A randomised controlled feasibility trial of alcohol consumption and the ability to appropriately use a firearm

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See Policy forum, page 425

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ABSTRACT

Objective: To show the feasibility of using a controlled trial to investigate the effect of alcohol on firearm use.

Methods: Randomised, blinded, placebo-controlled trial in the Firearm Usage and Safety Experiments (FUSE) Lab. Treatment subjects (male, 21–40-year-old, non-habitual drinkers, with no professional firearms training) received alcohol; control subjects received placebo alcohol. The AIS PRISim Firearm Simulator, including real pistols retrofitted to discharge compressed air cartridges that simulate firearm recoil and sound, was used to measure firearm performance. Accuracy and speed for target shooting, reaction time scenarios, and scenarios requiring judgement about when to use a gun were measured.

Results: 12 subjects enrolled in the trial, completing 160 training scenarios. All subjects in the alcohol arm reached target alcohol level. 33% of placebo subjects reported alcohol consumption. Mechanical malfunction of the simulator occurred in 9 of 160 (5.6%) scenarios. Intoxicated subjects were less accurate, slower to fire in reaction time scenarios, and quicker to fire in scenarios requiring judgement relative to controls.

Conclusions: The feasibility of a randomised, controlled trial exploring the relationship between alcohol consumption and firearm use was shown. The hypothesis that alcohol consumption worsens accuracy and retards judgement about when to use a gun should be tested. Larger trials could inform policies regarding firearm use while intoxicated.

Injury is a leading cause of alcohol-related death and alcohol is a leading risk factor for injury.[1 2] About one-quarter of alcohol-related injury deaths are due to motor vehicles, and most research on the relation between alcohol and injury has targeted drunk driving. An association between heavy alcohol consumption and firearm injury has been shown,[3] but little research has focused on alcohol related firearm use.

Randomised, blinded, placebo-controlled trials were important to the creation of national blood alcohol concentration (BAC) limits for driving and have influenced public policy, resulting in a decrease in the number of traffic fatalities involving alcohol.[4] The prevention of drinking and driving has been hailed as one of the top ten US public health achievements of the 20th century by the Centers for Disease Control.[5 6] The use of similar trials could help to establish proscribed BAC levels for alcohol-impaired possession or discharge of firearms, resulting in a reduction of firearm-related injuries.

No scientific trial has been undertaken to establish a shooter's ability to appropriately use a firearm relative to their BAC. We performed a trial with a primary aim of determining the feasibility of performing a large randomised, double-blind, placebo-controlled, parallel group trial to determine the minimum effective level of alcohol consumption that significantly affects the ability to appropriately use a firearm. A secondary goal was to generate hypotheses related to the effect of alcohol on firearm performance.

METHODS

Selection and description of participants

Newspaper advertisements were used to recruit men aged 21–40 years who consumed alcohol and had no professional firearm training. Respondents were screened over the phone. Pertinent inclusion criteria included weight (100–250 lb), ⩾5 drinks in the last 30 days, no history of counselling for alcohol dependence, a score of <5 on the short Michigan alcohol screening test, and corrected vision of 20/20. Pertinent exclusion criteria included professional firearm training (military or police), personal (current) gun ownership, or any incarceration or court-ordered therapy for alcohol related violations. The trial was approved by the institutional review board (IRB) at the University of Pennsylvania. The IRB did not request that the ethics committee review the proposal. All testing sessions were conducted from June to August of 2007.

Technical information

Subject processing

Enrolment took place at the University of Pennsylvania Police Department. Subjects were screened for weapons and contraband by an off-duty police officer. A physician was present at all times in case of adverse reactions to intoxication. Subject enrolment and all study activities were conducted individually and without the off-duty police officer in the room. Following consent and baseline data collection, subjects were oriented to the firearm simulator and baseline shooting data were collected. They were then escorted to a separate room for randomisation and consumption prior to returning to the simulator for further firearm use measurement.

Firearm simulator

The ability to use a firearm was assessed with the AIS Professional Range Instruction Simulator (PRISim), an interactive firearms shooting and judgement training simulator.[7] This simulator is a desktop, low cost, modifiable system that includes software, a central processing unit, a laptop computer, a projection unit, and a hit detection camera. The PRISim utilises actual firearms that have been retrofitted with laser firing capabilities and are completely untethered. These firearms are modified to fire

compressed air cartridges that simulate actual firearm recoil with each trigger pull. Our PRISim platform includes a Smith & Wesson 5946 Tactical pistol that was used by all study subjects. The platform produces realistic video-based environments for all aspects of firearms handling including marksmanship, decision-making, and tactical strategies. The simulator automatically stores shooting data, including the number of shots fired, time (to the hundredth of a second) of each shot fired, bullet-strike location of each shot fired, and for human targets, specific anatomic damage of each shot fired. Figure 1 illustrates the ante-space and open space of a simulation environment.

Alcohol consumption

The alcohol we served was double-distilled, 100-proof Absolut Vodka and effervescent tonic water. The placebo was chilled, flat tonic (in 100-proof Absolut Vodka alcohol bottles) mixed with effervescent tonic. Participant alcohol dosages were based on body weight and were randomised to be titrated to 0.05 or 0.10 g% as per previous laboratory studies.[8–10] Alcoholic beverages were prepared using a 1:4 dilution ratio.[8–10] Staff enrolling subjects were blinded to whether the subject was receiving alcohol or placebo. To prevent placebo detection, subjects observed a rigged coin toss[11] and were told they had been randomised into the alcohol arm of the study. Participants observed preparation of their beverages from bottles with visible commercial labels (including flat tonic in a vodka bottle) and received them in a glass with a fresh lime slice. All limes were dipped in a negligible amount of vodka and rubbed on the rim of the glass to convey authenticity. At the end of the consumption period, and at 15 minute increments, breath alcohol measurements were measured. On completion of the study, subjects were asked whether they had consumed alcohol, to rate their degree of intoxication, and underwent field sobriety testing. All participants were unblinded at the close of the trial and monitored by research staff until they were sober.

Firearm use

Three types of data described below were obtained using the training laboratory at baseline (pre-consumption) as well as after consumption of alcohol or placebo.

Target practice

The first set of trials measured accuracy and speed using still and moving targets. To test accuracy, participants were shown still targets at variable distances and told: "Please shoot for the X. Count out 8 shots." To test speed, participants were shown five still plates of different sizes and told: "Please place at least one shot in each of the five plates as quickly as you can. The clock will not start until you take your first shot."

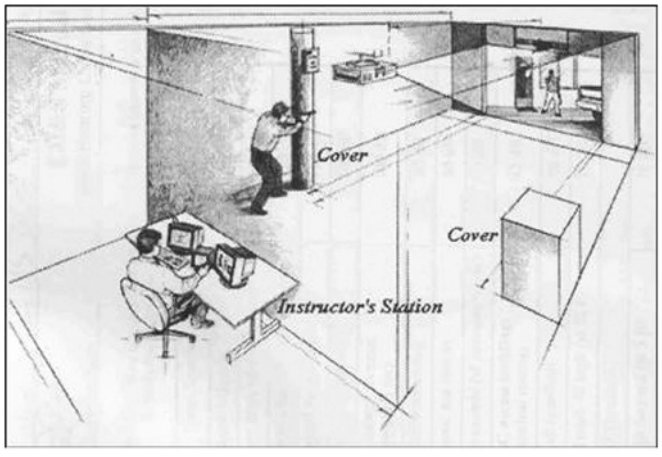

Figure 1 Laboratory space with the shooting simulator.

Human scenarios

- *Reaction time scenarios*. In the second set of training scenarios, we tested speed and accuracy (without judgement about when to use lethal force) in human scenarios consisting of a single subject with a concealed weapon who drew their weapon, pointed it at the participant, and fired the weapon. Subjects were instructed prior to the beginning of the scenario to "Please hold your gun down at your side. Shoot when you see a gun."
- *Judgement scenarios*. The final series of scenarios tested participants in more realistic situations. These situations placed participants in several situations in which: (1) they were clearly being threatened with a weapon; (2) it was ambiguous as to whether they were being threatened; and (3) they were clearly not threatened. The scenarios required participants to rapidly judge whether or not they needed to use their firearm. Examples include a scenario in which the subject: (1) observes a drug deal and then is threatened with a weapon; (2) encounters a situation in which a hostage is being held by an armed assailant who then points the gun at the subject; and (3) encounters an individual who without provocation produces and discharges a firearm. We included scenarios with intentionally ambiguous threats to test how alcohol might influence rapid information processing and assessment about whether or not to use force. At the beginning of each session, subjects were told: "You will now be placed in several simulated real-world situations. Sometimes these situations will be life-threatening. Use your gun whenever you need to protect yourself."

Research staff documented the number of times participants placed their hand on the weapon, produced the firearm, and fired the weapon. The PRISim platform recorded anatomic location of the shot and the time from the appearance of the threat to when the shot was fired. All data were recorded in real time onto data collection forms and then transcribed into a computer database.

Statistics

Descriptive statistics were used to describe the population and the results. To control for the learning that would likely occur over the course of the trial, we calculated the difference between pre- and post-consumption performance and qualitatively compared this difference in the experimental group to the difference in the control. While we formally compared the groups with respect to intoxication, in general we did not compare the groups statistically as the primary intent of this pilot was to demonstrate the feasibility of the trial's methods. Instead, we compared firearm use for each group before and after consumption and used the difference in performance to estimate the effect of the alcohol on performance.

RESULTS

Feasibility

We received 57 calls in response to our advertisements in the newspaper and scheduled 12 subjects to enrol in the study. Of these, 4 subjects (33%) did not show up and replacements had to be contacted and scheduled. Of the 12 subjects who eventually presented to be enrolled in the study, all completed the study and are described in table 1. Subjects in the alcohol group were older, but generally equivalent with respect to demographic and anatomic (eg, hand grip) factors. All subjects in both groups

Table 1 Description of the population

	Alcohol (n = 6)	Placebo (n = 6)
Demographics		
Age (mean)	35.83 (4.07)	26.00 (4.53)
Weight (without shoes) (lb)	184.00 (20.88)	192.00 (31.98)
Height (without shoes) (in)	69.67 (3.21)	71.17 (3.30)
Body mass index	36.85 (3.82)	26.65 (3.94)
Systolic blood pressure (mm Hg)	124.67 (10.01)	122.67 (8.91)
Diastolic blood pressure (mm Hg)	85.00 (8.94)	85.33 (4.68)
Heart rate (bpm)	74.00 (15.67)	68.00 (7.59)
Respiratory rate (brpm)	15.67 (4.27)	13.33 (1.63)
% smoke cigarettes	0	0
Thumb crotch–index finger length (cm)	12.80 (1.55)	13.80 (1.15)
Index finger length (cm)	8.35 (1.46)	8.40 (2.18)
Index finger distal phalynx length (cm)	2.73 (0.16)	2.68 (0.15)
Hand dynamometer reading (psi) (lb)	103.88 (25.94)	102.80 (9.30)
Cognitive		
Mini-mental score (0–30) (mean)	29.67 (0.52)	29.17 (1.60)
% graduated high school	100	100
Firearm use		
% with professional gun training	0	0
No. times shot or used a gun (ever)	20.50 (18.80)	21.67 (39.55)
% who ever had a gun in public	0	0
Alcohol use		
CAGE screen score (0–4) (mean)	0 (0)	0.04 (0.10)
% that drink alcohol	100.00	100.00
% that drink alcohol more than once a week (last year)	66.67	66.67
No. drinks on average on days that you drink	2.33 (0.98)	3.00 (0.77)
No. drinks in a 24 hour period (last year)	6.83 (2.21)	6.58 (1.43)
% that had 5 or more drinks in a 2 hour period (last year)	66.67	50.00

SD in parentheses.

screened negative for alcohol dependence, passed field sobriety testing, and screened negative for alcohol on breathalyser.

All subjects randomised into the alcohol arm of the study effectively reached their target alcohol level. The low dose group (target 0.050) had an average initial testing dose of 0.061 and the moderate dose group (target 0.105) had an average target dose of 0.106. No subject deviated from goal BAC by more than 20% within the testing period. At the close of the testing period, one third of the subjects in the placebo arm erroneously reported that they had consumed alcohol. There was a significant decrease in performance on all field sobriety tasks (horizontal gaze nystagmus ($p = 0.04$), walk and turn test ($p = 0.01$), and one leg stand test ($p = 0.005$)).

Overall, the 12 subjects completed 32 scenarios testing their reaction time and 128 human (reaction time and judgement) firearm training scenarios. On average, the subjects spent 72.5 minutes in the simulator being tested on the firearm. Eight of the human training scenarios (6.25%), and one (3.13%) of the reaction training scenarios were disrupted as a result of a mechanical or technical failure of the PRISim system.

Firearm use

No subject in either group had ever received professional firearm training or carried a gun in public, and there was no difference between groups in the number of times that participants had fired a gun. Pre-consumption target practice revealed that subjects in the alcohol group were slightly slower and more accurate than subjects in the placebo group as detailed in table 2.

Following consumption, the groups were similar with respect to the number of times per scenario that they reached for their gun (1.5 vs 1.4), and the number of times they produced their gun (0.98 vs 0.89). We first considered the change in accuracy between groups before and after consumption. In target practice, both groups improved their accuracy, although the alcohol group improved less than the placebo group. We next considered the difference in the speed of shots between groups before and after consumption. In target practice, the alcohol group had a marginal decrease in speed, but in scenarios measuring only reaction time the alcohol group had an increase in both time to first shot and time to first hit, whereas the placebo group decreased the time required to shoot and time required to hit the target. In scenarios requiring judgement before using a firearm, both groups decreased the time to shoot and time to hit the target, with the alcohol group decreasing both times slightly more than the placebo group. Table 2 describes all findings. We noted a substantial increase in the

Table 2 Firearm performance

	Alcohol group baseline	Placebo group baseline	Baseline (pre-consumption) difference (alcohol − placebo)	Alcohol group post-consumption change	Placebo group post-consumption change	Post-consumption difference (alcohol − placebo)*
Target practice						
Speed (seconds)	6.8	5.24	1.56	−1.68	−1.09	−0.59
Accuracy (% bulls eye)	98.86	85	13.86	1.14	8.07	−6.93
Reaction time scenarios						
Speed (seconds)						
First shot	8.35	8.01	0.34	0.87	−0.58	1.45
First hit	8.81	8.8	0.01	1.49	−0.95	2.44
Accuracy (% hit target)	100%	100%	0	100%	100%	0
Judgement scenarios						
Speed						
First shot	36.41	35.87	0.54	−5.22	−4.36	−0.86
First hit	36.5	36.82	0.32	−4.41	−1.51	−2.9
Accuracy	50	27.78	22.22	−0.47	12.22	−12.69

*A positive number represents increase in the alcohol group relative to the placebo group.

average number of shots fired after the target was hit following consumption in the alcohol group (1.1 vs 2.4). A total of 12 (7.5%) firearm scenarios experienced a malfunction of the system requiring data for the failed scenario to be discarded.

DISCUSSION

The primary goal of this study was to demonstrate the ability to perform a blinded randomised trial investigating the relation between alcohol consumption and gun use. We show that this is feasible, successfully enrolling 12 subjects in the trial and completing 160 firearm scenarios. A secondary goal of the trial was to explore the effect of alcohol on the ability to appropriately use a firearm. We observed small increases in the frequency with which intoxicated subjects reached for their gun, produced their gun, and fired their gun. We also observed that intoxicated subjects had either an absolute decrease in accuracy or a relative decrease in accuracy, suggesting they failed to learn over time. The findings about speed were mixed, with intoxicated subjects demonstrating slower reaction time in scenarios not requiring judgement, but faster response time in scenarios requiring complex decision making before deciding to use force.

The trial that we report here is primarily a feasibility trial and thus, the primary limitation is that the trial is underpowered to appropriately determine the relationship between alcohol and firearms. As such, we have only descriptively compared differences in speed and accuracy following consumption and have only interpreted our findings as hypothesis generating. Performing this pilot, however, was very helpful in the planning of a larger trial. We excluded individuals with professional firearm training as we believe this population may require a separate trial. Our trial may have been biased by our use of a rigged coin toss and a placebo. While these methods have been used in previous alcohol trials, they raise some concerns, for example that placebo alcohol consumption may influence performance.[12]

An association between firearm injury and heavy alcohol consumption has been demonstrated.[3] However, only 26 US states explicitly restrict firearm use for persons who are intoxicated.[13] Because alcohol-related firearm injuries exact a significant US and worldwide[14] toll, better understanding of the alcohol levels at which individuals can no longer appropriately use firearms could inform policies regarding gun carrying and use while intoxicated. Assuming a larger trial that follows this pilot finds that intoxication causes inappropriate gun use, any resultant policies restricting firearm carrying/use while intoxicated could have larger policy impacts via: the discovery and punishment of gun carriers (legal and illegal) who are intoxicated before they discharge their weapons, and the discovery and punishment of gun carriers (legal and illegal) who are intoxicated after they discharge their weapons.[i]

CONCLUSION

We demonstrate the feasibility of a randomised, controlled trial exploring the relationship between alcohol consumption and firearm use. The hypothesis that alcohol consumption worsens accuracy and retards judgement about when to use a gun should be tested. Larger trials could inform policies regarding firearm use while intoxicated.

[i] With regard to the latter group, criminal gun users found to be intoxicated during their crimes may be assigned lesser penalties given their impaired state and the resultant inability for prosecutors to demonstrate criminal intent or "malice aforethought" to commit the crime in question, up to and including crimes such as first-degree murder.

What is already known on the subject

- Alcohol impacts the mental and physical capability to perform complex tasks, including driving a motor vehicle and possibly using a firearm.
- The reduction of deaths attributed to state restrictions on drinking and driving has been recognised as a public health success.
- Few states regulate the possession and use of firearms by intoxicated individuals.

What this study adds

- We describe methods that may be used to scientifically study the relationship between alcohol use and firearm use.
- Larger trials using these methods could be used to inform policies related to the intersection of alcohol use and firearm use.

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Competing interests: None declared.

Ethics approval: The trial was approved by the institutional review board (IRB) at the University of Pennsylvania. The IRB did not request that the ethics committee review the proposal.

Provenance and peer review: Not commissioned; externally peer reviewed.

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