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Trial of Training to Reduce Driver Inattention in Teens with ADHD

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Abstract

BACKGROUND—Teens with attention deficit–hyperactivity disorder (ADHD) are at increased risk for motor vehicle collisions. A computerized skills-training program to reduce long glances away from the roadway, a contributor to collision risk, may ameliorate driving risks among teens with ADHD.

METHODS—We evaluated a computerized skills-training program designed to reduce long glances (lasting ≥2 seconds) away from the roadway in drivers 16 to 19 years of age with ADHD. Participants were randomly assigned in a 1:1 ratio to undergo either enhanced Focused Concentration and Attention Learning, a program that targets reduction in the number of long glances (intervention) or enhanced conventional driver's education (control). The primary outcomes were the number of long glances away from the roadway and the standard deviation of lane position, a measure of lateral movements away from the center of the lane, during two 15-minute simulated drives at baseline and at 1 month and 6 months after training. Secondary outcomes were the rates of long glances and collisions or near-collisions involving abrupt changes

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A Quick Take is available at NEJM.org

Videos of the intervention driver-training program are available at NEJM.org

in vehicle momentum (g-force event), as assessed with in-vehicle recordings over the 1-year period after training.

RESULTS—During simulated driving after training, participants in the intervention group had a mean of 16.5 long glances per drive at 1 month and 15.7 long glances per drive at 6 months, as compared with 28.0 and 27.0 long glances, respectively, in the control group (incidence rate ratio at 1 month, 0.64; 95% confidence interval [CI], 0.52 to 0.76; $P<0.001$; incidence rate ratio at 6 months, 0.64; 95% CI, 0.52 to 0.76; $P<0.001$). The standard deviation of lane position (in feet) was 0.98 SD at 1 month and 0.98 SD at 6 months in the intervention group, as compared with 1.20 SD and 1.20 SD, respectively, in the control group (difference at 1 month, −0.21 SD; 95% CI, −0.29 to −0.13; difference at 6 months, −0.22 SD; 95% CI, −0.31 to −0.13; $P<0.001$ for interaction for both comparisons). During real-world driving over the year after training, the rate of long glances per g-force event was 18.3% in the intervention group and 23.9% in the control group (relative risk, 0.76; 95% CI, 0.61 to 0.92); the rate of collision or near-collision per g-force event was 3.4% and 5.6%, respectively (relative risk, 0.60, 95% CI, 0.41 to 0.89).

CONCLUSIONS—In teens with ADHD, a specially designed computerized simulated-driving program with feedback to reduce long glances away from the roadway reduced the frequency of long glances and lessened variation in lane position as compared with a control program. During real-world driving in the year after training, the rate of collisions and near-collisions was lower in the intervention group.

Motor vehicle collisions are one of the leading causes of death among teens.[1] Teen drivers are four times as likely to be involved in a collision as adult drivers.[2] Teens with attention deficit–hyperactivity disorder (ADHD) are twice as likely as neurotypical teen drivers to be in a collision.[3] Teen drivers, particularly those with ADHD, have difficulty sustaining visual attention to the roadway, especially when distracted.[4,5] When performing distracting tasks, teens take long glances (≥2 seconds) away from the roadway rather than repeated brief glances between the secondary task and the roadway[6] (Videos 1 and 2), a behavior that increases the risk of motor vehicle collision.[7,8] Teens with ADHD have higher rates of long glances than neurotypical teens.[9]

The Focused Concentration and Attention Learning (FOCAL) program is a single-session, desktop-based software program that trains neurotypical teen drivers to limit long glances away from the roadway.[10,11] Because teens with ADHD have difficulties in implementing learned skills in everyday life,[12] we enhanced the FOCAL desktop training (FOCAL+) to include multiple sessions and to include simulator training with immediate auditory feedback when long glances occurred. We conducted a randomized, controlled trial to compare the effect of this intervention program with a modified conventional driver's training (control) with regard to long glances and lane variation during simulated driving at 1 month and 6 months after training and with regard to long glances and collisions or near-collisions during 1 year of real-word (naturalistic) driving.

METHODS

PARTICIPANTS AND TRIAL OVERSIGHT

Teens 16 to 19 years of age with ADHD who had a valid driver's license were recruited at the Cincinnati Children's Hospital Medical Center by means of radio, social media, and print advertisements. Teens were randomly assigned in a 1:1 ratio to undergo either the intervention training (FOCAL+) or control training and were followed for 1 year afterward (Fig. 1).

The trial was approved by the institutional review board at Cincinnati Children's Hospital Medical Center. All the teens 18 years or age or older and all the parents and guardians provided written informed consent for trial participation; teens younger than 18 years of age provided written informed assent. No commercial interests were involved in the trial. The authors vouch for the accuracy and completeness of the data and for the fidelity of the trial to the protocol, which is available with the full text of this article at NEJM.org.

Participants met the diagnostic criteria for ADHD according to the clinician-administered Kiddie Schedule for Affective Disorders and Schizophrenia[13] interview with the parent and the teen. Eligibility criteria included the spending of at least 3 hours per week in unsupervised driving according to report by the teen, a parent willing to participate, and an average score (>80) on any of the composite scores of the Kaufman Brief Intelligence Test, 2nd edition (scale, 40 to 160, with higher scores indicating higher intelligence).[14] Teens were excluded if they were unable to discern task stimuli in the simulator without eyeglasses, reported motion sickness on the Georgia Tech Simulator Sickness Screening survey[15] after a 2-minute simulated drive, had substance use problems (defined as a score of ≥4 on the Simple Screening Instrument for Alcohol and Other Drugs16; range, 0 to 21, with higher scores indicating higher degree of risk of alcohol and other drug abuse), could not stop taking ADHD medication on days on which driving was evaluated, or had a history of multiple head traumas or had lost consciousness for more than 30 minutes. In addition, teens were excluded from the trial if the eye-tracking equipment that was used at baseline was not able to successfully capture eye gaze (i.e., captured data <80% of the time).

Families were paid $180 for completing three in-person driving-evaluation visits, $20 for each training visit, and $20 for deinstallation of the in-vehicle recording device. Participants who were taking ADHD medications refrained from taking ADHD medication on the days of training and driving-simulation visits, which was confirmed at all visits.

TRAINING SESSIONS

Training consisted of five sessions, each lasting approximately 90 minutes. Each session had two stages. To learn and reinforce the skills with their teen, parents were invited to participate in stage 1 of the first and fifth training sessions of their teen's randomly assigned program.

INTERVENTION TRAINING

In the intervention group, teens were informed of the risks associated with long glances and were instructed to use repeated brief glances to complete tasks while driving. Stage 1 of each training session consisted of the five-step standard desktop FOCAL program in the following steps. In step 1, participants watched a video of a drive from the driver's perspective on the top half of a computer screen (Fig. 2). While the video was playing, participants were instructed to search for street names on a map that was displayed on the bottom half of the screen (street name search task). When the participant pressed the spacebar, the view of the forward roadway was replaced by a view of a map while the video of the roadway, no longer visible, continued in the background. Toggling between the roadway and map simulated the multitasking that occurs when a driver engages in a distracting task while driving. Glance durations were measured by the intervals between spacebar presses.

In step 2, the drive was replayed, but the roadway view was blacked out while participants were viewing the map; this setup showed the participant how long glances affect roadway viewing. In step 3, the drive was replayed again with a visible timer during the blacked-out periods in order to show the duration of the long glances. In step 4, a new drive was played with the same street name search task; however, a warning tone sounded when glances at the map lasted 3 seconds or longer. Participants repeated the drive until all their long glances at the map were less than 3 seconds. Finally, in step 5, the drive for step 4 was repeated until the participant was successful at having only brief glances away from the roadway with a 2-second threshold, which was the ultimate target that we wished for the drivers to attain.

During stage 2 of training, teens wore eye-tracking glasses with embedded accelerometric and gyroscope sensors to detect head and eye movements (Tobii Glasses 2, Tobii Pro) in a driving simulator (STISIM Model 400, Systems Technology) with three driving displays offering a 135-degree field of view for the driver with integrated rearview and side mirrors, a full-sized steering wheel with haptic-based resistance and vibration, gas and brake pedals, and a car seat. The simulated roadway consisted of straight and curved two-lane roads in urban and suburban settings.

At each training session, teens completed one 5-minute drive during which the driver was alerted with an auditory tone and visual symbol cue on the dashboard approximately once per minute. The driver had to identify within 20 seconds how many times that symbol was present within a 6 × 6 symbol array displayed on a simulated center console (symbol search task). Real-time eye-tracking and onboard sensor data were used to identify long glances (lasting ≥2 seconds), and a continuous auditory alarm alerted the teen until the visual gaze returned to the roadway (Video 3). Participants who had any long glances or who had no more than 50% accuracy on the symbol search task completed additional 5-minute drives until they succeeded in having no long glances and had a response accuracy of more than 50%. Participants underwent a maximum of five training drives regardless of performance.

CONTROL TRAINING

The control driver's education program did not include a module on driver inattention. Stage 1 of the control program included desktop-based slides, videos, and knowledge tests from three units (Traffic Control Devices and Laws, Adverse Driving Conditions and Emergencies, and Tire Safety and Maintenance) of the 2016 American Driver and Traffic Safety Education Association curriculum, version 3.0.[17]

During stage 2, teens in the control group completed the same driving simulation and symbol search task as participants in the intervention group but without auditory feedback in response to long glances. Participants in the control group were told that driving simulation was a time to practice the rules learned during stage 1. The main difference between stage 2 of the intervention program and the control program was the absence of auditory feedback to signal and correct long glances.

The comparator training controlled for the number and duration of the intervention training sessions, amount of trainer attention, parent involvement, and exposure to simulated driving. Each participant in the control group was matched to a participant in the intervention group and completed the same number of training drives that the intervention participant had completed in order that the number of training drives completed within each of the five sessions would be equal across the two groups.

EVALUATION OF SIMULATED DRIVING

For the evaluation of the primary outcomes (see below), participants completed two 15-minute simulated drives, using the driving simulator and eye-tracking hardware described above, at baseline and then at 1 month and 6 months after training. These evaluation drives differed from the training drives in that each drive was longer than the 5-minute drive in stage 2 of training, there was no auditory feedback in response to long glances, and the distraction task was altered to reduce practice effects. Once per minute, the driver was alerted with an auditory and visual cue (i.e., a letter on the dashboard). The participant then had to identify, within 20 seconds, how many roads started with the target letter on a map displayed on the center console (map search task). With the use of visual mapping from the eye-tracking data, a forward roadway–gaze area was defined. For each 20-msec epoch, gaze-analysis software (Tobii Pro Lab, version 1.98.1) was used to determine whether the gaze was off the forward roadway.

EVALUATION OF REAL-WORLD DRIVING

For the evaluation of real-world driving in both groups, after the completion of training an in-vehicle recording system (DriveCam DC3, Lytx) was installed below the rearview mirror for 1 year in the vehicle driven most by the teen. This in-vehicle recording device has two integrated cameras: one facing the forward roadway and one facing the driver. If the built-in accelerometer detected a forward or lateral g-force (gravitational force equivalent) of at least 0.6 g, the device recorded the 8 seconds before and 4 seconds after the triggered incident (g-force event). Four g-force events were randomly selected for scoring if a teen had more than four such events within 1 week. Using an established system,[5] two scorers who were unaware of the trial-group assignments determined whether the g-force event included a collision or near-collision. In addition, for each g-force event in which the driver's eyes were visible in a camera, the onset and offset of glances away from the roadway were scored. Scoring discrepancies were handled by discussion among scorers until consensus was reached.

OUTCOMES

This trial had two primary outcomes. The first primary outcome was the number of long glances (lasting ≥2 seconds) away from the roadway during the map search tasks during two 15-minute simulated drives that were conducted at baseline and at 1 month and 6 months after training. The second primary outcome was the standard deviation of lane position, as measured in feet, during the simulator drives. Specifically, every 17 msec during the map search tasks for these drives, the software located the center of the car in relation to the center of the lane. A standard deviation around each participant's mean lane position was computed with the use of these values. A standard deviation of 0 indicated no deviation in lane position.

Data on secondary outcomes were obtained during real-world driving over the 1-year period after training. Data consisted of a binary determination of whether a glance away from the roadway lasted at least 2 seconds during the 5 seconds before and the 1 second after each g-force event and whether the g-force event involved a collision (i.e., contact between vehicle and another object) or near-collision (i.e., evasive maneuver to avoid a collision).[18]

STATISTICAL ANALYSIS

We powered our trial with a sample of 152 for the exploration of moderators of training effects (see the Supplementary Appendix, available at NEJM.org). For the two primary outcomes, which were assessed at 1 month and 6 months after training, we estimated that, at a two-tailed alpha level of less than 0.05, a sample of 152 participants (76 in each group) would provide the trial with 96% power to detect an incidence rate ratio of 0.88 or less between the intervention group and the control group for the count of long glances and an adjusted mean between-group difference of −0.36 SD or less for the standard deviation of lane position in feet.

The primary analyses were performed in the intention-to-treat population, which included all the participants who had undergone randomization. Given that driving experience affects driving outcomes,[19] the analyses of the primary outcomes included prespecified adjustment for driver's experience (i.e., the number of months with a driver's license). To assess the primary outcomes, we used generalized estimating equations with an independent correlation structure and with accounting for clustering within participants for each outcome. Trial group (intervention or control), time point (baseline, 1 month after training, or 6 months after training), and two interaction terms between group and time point (baseline vs. 1 month and baseline vs. 6 month) were tested. A Poisson distribution with a natural logarithmic link function was specified in the analysis of the count of long glances. A normal distributional assumption with an identity link function was specified in the analysis of standard deviation of lane position. To control for the four tests of the two primary outcomes (each primary outcome at 1 month and 6 months), we used a Bonferroni-corrected alpha of 0.0125.

To assess secondary real-world outcomes, the number of days that the in-vehicle recording device was operational was included as a covariate to control for cases in which the in-vehicle recording device had been removed early (e.g., if the motor vehicle was destroyed in a collision). These analyses were conducted in the as-treated population, which involved participants for whom data from the in-vehicle recording device were available. The number of months of driving experience was included as a covariate. Modified generalized estimating equation analyses[20] with assumption of a Poisson distribution and natural logarithmic link function were used to analyze individual events on the in-vehicle recording device per participant (random effect) and to assess the estimated relative risk of each dichotomous outcome (i.e., presence or absence of long glance and presence or absence of collision or near-collision per g-force event). Because there was no plan for adjustment of the widths of confidence intervals for multiplicity correction for secondary outcomes, no definite conclusions can be drawn from these results.

Missing data were handled with the use of 100 imputed data sets that were based either on fully conditional specification imputation for long glances or on model-based imputation for standard deviation of lane position (primary outcomes) and for missing data on the presence or absence of long glances as assessed by the in-vehicle recording device (secondary outcome) (see the Supplementary Appendix). The incidence of adverse events related to simulated driving during training and evaluation was compared between groups with the use of Fisher's exact tests.

RESULTS

TRIAL PARTICIPANTS

Trial recruitment took place between December 21, 2016, and March 4, 2020. A total of 76 teen drivers with ADHD were assigned to each trial group (Fig. 3). The demographic characteristics of the participants were similar in the two groups (Table 1) and were representative of teens with ADHD, except with regard to race, which underrepresented Black teens (Table S1 in the Supplementary Appendix).

Teens in the intervention group attended a mean (±SD) of 4.6±1.0 of the 5 training sessions, and those in the control group attended a mean of 4.9±0.6 of the 5 training sessions. Most teens (87% of those in the intervention group and 96% of those in the control group) attended all 5 sessions. In both groups, participants completed a mean of 4.6 of the possible 5 training drives per session.

During training drives in the intervention group, alarms sounded a mean of 23.2±20.4 times per drive during the first training session, decreasing to 17.0±12.1 alarms per drive during the final training session. Parent attendance was low at both the initial training session (48 parents in the intervention group and 52 in the control group) and the final training session (17 and 30, respectively).

PRIMARY AND SECONDARY OUTCOMES

At baseline, the mean number of long glances per 15-minute drive was 21.5 in the intervention group and 23.1 in the control group. During the simulated-driving evaluations after training, teens in the intervention group had 16.5 long glances per 15-minute drive at 1 month and 15.7 long glances per 15-minute drive at 6 months, as compared with 28.0 and 27.0 long glances per 15-minute drive, respectively, among teens in the control group (incidence rate ratio at 1 month, 0.64; 95% confidence interval [CI], 0.52 to 0.76; P<0.001; incidence rate ratio at 6 months, 0.64; 95% CI, 0.52 to 0.76; P<0.001). Teens in the intervention group had 0.98 SD of lane position per drive at 1 month and 0.98 SD of lane position in feet per drive at 6 months, as compared with 1.20 SD and 1.20 SD per drive, respectively, among teens in the control group (adjusted mean difference at 1 month, −0.21 SD; 95% CI, −0.29 to −0.13; P<0.001; difference at 6 months, −0.22 SD; 95% CI, −0.31 to −0.13; P<0.001) (Table 2 and Figs. S3 and S4).

The in-vehicle recording device was not installed in the cars of 5 participants (3 in the intervention group and 2 in the control group). During 1 year of real-world driving, the in-vehicle recording device was operational for a mean of 316.4±97.4 days (308.1±107.9 days in the intervention group and 324.6±85.5 days in the control group), during which 6031 g-force events were recorded. The total number of yearly g-force events across all the participants ranged from 0 to 190 (mean, 42.3±46.2 g-force events in the intervention group and 37.1±37.9 g-force events in the control group). Three teens (1 in the intervention group and 2 in the control group) had no g-force events during the 1-year follow-up for the evaluation of secondary outcomes. Teens in the intervention group had long glances during 588 of 3213 g-force events (18.3%), as compared with long glances during 674 of 2818 g-force events (23.9%) among teens in the control group (relative risk, 0.76; 95% CI, 0.61 to 0.92). Motor vehicle collisions or near-collisions occurred during 110 of the 3213 g-force events (3.4%) among teens in the intervention group, as compared with during 159 of the 2818 g-force events (5.6%) among teens in the control group (relative risk, 0.60; 95% CI, 0.41 to 0.89). Additional analyses (not prespecified) that examined the effects of stimulant medication and of the coronavirus disease 2019 pandemic on the effectiveness of the intervention training program are presented in the Supplementary Appendix.

ADVERSE EVENTS

During evaluation drives, motion sickness in the simulator occurred in none of the participants in the intervention group and in 3% of the those in the control group. Motion sickness occurred during training drives in 8% of the participants in the intervention group and in 5% of those in the control group. Frustration with the simulator training occurred in 3% of the participants in the intervention group and in none of the participants in the control group (Table S3).

DISCUSSION

In teens with ADHD who were distracted during simulated driving, an intervention involving FOCAL+ training resulted in fewer glances away from the roadway lasting at least 2 seconds and in less lane variation, an indicator of weaving that is associated with collision risk,[21] at 1 month and 6 months than training with a modified conventional driver's education program. The effects of the intervention were observed on secondary real-world driving outcomes, in which participants in the intervention group had numerically lower rates of long glances and of collisions or near-collisions during g-force events than participants who underwent the control training program.

The intervention program that was used in this trial was devised to reduce the duration of glances to distracting tasks by training teens to use repeated brief glances between the secondary task and the roadway. The training used artificial secondary tasks in a laboratory driving environment that consisted of a desktop computer and driving simulator — a setup that differs from driver-motivated, impulse-susceptible secondary tasks, such as looking at a cellular telephone, that teens encounter during real-world driving.[22] However, the effects of training were observed during real-world driving, which suggests that the teens with ADHD in our trial were able to carry over trained skills to real-life settings.

Stimulant medication has been shown to improve real-world driving in teens with ADHD.[23–25] The pharmacologic effects of these medications last approximately 10 to 12 hours.[26] Yet, teens drive and are susceptible to motor vehicle collisions during the late afternoon after school and during the evening,[5,27–29] when the effects of stimulant medication are typically waning.[26] Nonpharmacologic interventions for reducing ADHD-related driving risks typically target teen–parent interactions and hazard detection[24,30,31] and have not affected adverse driving outcomes in naturalistic settings.

Limitations of this trial include our inability to determine the influence of ADHD medication on collisions or near-collisions. Although the proportion of teens taking ADHD medication was similar in the two trial groups both at baseline and over the course of the post-training period, it was not possible to determine whether participants were taking medication at the time of g-force events. Because the trial included li-censed drivers who had already completed required state driver trainings that included coursework and supervised driving, we do not know whether the intervention program would be effective in the absence of previous training. In addition, the trial took place in Cincinnati, which could affect generalizability, especially given the Ohio policies mandating graduated licensing, driver's education, and behind-the-wheel training in teens.[32] Whether training with FOCAL, FOCAL+, or some other program to reduce glances from the roadway can be effective at remediating driving risks among neurotypical teens is unclear. Finally, parents are known to have a positive effect on their children's driving,[33] and it was difficult to involve parents in training sessions.

In this trial involving teen drivers with ADHD, we found that a computerized program designed to train participants to limit long glances from the roadway decreased risky long-glance behavior at 1 month and 6 months after training, as compared with an enhanced conventional driver's education program, and reduced the risk of collision or near-collision during 1 year of real-world driving conditions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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The computer-based training that was used in stage 1 of our trial (Focused Concentration and Attention Learning [FOCAL]) is not proprietary and can be downloaded from the Human Performance website of the Department of Mechanical and Industrial Engineering at the University of Massachusetts, Amherst (http://www.ecs.umass.edu/hpl). Stage 2 of the enhanced training (FOCAL+) requires a driving simulator, gyroscope, and eye-tracking glasses. However, the software that was used to generate glance feedback to participants is not proprietary and is available from the corresponding author. The units of the American Driver and Traffic Safety Education Association training program that were used for the control training program are proprietary, and there is a charge for their use.

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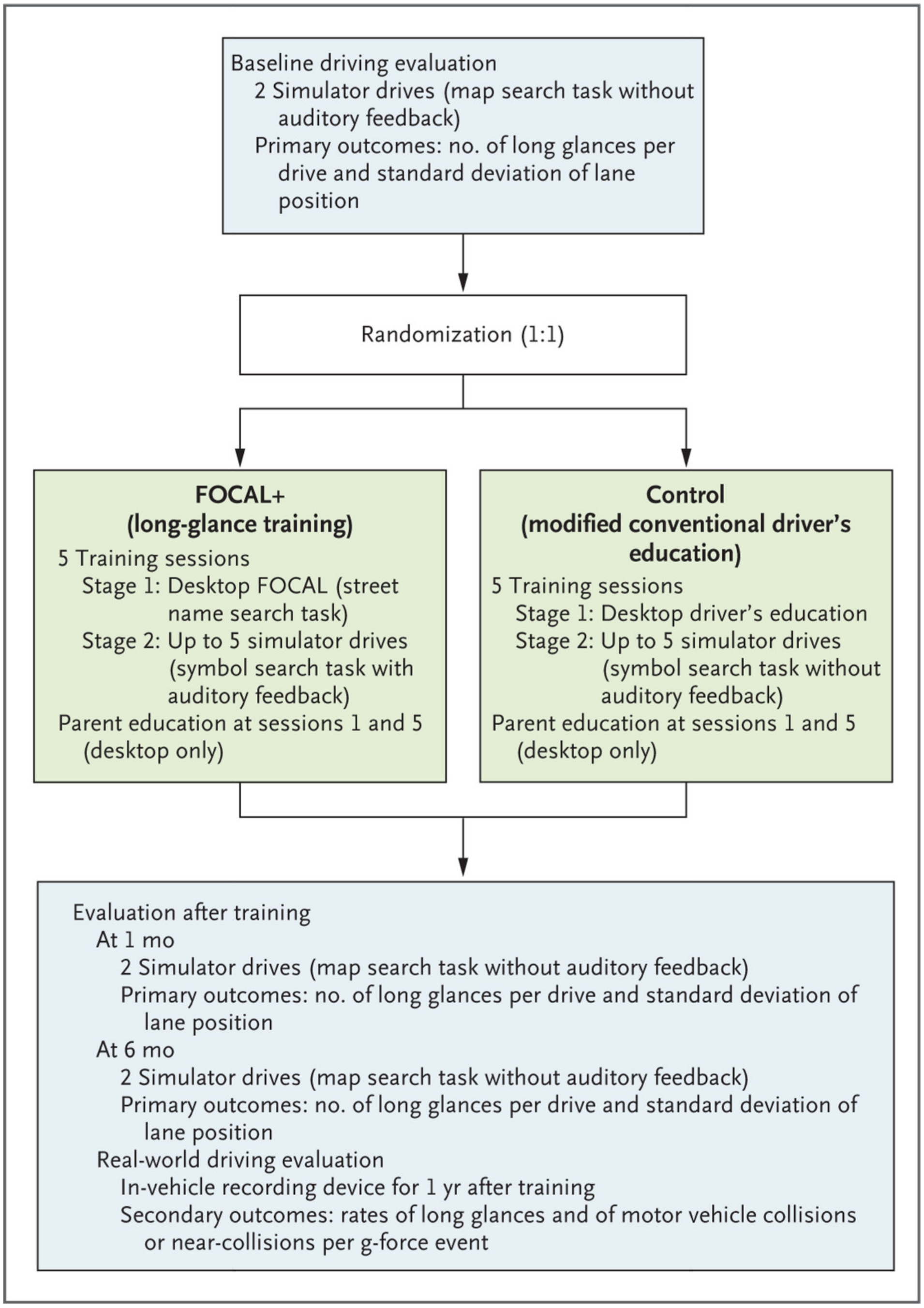

Figure 1. Trial Design.

In this trial, teens with attention deficit–hyperactivity disorder (ADHD) were assigned to undergo an intervention driver-training program that was designed to reduce the incidence of long glances away from the roadway (enhanced Focused Concentration and Attention Learning [FOCAL+]) or a modified driver's education program (control). Blue boxes indicate evaluation periods, and green boxes indicate training periods. At baseline, participants underwent a map search task in which they were asked to identify within 20 seconds how many roads started with the target letter on a map displayed on the center console. During the task, the number of long glances away from the roadway and the standard deviation of lane position were noted. Each training program consisted of five sessions, each with two stages involving different tasks. During stage 1, participants in the intervention group completed the street name search task, which involved searching for street names on a map. During stage 2, participants in each group completed the symbol search task, which involved searching for the number of target symbols in a 6 × 6 array displayed on the center console. Only participants in the intervention group received auditory feedback regarding long glances (lasting ≥2 seconds) away from the roadway. Parents were invited to participate in the first and fifth training sessions. At 1 month and 6 months after training, the evaluations were repeated. A recording device with eye-tracking and roadview capability was installed in the teen's car to evaluate the number of long glances from the roadway and the incidence of motor vehicle collisions or near-collisions per g-force event (a forward or lateral change in momentum of ≥0.6 g) that occurred in the 1 year after training.

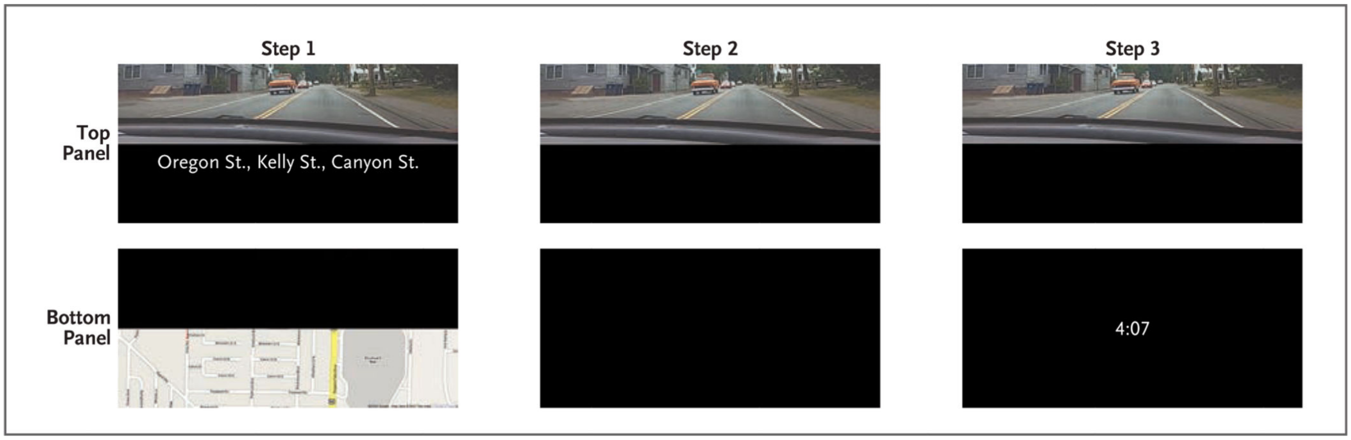

Figure 2. Stage 1 of the Intervention Training Program.

Stage 1 of the intervention training program was divided into five steps. In the step 1, the screen was split into top and bottom halves; the top panel showed split-screen driving video and street names (street name search task), and the bottom panel showed the secondary task view. In step 2, the top panel was visible during periods when driver was looking at the forward roadway, and the bottom panel was shown when the driver was glancing at the secondary task. Step 3 was the same as step 2 except that a timer was shown when driver was glancing at the secondary task. The timer showed the number of seconds (e.g., 4:07 means 4.07 seconds) that the driver was glancing at the secondary task. In step 4 (not shown), a new drive was played with the same street name search task, but a warning tone sounded when glances at the map lasted 3 seconds or longer. Participants repeated the drive until all glances at the map lasted less than 3 seconds. In step 5 (not shown), the step 4 training was repeated until the participant was successful at having only brief glances away from the roadway with a 2-second threshold.

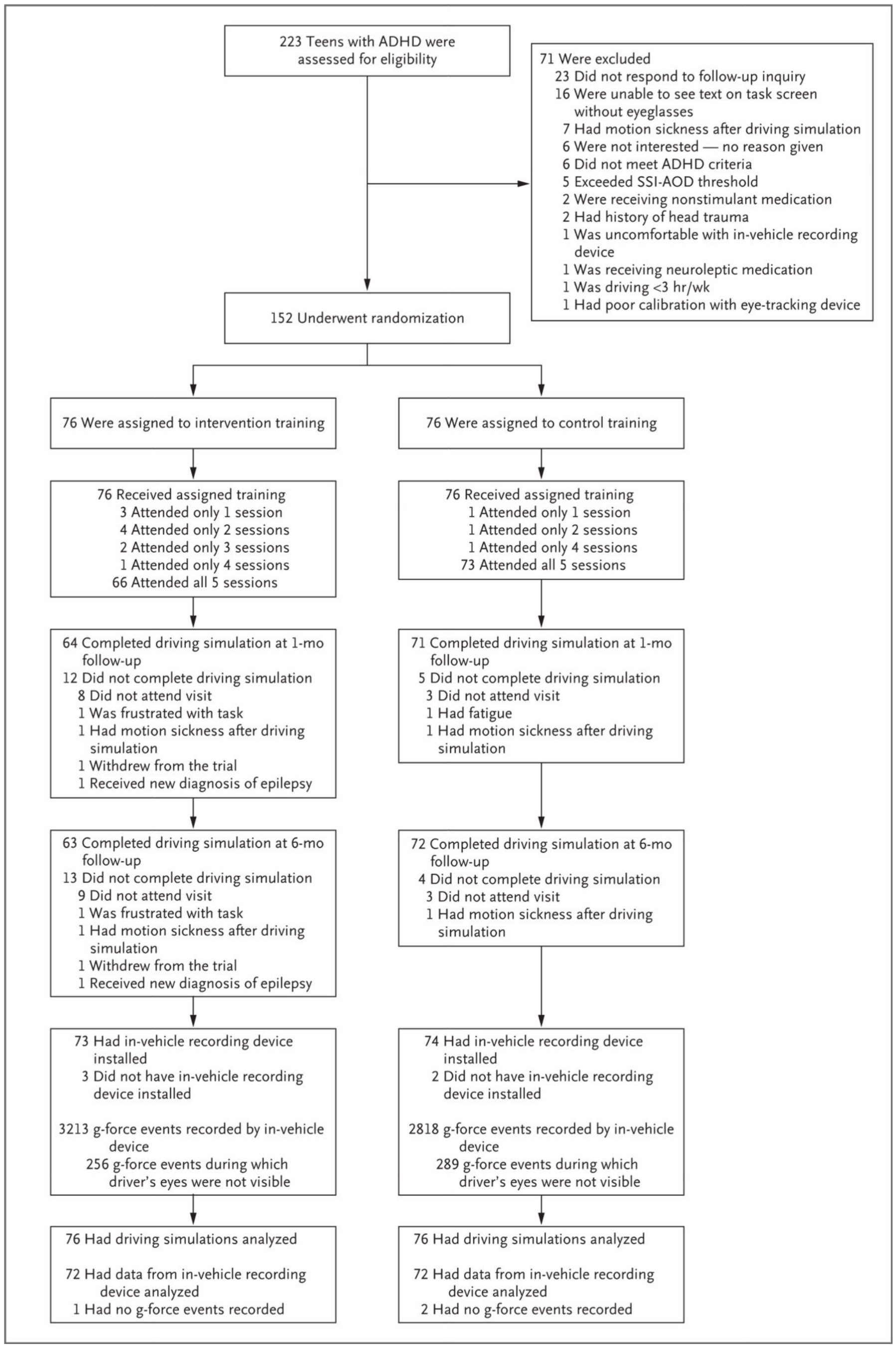

Figure 3. Randomization and Follow-up of the Participants.

Teens with substance-use problems, defined as a score of 4 or higher on the Simple Screening Instrument for Alcohol and Other Drugs (SSI-AOD; scale, 0 to 21, with higher scores indicating a higher degree of risk of alcohol and other drug abuse)[16] were excluded from the trial. At 1 month post-training, data were not available for 12 participants in the intervention group and for 5 in the control group; at 6 months, data were not available for 13 and 4, respectively. For the secondary outcomes regarding real-world driving, 144 participants had data available from the in-vehicle recording device. Multiple imputation was used in the case of missing data.

Video 1.

Video 2.

Video 3.

Table 1.

Demographic and Clinical Characteristics of the Participants.*

Characteristic	Overall (N = 152)	Intervention Group (N = 76)	Control Group (N = 76)
Age — yr			
At baseline	17.4±0.9	17.3±0.9	17.5±0.9
At licensure	16.6±0.7	16.6±0.6	16.7±0.7
State of licensure — no. (%)			
Ohio	126 (83)	64 (84)	62 (82)
Kentucky	24 (16)	11 (14)	13 (17)
Indiana	2 (1)	1 (1)	1 (1)
Driver's license type — no. (%)			
Graduated†	121 (80)	62 (82)	59 (78)
Full, unrestricted	31 (20)	14 (18)	17 (22)
No. of months with driver's license	9.4±9.3	9.2±9.7	9.5±9.0
Male sex — no. (%)	94 (62)	48 (63)	46 (61)
Race — no. (%)‡			
White	134 (88)	65 (86)	69 (91)
Black	10 (7)	6 (8)	4 (5)
Asian	2 (1)	1 (1)	1 (1)
Other	5 (3)	4 (5)	1 (1)
Latinx ethnic group — no. (%)‡	4 (3)	1 (1)	3 (4)
Full-scale IQ§	101.9±13.8	102.3±14.3	101.5±13.4
Stimulant medication use — no. (%)			
At baseline	104 (68)	52 (68)	52 (68)
During 1 yr of post-training driving¶	99/140 (71)	46/67 (69)	53/73 (73)
Vanderbilt Assessment Scale–Parent‖	25.4±8.9	25.6±9.6	25.2±8.2

* Plus–minus values are means ±SD. Participants were randomly assigned to undergo an intervention driver-training program that was designed to reduce the incidence of long glances away from the roadway (enhanced Focused Concentration and Attention Learning [FOCAL+]) or a modified driver's education program (control). Percentages may not total 100 because of rounding. ADHD denotes attention deficit–hyperactivity disorder.

† Graduated licensing refers to a three-stage licensing approach that includes supervised driving, subsequent receipt of an intermediate license with restrictions, and finally, receipt of a full, unrestricted license.

‡Race and ethnic group were reported by the participants. One teen in the control group did not report race or ethnic group.

§Intelligence was assessed with the Kaufman Brief Intelligence Test, 2nd edition.[14] Scores range from 40 to 120, with higher scores indicating higher intelligence.

¶A total of 140 participants completed the post-training medication-use questionnaire.

//Scores on the Vanderbilt Assessment Scale–Parent from the National Institute for Children's Health Quality range from 0 to 54, with higher scores indicating greater severity of ADHD symptoms.

Table 2.

Driving-Simulation Outcomes at Baseline and at 1 Month and 6 Months after Training.

Outcome	Intervention Group (N = 76)	Control Group (N = 76)	Treatment Effect (95% CI)	P Value
Primary outcomes *				
No. of long glances per 15-min evaluation drive (95% CI) †				
At baseline	21.5 (19.4 to 23.7)	23.1 (21.2 to 25.1)	—	—
At 1 mo	16.5 (14.0 to 19.1)	28.0 (26.0 to 30.2)	0.64 (0.52 to 0.76)	<0.001
At 6 mo	15.7 (13.2 to 18.2)	27.0 (24.9 to 29.1)	0.64 (0.52 to 0.76)	<0.001
Standard deviation of lane position (95% CI) — ft ‡				
At baseline	1.11 (1.05 to 1.16)	1.20 (1.16 to 1.25)	—	—
At 1 mo	0.98 (0.92 to 1.04)	1.20 (1.14 to 1.25)	−0.21 (−0.29 to −0.13)	<0.001
At 6 mo	0.98 (0.92 to 1.05)	1.20 (1.14 to 1.27)	−0.22 (−0.31 to −0.13)	<0.001
Secondary outcomes §				
No. of long glances per total no. of g-force events (%)	588/3213 (18.3)	674/2818 (23.9)	0.76 (0.61 to 0.92)	
No. of motor vehicle collisions or near-collisions per total no. of g-force events (%)	110/3213 (3.4)	159/2818 (5.6)	0.60 (0.41 to 0.89)	

* Between-group differences at baseline were not assessed. P values for the two primary outcomes are for the interaction between group (intervention vs. control) and time point (baseline vs. 1 month or baseline vs. 6 months).

† The treatment effect for the primary analysis of the number of long glances away from the roadway (lasting ≥2 seconds) is shown as an incidence rate ratio.

‡ A standard deviation of 0 indicated no deviation in lane position relative to the center of the lane. The mean values and their differences (treatment effect) were adjusted for driving experience (the number of months with a driver's license).

§ A total of 72 participants in each group could be evaluated for the secondary outcomes, in which data from an in-vehicle recording device were analyzed. If the built-in accelerometer in the device detected a forward or lateral g-force (gravitational force equivalent) of at least 0.6 g, the device recorded the 8 seconds before and 4 seconds after the triggered incident (g-force event). The numbers of long glances and of collisions or near-collisions per the total number of g-force events are shown. Relative risks (treatment effect) were adjusted for driving experience (the number of months with a driver's license) and the number of days that the in-vehicle recording device was operational. The widths of confidence intervals for the secondary outcomes are not adjusted for multiple comparisons, and no definite conclusions can be drawn from these results.