroying drugs/avoiding drugs in the context of the game, players will experience increases in their self-efficacy and behavioral capability for drug refusal and avoidance in the real world [17]. This may occur because players will develop self-schemas of themselves as drug destroyers or avoiders rather than users [18]. Furthermore, drug refusal skills and self-schemas as non-users will be further enhanced by the constant repetition of the phrase "I'm Clean!" throughout the game, so that participants will be primed to use it if offered drugs in a future situation [19].

Additionally, based on RTM, we hypothesize that youth will be better able to learn these skills, if the learning process is paired with rewards. In this case, rewards associated with playing immersive video games may include such positive feelings as a sense of mastery; eustress; and pleasure, activation and arousal from the game-based exercise and physical exertion [20,21]. Finally, because this game is being designed as a social game to be played in the company of others in treatment, it is also hypothesized that social learning will contribute to the mastery of refusal skills and drug avoidance [17]. Participants will learn the skills of avoiding drugs/refusing drugs by not only repeatedly playing themselves, but by watching others practicing these skills in the context of the game.

TAU

Treatment as usual (TAU) at MMTC consisted of individual and group counseling as well as pharmacotherapy where recommended. MMTC is a Joint Commission accredited community treatment program for substance use disorders and co-occurring mental health conditions. Typically, patients stay in the inpatient program for 1-2 weeks and then transition to the outpatient program at MMTC or other treatment center.

Measures

The baseline survey included measures of the demographic characteristics of participants, current video game use, and the drug use history of participants. Participants were asked about the primary drug that they were in treatment for. Opioid and marijuana use at follow-up was ascertained by self-report of any use in the past 7 days and past 30 days, using the Time Line Follow Back, as well as the date of last use.

For the intervention group at the 4-week follow-up, participants were asked about their perceptions of the most helpful game among the games played and the mode of game play that was seen as most helpful

(e.g. destroy drugs, avoid drugs, avoid and collect goodies). Computer records of game play were also used to measure minutes of game play for each participant and days of game play. Measures of user engagement in Recovery Warrior were collected through a retrospective review of the computer records from game play. The system recorded each time a user played the game in minutes of game play. For each participant, the number of total minutes of game play was calculated across the intervention period.

Additionally, the 4-week follow-up survey assessed refusal skills taught by the game. Refusal skills were measured by asking participants if they agreed that they would use the phrase, "I'm Clean" to refuse drugs (1=not agree to 5=highly agree), if they had used the phrase "I'm Clean" since discharge to refuse drugs, and if the phrase "I'm Clean!" still rings in their head (not at all, less than once per week, a few times a weeks or more).

For both groups, psychosocial mediators of recovery, self-efficacy and cravings were measured. Self-efficacy for refusal of drugs was measured with the Marijuana Resistance Self-Efficacy (MRSE) scale on the baseline, discharge and follow-up surveys [22,23]. It used a 4-item, 4-point scale (1= very easy; 4= very hard) that asked how easy or hard it would be to refuse the drug if offered, explain why you didn't want it, to avoid the situation in the first place, and to leave the situation. It was adapted so that there was a similar version for opioid use. Participants were only asked about the primary drug for which they enrolled in treatment (i.e. marijuana or opioids).

For cravings, the 5-item Penn Alcohol Craving Scale (PACS) [24] was included on the baseline, discharge and post-discharge follow-up surveys, but modified to apply to marijuana and opioid use. It assessed the intensity of a participant's cravings (0=none at all; 6=very strong and summed for a maximum total of 30 points).

Treatment rating was measured in 3 ways. First, it was measured with the Counselor Alliance Scale (CAS), which was taken from the Working Alliance Inventory, [25-27] and used to measure treatment progress with their counselor at discharge, 4-weeks, and 8-weeks. CAS uses 7-items; 7-points to measure how well participants believe counselors are working with them to improve their situation (1=Never; 7=Always). Treatment rating was also measured by asking participants about their satisfaction with inpatient care at time of discharge, and satisfaction with outpatient care at the 4-week and 8-week follow-up surveys.

Treatment use was measured by self-report of use of outpatient services including meeting with a doctor, meeting a counselor, attending group sessions, taking medications and other services. The total number of services used was summed for each participant. Participants were also asked at the 4-week and 8-week follow-up about number of outpatient counseling sessions attended in the past 30 days. Drug use outcomes were measured by asking participants at the 4-week and 8-week survey if they had used their treatment drug (e.g. opiates or marijuana) over the past 7 and 30 days.

Analysis

Means and standard deviations or percentages were calculated for key variables and compared between intervention and control groups. Chi-squared tests were used for categorical variables and t-tests for continuous variables. Outcome analyses were conducted both with collected data only, and with missing

values imputed as positive for drug use. Also, in addition the combined analyses, outcome analyses were conducted separately for marijuana and opioid patients.

III. RESULTS

Participant Characteristics

Eighty participants were recruited, with 36 randomized to the intervention group and 44 randomized to the control group. Of the 80 participants, 64 completed a discharge interview (80.0%), 48 completed a 4-week follow-up interview (60.0%), and 46 completed an 8-week follow up interview (57.5%). There were no significant differences between groups in survey completion.

Most participants were between 18-20 years old. More than half of the participants were not attending school at the time of the study (65.0%), while 26.3% were in high school and the other 8.8% were in college. The majority of participants were males (77.5%). Most participants identified themselves as white (63.8%) or black (28.8%). Half of participants had a mother that finished high school/GED as their highest level of education (50.0%) and almost half had a father with a similar level of education (46.3%). Participants were in treatment for opioid (57.5%) or marijuana (42.5%) use disorder. Almost half of participants reported daily pre-study video game use (46.3%) and to a lesser extent weekly (18.8%), monthly (23.8%) and not at all (11.3%). Most participants in our sample spent 4-6 days at MMTC (51.3%), followed by 7-10 days (31.3%) (Table 1).

On the whole, there were no significant differences on demographic items between the intervention and control groups, with the exception of gender such that the intervention group was more likely to be male than female ($p < 0.05$). Those who completed the 4-week survey were similar to non-completers on all demographic variables. As expected, there were some differences in the demographic characteristics of marijuana and opioid users, with the opioid users more likely to be older ($p < 0.001$) and not in school ($p < 0.001$).

Game Rating and Engagement

Intervention participants (n=36) played on average 36.6 minutes during the total intervention, of which 35.7 minutes on average was during inpatient and 0.9 minutes during outpatient. Participants played for 3.6 days, of which 3.4 days on average was during inpatient and 0.2 days during outpatient. Only 3 intervention participants (8.3%) played the game during the outpatient period. For these participants, the average number of outpatient game play days was 2 days and the average number of game play minutes 0.9 minutes (See Table 2).

Among the intervention group participants who completed the discharge survey (n=32, 88.9%), participants expressed views on their game play preferences. Recovery Ninja was rated most frequently as most helpful game, followed by Recovery Runner +Goodies. Participants noted that the most helpful mode of game play was avoiding drugs while collecting goodies (e.g. Recovery Runner + Goodies), followed by destroying drugs (e.g. Recovery Ninja).

The games used the phrase “I’m Clean” to train participants on drug refusal skills. At 4 weeks, among intervention participants who completed the survey (n=23, 63.9%), the majority of participants agreed or strongly agreed that they could imagine using the phase, “I’m Clean” in their real lives to refuse drug

offers and the majority stated that when they were not playing the game, the phrase “I’m Clean” rang in their head either a few times a week or daily. Finally, the slight majority (52.2%) stated that they had used the phrase “I’m Clean” to refuse drugs since leaving inpatient treatment.

Self-Efficacy, Craving, Treatment Rating and Treatment Use

Overall, cravings declined for both groups from baseline to the 4-week follow up, and to the 8-week follow up, but the differences between groups were not statistically significant. Self-efficacy fluctuated slightly between baseline, the 4-week follow up, and the 8 weeks follow-up but did not change differentially between the intervention and control groups (Table 3). These findings do not lend support to the hypothesis that participants who received Recovery Warrior 2.0 reported greater improvements in the predicted mediators of addiction recovery compared to those in usual care.

Measures of treatment rating and treatment use did not reveal differences between groups. Both groups had similar scores on the counselor alliance scale and on their satisfaction with inpatient and outpatient care. Additionally, the utilization of outpatient services did not differ by group at 4 weeks. By 8-weeks those in the intervention group reported having attended more outpatient counseling sessions (10.08 vs. 4.80) but the differences did not reach significance ($p=.19$) (Table 3).

Effect of Game on Drug Use

At the 4- and 8-week period follow-up periods, there were no significant differences in the rates of either past 7-day and past 30-day abstinence between groups, considering both imputed and complete cases and marijuana and opioid patients together. Analyses were also repeated controlling for gender, which was not balanced at baseline between groups. Results were similar for gender-adjusted and unadjusted models. Unadjusted models are presented in Table 4.

While differences were not significant in the combined marijuana and opioid analysis, these patients were also analyzed separately. For marijuana patients, for analyses with drug use imputed for those missing, 4 weeks after the intervention, 13 of the participants in the intervention group (72.22%) reported that they did not use drugs in the past 7 days compared with 6 people in the control group (37.50%) ($p<.05$). Other results for marijuana patients (past 30 days at 4 weeks; past 7-and 30 days at 8 weeks) were not found to be significant. No differences were observed for opioid patients.

IV. DISCUSSION

This study represents the first randomized trial of a body-motion activated game targeting drug relapse prevention for patients who were enrolled in an inpatient treatment program and the first trial of a motion activated video game aimed at the treatment of addiction in youth in any setting. The program was found to be feasible, primarily in the inpatient setting. Participants in the intervention group played on average for 3.6 days, which was close to the 4 days of game play target set by the study protocol for inpatient care. Those randomized to game play mostly agreed that they would use the refusal skills taught by the game and a slight majority reported that they did use those skills 4-weeks after discharge. There was a trend for those in the intervention group to report attending more outpatient counseling sessions than the control group, but differences were not significant. There was a trend for an effect of the game on past 7- and 30-day drug use at 4-weeks post discharge, with a significant benefit for a sub-group of participants who

were in treatment for marijuana use disorder. No evidence was found that the game worked by differentially improving self-efficacy for drug refusal or by differentially reducing cravings.

Overall, the dose of game play was small, limiting the potential for demonstration of effect. Contrary to the intended protocol, most intervention participants never received any game play after discharge from inpatient treatment. Thus, as designed, this study could not address the question of the effects of continued exposure to game play in the outpatient setting. Difficulties encountered for outpatient treatment largely were due to characteristics of the trial. Only about half of intervention participants came to MMTC for outpatient care. For the few who did come, game play could only be offered in the outpatient setting on an individual basis as there were too few trial participants at any given time to form a group. Participants expressed that they did not want to leave their outpatient group counseling sessions for individual game play and therefore declined to play in this setting. Future tests of the game may benefit from careful consideration of group dynamics, and where possible, deliver the game in a group, social format rather than as an individual game. Furthermore, if patients are unlikely to get access to the game in their outpatient treatment setting, then additional opportunities should be developed for game play in other settings, perhaps using home-based play on a computer or smartphone. This may have the potential to make the effects of the game more long-lasting, and should be investigated further.

That some effect of the game was found for marijuana participants but not opioid participants may indicate that the game is more promising for this sub-group. It may be that these patients are younger, with lower addiction severity and chronicity, and more likely to respond to a behavioral intervention. A game may also be more consistent with younger patients' preferences for less "serious" and more experiential treatments. It may be that higher doses of game play are needed for more entrenched physiological addiction such as for opiates.

While originally hypothesized as mediators of the effect of the game, the game play did not appear to increase levels of self-efficacy for drug refusal as self-efficacy remained constant. It may be that the game does not operate as hypothesized through refusal self-efficacy. It also appears that the game does not differentially decrease cravings. Other mechanisms such as repetition priming can be explored as mechanisms in future studies of the game.

Strengths of this study include that it was the first randomized study of a motion activated video game aimed at the treatment of addiction in youth. The game was built around an affordable off-the shelf motion-sensing peripheral that is widely used by youth, the Microsoft Kinect, which is most famous for its use with Microsoft's popular Xbox video game platform. The potential for dissemination is high, with possibility for play not only in treatment centers, but also potentially for play at home.

Limitations include that the study experienced significant loss to follow-up as about 40% of participants were not available for the 4-week and the 8-week follow-up interviews. While this is a high level of attrition, this level of attrition is not unusual for youth attending drug treatment facilities as participants following discharge are at high risk for dropout, relapse, incarceration and/or readmission to inpatient treatment. Additionally, marijuana and opioid patients were found to have different demographic characteristics and possibly different responses to the game. Also, treatment adherence in the intervention group was low in the post-discharge period, and few participants experienced game play after leaving the

in-patient setting. Another limitation is that the intervention group was not balanced with the control group for gender as there were fewer females in the intervention group than in the control group, although we did not find differential effects of the game by gender. Finally, the drug use outcome measures in this study relied on self-report only and because of social desirability, may represent undercounts of relapse rates. Future studies should use drug testing to verify abstinence.

Conclusions

This pilot study gives encouraging proof-of-concept results that an early prototype of the Recovery Warrior game is feasible and acceptable in inpatient treatment settings and produces some encouraging outcomes. Future, larger studies with more refined version of the game of the game are warranted to test its implementation in outpatient treatment settings, its overall efficacy, as well as how to best adapt it to different drug-using sub-groups.

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