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16. Abstract
This research hypothesized that participation in a structured exercise program by inactive adults 70 or older would result in improved road test performance and increased driving exposure (the amount and circumstances under which people choose to drive). While the project design called for 90 participants (60 in exercise groups and 30 in a control group), the 6-month participation period proved too demanding for many potential participants. Despite efforts to meet recruiting goals, the research team was only able to recruit 30 participants. These participants were randomly assigned to an exercise group (n=20), which involved activities including weight-bearing, resistance, or dance/movement elements, or a control group (n=10), whose members participated in group activities involving little or no physical activity over the same time span.

The researchers assessed physical and cognitive status before and after training, and a certified driver rehabilitation specialist evaluated behind-the-wheel performance using a recognized road test. Exposure was captured over 1 month using instruments installed in participants' vehicles.

Treatment effectiveness was gauged in terms of "change scores" for road test performance and for multiple indices of driving exposure. Correlations between measures of physical/functional status and driving performance, though usually in the predicted direction, were weak or very weak; only one analysis demonstrated a modest improvement in driving tasks associated with the exercise intervention. Analyses revealed no effects of treatment on exposure. While the use of increased physical activity as a traffic safety countermeasure was not supported by this research, the present findings underscore the need for continuing research aimed at identifying countermeasures to preserve older adults' independent mobility.

17. Key Words
older driver, physical activity level, sedentary, driving performance, driving exposure, safety

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- Cyndee Crompton, CDRS, OTR/L, SCDCM, is the president, owner, and lead therapist of Driver Rehabilitation Services, McLeansville, NC. Crompton designed the test routes and carried out the on-road driving evaluations in this study. She also assisted with participant recruitment, and made suggestions for improving the study methodology.
- Chantel Post, office manager, Driver Rehabilitation Services. Post was responsible for participant scheduling and reminders; various logistical requirements, and other support as required to facilitate Crompton's activities.
- Hilda Ramirez Wooten, a certified instructor for one of the exercise programs used in the study.
- Arlene Bynum has been teaching and training for over 25 years, and is nationally certified as a group fitness instructor and a personal fitness trainer through the Aerobics and Fitness Association of America (AFAA). She is also certified in a variety of exercise programs, including one of those used in this study.

Executive Summary

This research examined whether participation in physical fitness classes improved driving performance and influenced driving exposure of previously sedentary older drivers. Researchers hypothesized that, people participating in a physical fitness class one to two times per week over a 23-week period would show improvement in driving performance and would increase their driving exposure (driving time, mileage, and trip counts) due to an increase in physical fitness, compared to a control group of older drivers who gathered for social interaction but did not exercise. While the project design called for 90 participants (60 in exercise groups and 30 in a control group), the 6-month commitment was longer than many older adults were willing or able to accept. Despite efforts to meet recruiting goals, the research team was only able to recruit 30 participants. The study team recruited participants from two senior residential communities in Chapel Hill and Burlington, NC. Participants ranged in age from 70 to 88 with an average of 77. Inclusion criteria included a current driver license, access to a vehicle, 70 or older, and not participating in regular program of physical activity in the preceding 6 months. The research was approved by the University of North Carolina at Chapel Hill's Institutional Review Board (Office of Human Research Protections IRB # 540). The Office of Management and Budget approved this information collection (OMB Control No. 2127-0711).

Pre- and post-intervention measures of physical activity included the Phone-FITT questionnaire, the VO_2 max questionnaire, and body measurements. Pre- and post-intervention functional status assessments included measures of head/neck/torso flexibility involving looking over the shoulder to identify a shape on a computer screen; lower limb strength, balance, and proprioception (rapid pace walk test); visual search with divided attention (Trail-Making Parts A and B tests); and executive function (maze test). A certified driver rehabilitation specialist (CDRS) scored driving performance on standardized test routes including suburban, urban, and commercial areas, with two-lane roads, four-lane arterials, and freeways. Test protocol included operational, tactical, and strategic driving tasks. The road test scoring was based on error counts and weights assigned by the CDRS to each error, according to its safety implications. Researchers obtained pre- and post-intervention driving exposure data (how much, and under what conditions, participants opted to drive) by instrumenting participants' own vehicles with a GPS logger and video camera for a period averaging 1 month for each study period. These naturalistic data provided the number and duration of trips, as well as vehicle speed; it also permitted the coding of weather and visibility conditions.

Treatment effectiveness was gauged in terms of "change scores" for measures obtained just prior to and immediately after the intervention period. As expected, change scores on responses to the Phone-FITT questionnaire indicated significantly greater participation by treatment group members in multiple physical activities compared to the control group. Change scores for the VO_2 max measure were in the predicted direction, but the differences were not statistically significant. The measures of treatment effectiveness on driving performance and exposure outcomes were weak. Inferential statistical tests found no significant differences between groups in terms of changes in their scores on any driving skill subset score or on total road test score. Similarly, analyses of between-group differences on the various exposure measures did not indicate statistically significant effects. Only one analysis, a technique used by engineers to evaluate the safety effect of crash countermeasures based on event counts (Hauer's method for analyzing frequency count data) found a significant improvement on tactical driving skills among the exercise group (Hauer, 1997).

These results provide, at best, limited support for the hypothesis that increasing a previously sedentary older individual's level of physical activity may translate to better on-road performance, a surrogate for safety. Only one of the analyses showed a statistically significant effect of increased physical activity (enhanced performance of tactical driving tasks). The failure to recruit the intended sample size in the current study may have resulted in inadequate power to detect significant group differences in the other analyses. While the use of increased physical activity as a traffic safety countermeasure was not supported by this research, the present findings underscore the need for continuing research aimed at identifying countermeasures to preserve older adults' independent mobility.

Introduction

Background

The number of drivers 65 and older is increasing, as is concern regarding their safety and fitness to drive. Older adults' ability to drive supports their sense of identity and autonomy and helps them maintain independence and social connections (Hartford Center for Mature Market Excellence and MIT AgeLab, 2013) The loss of a driver license is often perceived as a life-shattering event to older adults and has been associated with increased isolation and depression (Caragata, Tuokko, & Damini, 2009; Marottoli et al., 2007).

Current trends in fatality rates underlie a growing need to identify effective countermeasures to reduce crashes involving older drivers. Both the prevalence of age-related impairments in physical functioning, and evidence linking such declines with elevated crash risk, reinforce the notion that gains in fitness for older adults may result in safer mobility. Fortunately, research has shown that, for older adults, the development and progression of many age-related physical and cognitive declines can be ameliorated through improvements in physical fitness and physical activity. The appeal of fitness programs for seniors lies not only in its broader health benefits but also in its potential ability to maintain or improve driving performance.

This study examined whether sedentary older drivers who participated in a physical fitness training program would show improved driving performance or changes in their driving exposure. It built upon the findings of multiple studies of physical fitness and driving conducted from 1994 to 2013 (see Staplin, Lococo, Gish, Stutts, & Srinivasan, 2019 for a review). Fitness training influences a variety of cognitive processes, particularly the executive control processes (Colcombe & Kramer, 2003). These processes support abilities that are important for safe driving: planning, scheduling, working memory, inhibitory processes, and multi-tasking. Multiple researchers have reported significant correlations between diminished executive function and crash risk as well as between diminished processing speed and crash risk (see Staplin, Lococo, Martell, & Stutts, 2012). An increase in cardiovascular fitness gained through moderate aerobic activity results in an increase in the heart's ability to deliver oxygen to working muscles; this is thought to affect cognitive function through factors such as improved cerebral blood flow and changes in cerebral structure (Netz, Dwolatzky, Zinker, Argov, & Agmon, 2011). Observational studies support this relationship between cardiovascular health and cognitive function in older adults (Brown et al., 2010; Bugg et al., 2012; Netz et al., 2011). In addition to overall cognition, these studies show a direct relationship between aerobic capacity and *executive function* (Brown et al., 2010; Bugg et al., 2012; Netz et al., 2011); *attention* (Netz et al., 2011); *processing speed* (Brown et al., 2010; Bugg et al., 2012); *verbal ability* and *perception* (Brown et al., 2010); *hypocampal volume* (Bugg et al., 2012); and *cerebrovascular reserve*[1] (Brown et al., 2010).

The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommend that people 65 and older, and those 50 to 64 with chronic conditions or functional limitations, engage in aerobic exercise at the equivalent of 5 days a week at a moderate intensity (5 or 6 on a 10-point scale) or 3 days a week at a vigorous intensity (7 or 8 on a 10-point scale) and that they also engage in 8 to 10 muscle-strengthening exercises 2 days per week (Nelson et al., 2007). The ACSM and AHA state that these minimum requirements are sufficient to achieve

[1]Cerebrovascular reserve (CVR) is a quantitative measure of the brain's capacity to maintain blood flow in response to challenge (Parrish Neuroimaging Group, 2012).

health benefits but exceeding the minimum allows for greater results. However, when developing an exercise program for older adults, it is important to consider the older adults' capabilities. Depending on the mode of exercise, older adults may have difficulty reaching the recommended intensity, so they may require progressive exercises to reach advised activity levels (Snowden et al., 2011; World Health Organization, 2010).

Participation and adherence are essential to the success of any exercise program. Studies show that older adults prefer to exercise in structured, group environments, and would rather exercise with people of similar age rather than exercising at home or in groups that include younger participants (Beauchamp et al., 2007; Hong et al., 2008; Ziv & Lidor, 2011). Higher rates of attendance have been associated with group formats and facility-based settings, and programs of this type are often more beneficial for older adults (Hong et al., 2008). This may be due in part to the social aspect of group exercise, which can have positive effects. When people enjoy a program, they are likely to adhere to program requirements, which may lead to enhanced benefits (Ziv & Lidor, 2011).

The study team selected the exercise interventions based on their review of the literature published between 2007 and 2013 analyzing changes in older people's functional ability and driving performance from physical fitness interventions. Findings indicated that the mode of exercise was not necessarily as relevant to improved driving performance as simply engaging in sufficiently intense activity. Since 42% to 58% of older adults do not participate in any leisure-time physical activity (U.S. Department of Health and Human Services, 2013), accessibility and desirability may determine the success of an exercise program. The study team selected two exercise programs. Both included similar core components (i.e., cardio-respiratory fitness, muscle strength, flexibility, and balance), were choreographed to music for presentation in group format by trained instructors, and were readily available and easily accessible throughout the United States.

The literature review findings indicated that dance is beneficial for older adults because it includes changing steps and patterns and can be performed at different levels of intensity. Physical movements choreographed to music can stimulate brain activity, regulate mood, and increase physical output by diverting attention away from fatigue (Kattenstroth et al., 2013; Ziv & Lidor, 2011). Dancing, like driving, is a motion performed in a three-dimensional space, and it requires "visual tracking of the direction and distance from reference points (landmark) during 3-D navigation in the environment" (Foster, 2013). Participation in dance, or other exercise programs shown to reduce falls by improving balance and executive function, may translate to a reduced risk of crashes as well, since there may be similar underlying causative factors in falls and motor vehicle crashes among older adults. Falls and motor vehicle crashes are adverse mobility events that have been associated with a deficit in cognitive ability (executive function). Research studies have found an increased risk of motor vehicle crashes among drivers who have experienced a fall in the prior two-year period (Gaspar et al., 2013; Staplin et al., 1999).

The reviewed studies showed many significant benefits of dance for older adults, including improvements in important cognitive domains like executive function. However, most of the improvements were not unique to dance and more likely resulted from the multicomponent/dual task nature of exercise combined with the social characteristics of a group format. On the other hand, Verghese et al. (2003) found that dancing was the only physical activity (compared to activities such as climbing stairs, walking or bicycling) that was significantly correlated with a decreased risk of developing dementia.

Classes from one program used in the current study included exercises designed to target cardio-respiratory fitness, muscular strength and endurance, flexibility, and balance. They were easy to follow, dance-based workouts that adhered to ACSM established guidelines (Sanders & Prouty, 2012). Implementing a dance intervention did not require expensive equipment and could be performed in a variety of settings, making it a practical and cost effective option (Keogh et al., 2009).

The other program selected for this study was also designed to improve the physical, mental, and social well-being of older adults, with both "classic" and "cardio fit" versions widely accessible to this population, offered at over 13,000 locations nationwide. The study team incorporated components of two intensity levels of this program, resulting in an age-specific group exercise class choreographed to music, designed to increase muscular strength, range of motion, and activities of daily living. This program used hand-held weights, elastic tubing with handles, and rubber balls for resistance. The program consisted of both seated and standing exercises; an aerobics component used low-impact movements focused on building upper body and core strength, as well as cardio endurance.

Objective and Project Scope

The research team designed a randomized control intervention study to answer the following research question: If sedentary older drivers participate in a fitness training program (aerobic and/or strength and flexibility training), will their driving performance improve or exposure (the amount of driving in terms of distance, time, number of trips, or under various conditions) increase? Data were collected pre- and post-intervention for a treatment and a control group of sedentary older drivers. Data included measures of:

- Cognitive and physical functioning measured using clinically recognized instruments;
- Physical activity level based on questionnaire responses;
- Driving performance demonstrated during a professional evaluation conducted by a certified driver rehabilitation specialist (CDRS); and
- Driving exposure based on data collected using instrumentation installed in participants' own vehicles for approximately one month of naturalistic data collection.

Methods

Participant Recruitment and Study Group Assignment

The study team recruited participants from the communities of Chapel Hill and Burlington, North Carolina. These communities were selected based on the recruitment sites' staff interest and enthusiasm in the study and staff members' anticipation that large proportions of their residents/members would participate. The researchers advertised the research opportunity in area newsletters, newspapers, and flyers, and made formal presentations about the project at local senior centers, continuing care retirement communities, and fitness centers. Several area newspapers carried stories about the project (see Appendix A). The Chapel Hill participants were recruited from the Carol Woods Retirement Community and the Seymour Senior Center. The Burlington participants were recruited from the John Robert Kernodle Senior Center and from Studio 1, a performing arts center. While responses to preliminary interactions suggested that the research team would be able to recruit and adequate number of participants from these areas, only a third of the planned number of participants volunteered for the study.

Interested candidates telephoned the research assistant and responded to screening questions to determine eligibility for participation. Inclusion criteria were:

- being a currently licensed driver in North Carolina,
- access to a vehicle that they could drive for the duration of the study,
- 70 or older,
- rarely or never do physical activities or participate only in light physical activities, and
- willingness and ability to participate in physical fitness classes 2 or 3 times per week for 6 months.

Exclusion criteria included reliance on adaptive vehicle controls to drive (e.g., steering knobs or pedal extensions) or self-report of a medical condition that their doctor had indicated could affect their ability to drive safely. The research assistant provided the following definitions of light, moderate, and vigorous activities during the telephone screening.

- **Light physical activities** cause your heart to beat only slightly faster than normal, and you can still talk and even sing while doing them. Examples include walking leisurely, stretching, and vacuuming or light yard work.
- **Moderate physical activities** make your heart beat faster, and although you might still be able to talk, you wouldn't be able to sing. Examples are fast walking, aerobics classes, strength training, or swimming gently.
- **Vigorous activities** increase your heart rate substantially, and you can't talk, or your speech is broken up because you are taking deep breaths. Examples of vigorous activities are using a stair machine, jogging or running, and playing tennis or racquetball.

The research assistant scheduled a date and time for those who met the eligibility requirements to formally consent to the study, undergo the functional assessments, complete questionnaire measures of physical activity, and have their vehicle instrumented to collect the driving exposure data. These study activities were performed at the Seymour Senior Center (Orange County Department on Aging) for Chapel Hill participants, and at the Kernodle Senior Center (Burlington

Recreation and Parks) for Burlington participants. The sites were 30 miles apart but within easy travel distance for the CDRS, research assistant, and vehicle instrumentation technician.

Using a stratified randomization approach, the research assistant classified participants into one of four strata based on sex (male, female) and age (70-79, 80+). Two-thirds of the participants in each stratum were randomly assigned to the exercise group and one-third to the control group. Exercise class type for each location was based on instructor availability. The researchers executed a consulting agreement for class instruction 2 to 3 days per week over the 6-month intervention period with an appropriately qualified instructor for each location. Control group members participated in a variety of games and other group activities that did not include an exercise component.

Neither the HSRC research assistant nor the participants were blinded to the study group to which they were assigned. However, the CDRS who conducted the driving evaluations was blind to participant study group. While it was possible that the CDRS became aware of study group assignment while conducting an evaluation (if, for example, the participant mentioned their study activity), the research assistant encouraged participants not to reveal this information to the CDRS.

Functional Assessments

The research assistant obtained each participant's consent to take part in the study (see Appendix B) and then administered brief assessments of physical and cognitive function using a computer-administered battery that presented instructions and test stimuli and recorded responses. The research assistant ensured that each participant understood the instructions prior to testing. Participants completed all functional assessments before participating in the exercise program or control group activities (pre-intervention) and again following the 23-week intervention (post-intervention). Participants completed pre-intervention functional assessments from March to June 2018 and post-intervention functional assessments from July to December 2018.

Head/neck/torso flexibility. The ability to turn one's head to check for traffic is critical to being able to enter traffic and change lanes or merge with traffic safely. The head/neck/torso flexibility measure required participants seated in an office chair to turn to identify a shape shown on a computer screen positioned directly behind them, 10 feet away without lifting from the chair. The test was accomplished by turning the head, neck, and upper body only. Performance was scored as pass (the participant could turn far enough to identify the object) or fail (the participant could not do so).

Rapid pace walk. This test measured lower limb strength and included elements of balance and proprioception. It has been shown to predict crash risk. For this test, the participant walked to a mark 10 feet away, turned, and walked back to the starting point as quickly as possible. Those who took from 7.5 to less than 9.0 seconds were considered to have a mild impairment in this functional ability; those who took 9 seconds or longer were considered to have a serious impairment.

Snellgrove Maze Test (modified for computer administration). This test measures executive function; scores have been found to correlate strongly with prospective crash experience. In a study employing five mazes of varying difficulty, Staplin et al. (2013) found that drivers who required 42.2 seconds or longer to complete both Maze 1 and Maze 2 were 4.58 times more likely to be involved in crashes during the 18 months following assessment than drivers who required less time. The stimuli included in the present study consisted of the easiest (Maze 1) and the most difficult (Maze 2) mazes in the protocol described by Staplin et al.

Trail-making test (Parts A and B). The trail-making tests also measure executive functioning. Parts A and B both test visual scanning, numeric sequencing, and visuomotor speed; Part B adds mental flexibility or divided attention. Participants who could not complete Part A in less than 40 seconds were considered to have a mild impairment in search and sequencing ability and those who took 55.4 seconds or longer a serious impairment (Staplin, Gish, & Wagner, 2003; Staplin, Gish, & Sifrit, 2014). Participants who could not complete Part B in less than 80 seconds were considered to have a mild impairment in search and sequencing ability with divided attention, and those who took 180 seconds (3 minutes) or longer a serious impairment (Roy & Molnar, 2013).

Measures of Physical Activity

The researchers employed two physical activity questionnaires to assess participants' general level of physical activity. Older adults may be physically active without participating in formal exercise programs or belonging to a gym. Accurate recall of such activity over a long period may be compromised for some (Washburn et al., 1993; Kowalski et al., 2012; Harada et al., 2006; Dipietro et al., 1993; Gill et al., 2008; Stewart et al., 2001); as a result, obtaining a valid measure is difficult. The study team applied the following guidelines in selecting the physical activity questionnaires.

- Inclusion of a broad range of less intense physical activities such as walking, housework, and gardening;
- Requiring a short period of engagement (15 minutes or less) for an activity to count;
- A short recall period (past week, or a typical week in the past month), to facilitate recall (especially of less regularly performed activities more typical in older adults); and
- Short and simple.

Phone-FITT questionnaire. Phone-FITT is a brief interview to determine the physical activity level of older adults (see Appendix C). The questionnaire asks about participants' household activities and conditioning and recreational activities *during a typical week in the last month*. For affirmative responses, participants provided the number of times per week and duration (1-15 mins, 16-30 mins, 31-60 mins or 61+ mins). Total score was calculated according to Gill et al. (2008) by assigning codes 0-4 to the duration responses, summing the frequency (times per week) and duration code (0-4) for each activity, and summing across all activities. Higher scores indicated greater activity levels. The authors suggested that the phone-FITT intensity measure did not fully capture the intensity of older adults' activities. Thus, the study team did not collect intensity data.

VO_2 max fitness questionnaire and measures. VO_2 max is a measure of how much oxygen a person consumes while exercising to exhaustion. Most people consume 30 to 60 milliliters of oxygen per minute per kilogram of body weight (ml/min/kg) (RunnersConnect, Inc., 2020). A higher value corresponds to better cardiovascular fitness.

To estimate VO_2 max, the researchers administered a questionnaire, took several body measurements, and used a regression model developed by Nes et al. (2011). The non-exercise regression model developed by Nes et al. was accurate in predicting measured VO_2 max in their healthy population of 4,260 males and females who exercised to exhaustion on a treadmill, and they consider it a valid tool for a rough assessment of cardiovascular fitness. The questionnaire obtained exercise frequency (almost never or less than once per week, once per week, 2 or 3 times per week, almost every day), workout duration (under 30 minutes or 30+ minutes), intensity (take it easy without breathing hard or sweating, little hard breathing and sweating, go all out), date of birth, and sex. The researchers coded responses according to Nes et al. using 0, 1, 2, or 3 for exercise frequency responses, 1 for duration under 30 minutes and 1.5 for duration 30+ minutes, and 0, 5, or 10 for intensity.

To calculate VO_2 max, the research assistant measured participants' height (cm), waist circumference (cm), and resting heartrate (beats per minute) using a fingertip pulse oximeter. The physical activity index (PA index), an element of VO_2 max, is the product of activity frequency, duration, and intensity. Participants self-reported their weight. The regression equation applied to the data for males was:

$$100 - (0.296 * \text{age}) - (0.369 * \text{waist circumference}) - (0.155 * \text{resting heart rate}) + (0.226 * \text{PA Index})$$

The regression equation applied to the data for women was:

$$74.74 - (0.247 * \text{age}) - (0.259 * \text{waist circumference}) - (0.114 * \text{resting heart rate}) + (0.198 * \text{PA Index})$$

Nes et al. (2011) indicated that including body mass index (using height and weight) instead of waist circumference yielded only negligible changes in the model; therefore, they included only waist circumference in the model.

Driving Exposure

While participants completed their functional assessments, a member of the research team instrumented their personal vehicle using a video camera and GPS recorder. The video and GPS recorders were independent (non-integrated); however, the camera images included a GPS time stamp that provided enough accuracy to correlate video for a given trip with the GPS coordinates for the same trip. A technician installed the video camera on the passenger-side A-pillar. Both devices drew power through cables connected to a 5-volt DC-DC converter (converts 12 volts DC to 5 volts DC). This DC-DC converter drew power from a standalone 12 volt, 15 Ah battery enclosed in a plastic box. The enclosure also contained the GPS data logger and excess cable.

The video recorder was equipped with a 90-degree horizontal field-of-view lens that recorded time-lapse video at 15 frames per second, allowing capture of the driver's face *plus* a view of a substantial part of the roadway beside and ahead of the vehicle. Data were stored on a 64-GB microSD card that could store 30 hours of video, or 1 hour per day of driving time, for the entire month. GPS data were logged at 1 Hz on a 1 GB microSD card.

The data collected included number and duration of trips and vehicle speed for 1 month. This allowed analysts to determine average and maximum trip length and trip speeds. Analysts coded weather and visibility conditions (wet/dry, day/dusk/night). Driver behaviors such as mirror and over-the-shoulder checks that could be affected by strength and flexibility were not coded, based on the findings from Staplin et al. (2019) indicating no relationship between physical fitness level and increased looking behavior. The authors hypothesized that while increased fitness may give drivers greater *capacity* for a whole range of behaviors, it may not override habits acquired over decades of experience.

Consistent with previous NHTSA research, the study team operationally defined a "trip" as any travel segment where a participant started the engine, began driving from a parked location to a different location, and then turned off the car's engine. This methodology permitted tabulation of the frequency of unique trips (travel to one destination). Thus, driving from home and making stops at a grocery store and a restaurant, then driving back home (assuming the driver leaves the car at each stop) would constitute three trips.

Driving Performance Evaluation

A CDRS developed four standardized, on-road test routes, two for Chapel Hill participants and two for Burlington participants. Two routes were developed at each study location to eliminate practice as a confounding factor in test performance between the pre- and post-intervention drives. At the pre-intervention evaluation at each site, half of the participants were evaluated on route 1 and the other half on route 2. At the post-intervention evaluation, participants drove the route not presented for the pre-intervention evaluation. The Chapel Hill routes were 22.9 and 18.6 miles, and the Burlington routes were 15.1 and 17.5 miles; each took approximately 60 minutes to complete (see Appendix D). The CDRS endeavored to equalize the routes in terms of maneuver types and counts within the same time to complete; the location of the Chapel Hill CCRC necessitated greater mileage to accomplish this goal. The test routes included suburban, urban, and commercial areas, with two-lane roads, four-lane arterials, and freeways, and included roadways commonly driven by the participants. The CDRS provided instructions to drive to the next destination via specific roadways, even if there were alternative ways to reach the destination. On occasion, participants did not follow the instruction and instead used a more familiar route.

The CDRS instructed participants to plan and make their own lane selection decisions for upcoming merges or turns. For example, one Chapel Hill route required merging onto I-40 West. Most participants were more accustomed to merging onto I-40 East at this juncture as that was the route to a popular shopping complex and the airport. Participants often requested input regarding which lane they needed to be in, stating, "I don't usually travel west." The CDRS advised them to watch the signage and make the appropriate decisions to access the merge ramp. A Burlington route included a left turn to merge onto the interstate. Participants were turning left out of a parking lot onto a 4-lane arterial when provided with the instruction to merge onto I-40 East. The participants frequently questioned if they needed to move into the right lane to make this merge. The CDRS again advised them to watch the signage and make the appropriate decisions to access the merge ramp. At locations where participants were asked to make a challenging turn or maneuver; they frequently offered alternative ways to accomplish the same goal, noting, "I would never turn that direction here." The CDRS assured participants that their decision to choose safer and easier travel routes was wise, but for study purposes, they were to follow the planned route, which included more difficult tasks.

By design, the test routes included situations in which older drivers are over-represented in crashes including:

- Left turns across cross-traffic that did not stop;
- Unprotected left turns at intersections controlled by traffic lights;
- Right turns at intersections controlled by yield signs or with channelized right turn lanes which require the driver to merge into traffic coming from the driver's left;

- Merging onto a controlled access highway from a ramp/acceleration lane controlled by a yield sign;
- Changing lanes on a multi-lane roadway;
- Negotiating two-way stop-controlled intersections; and
- Parking and backing in congested parking lots, including parking between two vehicles.

Chapel Hill route 1 included 6 right turns (all signal-controlled), 12 left turns (9 signal-controlled, 2 moving, and 1 from a stop sign), 2 Interstate merges on and off, 2 lane changes, and 2 opportunities for parking and backing. Chapel Hill route 2 included 7 right turns (3 signal-controlled, 3 moving, and 1 from a stop sign), 12 left turns (7 signal-controlled, 3 moving, and 1 from a stop sign), 2 merges on and off interstates, 4 lane changes, and 2 opportunities for parking and backing. Both routes included turns with dual turning lanes.

Burlington route 1 included 9 right turns (8 signal-controlled and 1 from a stop sign), 14 left turns (9 signal-controlled, 2 moving, and 3 from stopped), 4 lane changes, 3 occasions for parking and backing, and 2 merges on and off interstates. Burlington route 2 included 12 right turns (5 signal-controlled, 4 moving, and 3 from a stop sign), 10 left turns (5 signal-controlled, 3 moving, and 2 from stop signs), 5 lane changes, 3 occasions for parking and backing, and 2 merges on and off interstates. Both routes included turns with dual turning lanes.

The CDRS, blind to participants' functional ability test results and physical activity level, used a score sheet with driving tasks grouped for each of three skill sets, operational skills, tactical skills, and strategic skills. Operational skills pertained to vehicle control such as the ability to use the key, to adjust the seat and mirrors, and to control steering, accelerating, and braking. Examples of tactical skills included context-appropriate visual scanning, vehicle position, merges, and speed control. Strategic skills related to making safe driving decisions and included memory for and ability to follow directions, maintaining conversation while driving and curtailing conversation when necessary, and recognizing and managing hazards such as road construction and maintenance vehicles. The CDRS totaled the three sub scores for an overall driving score.

The road test scoring was based on error counts and the point value assigned to each error. Errors were weighted 1, 3, 5, 10, or 100 points. Running a red light /stop sign was assigned a point value of 100 and resulted in an automatic failure. Higher road test scores indicated poorer performance.

Results

Participant Sample

The study team recruited and received consent from 33 participants. Three participants dropped out before completing both study phases. One female completed only the pre-intervention clinical assessments (and dropped out prior to group assignment), and 2 males in the treatment group completed all pre-intervention assessments but did not complete the intervention.

The final sample of 30 participants ranged in age from 70 to 88. Twenty participants (7 males and 13 females) were randomly assigned to the treatment group (10 from each site. Ten participants (1 male and 9 females) were randomly assigned to the control group. Table 1 presents the sample demographics by study group.

Table 1. Sample Demographics by Study Group

Group	Age (Years)			
	Average	Median	Range	Standard Deviation
Treatment (n=20)	76.79	75.31	70.57–87.64	5.02
Control (n=10)	76.98	76.79	71.36–87.98	5.17
Total (n=30)	76.85	75.31	70.57–87.98	4.98

Exercise Participation Rate and Control Group Contact Time

Treatment group. The exercise classes in Burlington were offered on Tuesday and Thursday mornings and on Thursday afternoons to provide flexibility in participants' schedules, with the intent that participants would attend two classes per week. Similarly, in Chapel Hill, classes were offered on Tuesdays and Thursdays specifically for study participants, but a similar class was offered by the same instructor on other days of the week, which were also available to participants. The exercises classes lasted 1 hour. The Burlington instructor modified the class to accommodate challenges many participants initially had with the activities.

Figure 1 presents the treatment group's class participation rate. While none of the participants exercised at least twice a week during every week of the intervention period, 17 of the 20 exercised at least twice during most weeks. Seven of the 20 exercised at least once every week (no weeks with 0 classes attended). Of the 3 participants with lowest class attendance, 1 reported that, instead of attending the assigned classes, she swam at least twice per week. Another participant reported missing classes due to knee pain. The third had a variety of medical problems and doctor's appointments that led to missing classes. For the treatment group, the average exercise participation time was 1.5 hours per week.

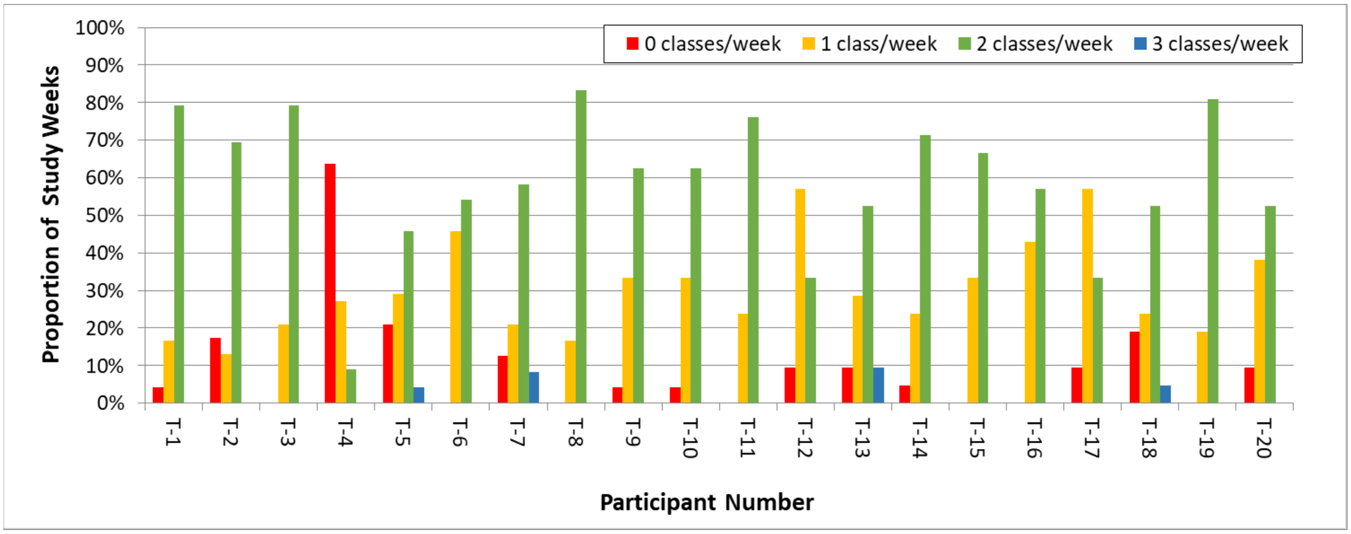

Figure 1. Exercise class participation rate

Control group. Participants in the control group at both sites met weekly for the first 5 weeks of the intervention period for 1 to 1.5 hours per week and then bi-weekly for longer event durations (2 to 3.5 hours per meeting). There were 11 total meetings in Chapel Hill and 13 in Burlington. Figure 2 presents the participation rate of the control group. Half of the participants attended slightly over 50% of the scheduled events, and half attended at least 75% of the meetings. For the control group, the average contact time was 0.8 hours per week.

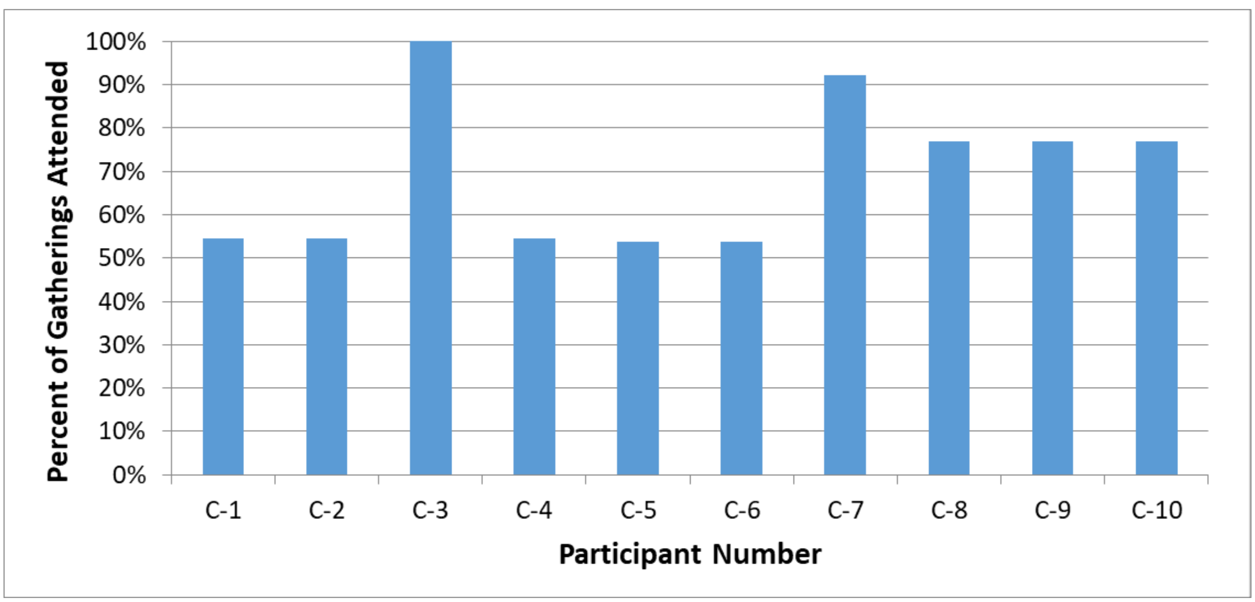

Figure 2. Control group participation rate

Group Functional Status at Pre-Intervention

This section presents the analyses of performance by study group prior to the exercise intervention. Except for head/neck/torso flexibility (which was scored as pass or fail), the analyst employed a two-tailed t-test to determine differences in the functional ability of participants across the treatment and control groups. Prior to performing each t-test, the analyst performed an F-test to determine whether the variances were equal, to assure selection of the appropriate t-test.

For the head/neck/torso flexibility test, the same percentage of participants in both groups (40%) could turn their heads and upper bodies to identify a shape behind them. Table 2 presents the performance of both groups on the remaining functional measures prior to the exercise intervention. The groups did not differ significantly on any of the tests of physical or cognitive function at pre-intervention.

Table 2. Performance on Functional Status Tests by Group at Pre-Intervention

Functional Status Test	Completion Time (seconds)							
	Treatment Group (n=20)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Rapid Pace Walk	6.8	6.4	4.6–11.7	2.0	6.3	6.0	4.6–9.2	1.5
Maze 1	27.8	12.5	5.0–121.9	32.8	14.8	8.8	4.3–54.2	16.3
Maze 2	24.1	16.3	8.4–121.2	26.8	15.1	14.3	8.2–22.3	5.5
Maze Total	51.9	31.3	15.2–243.1	54.8	30.3	28.4	12.5–75.0	19.0
Trails A	37.2	36.1	23.0–53.6	7.4	31.8	29.8	21.5–55.8	10.2
Trails B	106.0	92.5	62.0–192.4	36.4	104.5	89.6	44.6–230.0	52.8

Group Physical Activity and Cardiovascular Fitness Levels at Pre-Intervention

Table 3 presents measures of central tendency, by group, for the Phone-FITT and VO_2 max questionnaires. Higher scores on the Phone-FITT questionnaire indicated higher activity levels, and higher VO_2 max scores indicated better cardiovascular fitness. Two-tailed t-tests indicated no significant difference in activity level or cardiovascular fitness as a function of group assignment. Table 4 shows fitness level by age and sex norms for people 60 and older (Heyward, 1998), and Figure 3 shows the proportion of each group that scored at each fitness category prior to the exercise intervention. Table 5 presents the percentage of participants, by group prior to the exercise intervention, who indicated participating in each activity *in a typical week in the last month,* on the phone-FITT questionnaire**.**

Table 3. Performance on Measures of Physical Activity by Group at Pre-Intervention

Physical Activity Measure	Treatment Group (n=20)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Phone-FITT	39.2	40.8	12.8–64.3	13.8	37.3	38.1	21.5–54.0	8.7
VO_2 max	25.5	24.8	16.2–41.0	5.7	22.5	23.4	13.4–27.7	4.0

Table 4. Fitness Level According to Age and Sex Norms, for People 60 and Older

VO_2 max Fitness Level	Men	Women
Very Poor	<20.5	<17.5
Poor	20.5–26.0	17.5–20.1
Fair	26.1–32.2	20.2–24.4
Good	32.3–36.4	24.5–30.2
Excellent	36.5–44.2	30.3–31.4
Superior	>44.2	>31.4

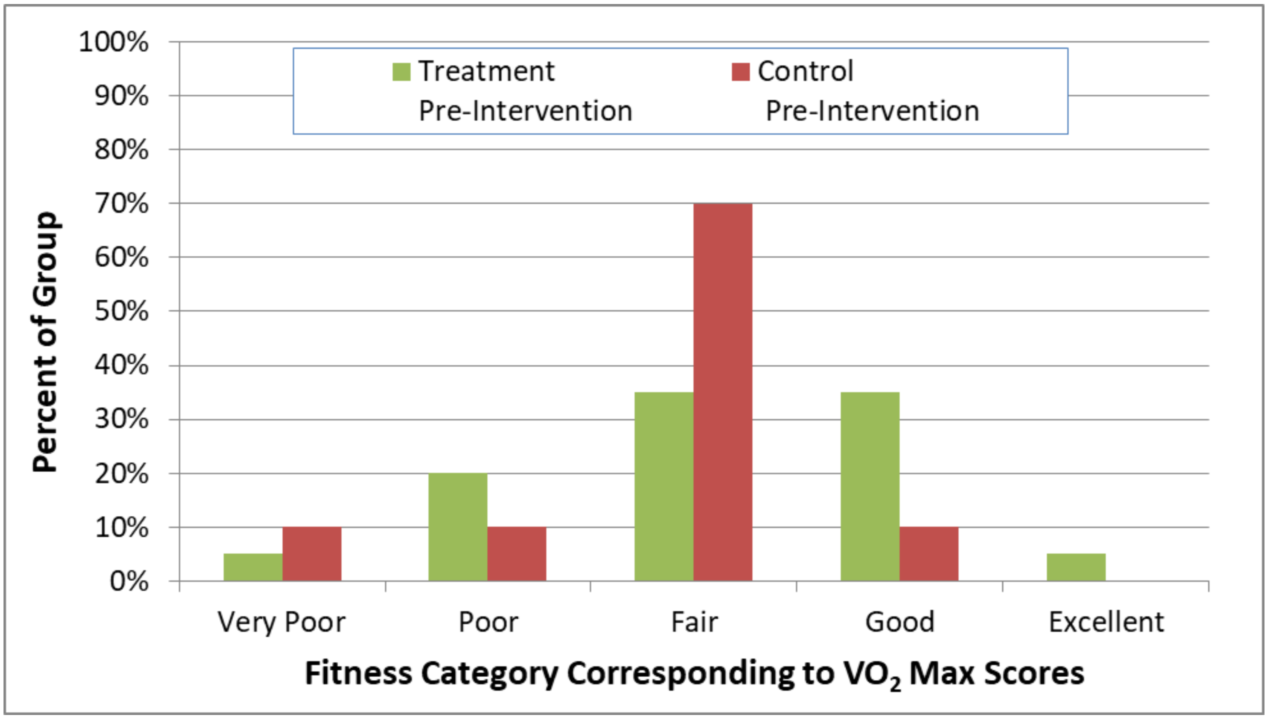

Figure 3. Categorization of VO_2 max scores (very poor to superior), by group at pre-intervention

Group Road Test Performance at Pre-Intervention

Table 6 presents summary statistics, by group, for the number of road test points scored off (i.e., error score) for each driving skills subset and the total error score. The higher the error score, the poorer the performance. Prior to the exercise intervention, there were no significant differences between the mean treatment and control group scores for operational skills or strategic skills; however, the treatment group had significantly more tactical skills points scored off than the control group. This could be the result of one treatment group participant who ran a red light, which added 100 points to the score, and resulted in an automatic failure on the test. For total road test points scored off, the treatment group's average was significantly higher than that of the control group because of the difference in the tactical skills.

Table 5. Responses to Phone-FITT Activities, by Group at Pre-Intervention

Activity	Group	
	Treatment (n=20)	Control (n=10)
	% Yes	% Yes
A. Light housework such as tidying, dusting, laundry, or ironing	85%	100%
B. Making meals, setting and clearing the table, and washing dishes	100%	90%
C. Shopping (for groceries or clothes, for example)	100%	90%
D. Heavy housework such as vacuuming, scrubbing floors, mopping, washing windows, or carrying trash bags.	65%	60%
E. Home maintenance such as painting, cutting grass, or other yardwork.	45%	30%
F. Caring for another person (such as pushing a wheelchair or helping a person in or out of a chair or bed)	5%	40%
G. Lifting weights to strengthen your legs	10%	10%
H. Other exercises designed to strengthen your legs (such as standing up/sitting down several times in a chair or climbing stairs)	45%	30%
I. Lifting weights to strengthen your arms or other exercises to strengthen your arms (such as wall push-ups)	25%	20%
J. Walking for exercise	60%	50%
K. Dancing	20%	10%
L. Swimming	0%	0%
M. Bicycling (either outdoors or indoors on a stationary bike)	5%	0%
N. Other aerobic exercise (includes programs included in this study, elliptical, rowing, stair stepper, etc.)	10%	0%
O. Stretching or balance exercises, including activities such as yoga and tai chi	35%	50%
P. Play golf (used cart)	5%	0%
Q. Play tennis (singles or doubles)	0%	0%
R. Gardening	45%	30%
S. Other	30%	30%

Appendix E shows the score sheet, provides the total number of participants who made each error, the total error score across participants for each task, and totals by subscore.

Table 6. Road Test Scores by Group at Pre-Intervention

	Road Test							
Road Test Subscore	**Treatment Group (n=20)**				**Control Group (n=10)**			
	Average	**Median**	**Range**	**SD**	**Average**	**Median**	**Range**	**SD**
Operational Skills	0.25	0	0 - 5	1.1	0.9	0	0–9	2.9
Tactical Skills	37.2	27.0	0 - 143	39.1	17.3	11.0	5–38	11.8
Strategic Skills	2.25	0	0 - 10	3.4	2.5	0	0–15	4.9
Overall	39.7	27.0	5 - 143	39.7	20.7	18.0	5–47	14.1

The CDRS converted scores to grades as follows.

- 0-24: A, pass with no restrictions
- 25-49: B, pass with recommendations
- 50-75: C, marginal with restrictions
- 76-99: D, Fail
- 100+: F, Fail

Figure 4 presents road test performance by group prior to the exercise intervention. Collapsing across both “passing” scores, 75% of the treatment group and 100% of the control group received passing grades.

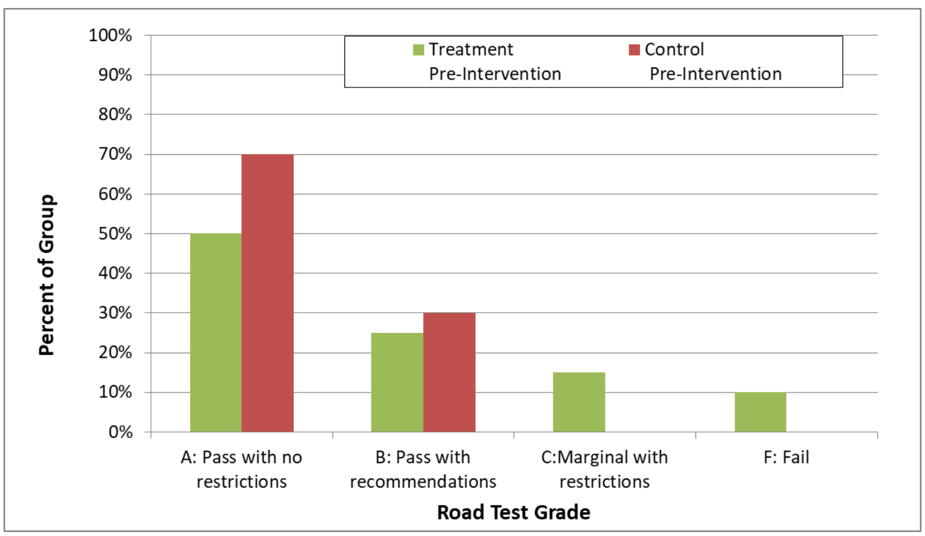

Figure 4. Road test performance by study group at pre-intervention

Driving Exposure During Pre-Intervention

The pre-intervention exposure period was March to July 2018. Table 7 summarizes the number of days participants’ vehicles were instrumented during the pre-intervention exposure period, by study group. Longer periods were due to delays in completing the on-road evaluations (at which time the in-vehicle equipment was removed from the participant's car). A t-test found no significant difference between groups.

Table 7. Days in Pre-Intervention Exposure Period, by Study Group

Measure	Treatment Group (n=20)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Vehicle Instrumentation Days	32.1	31	25–42	3.8	32.6	33.5	23-38	4.4

The researchers matched video to the GPS data to obtain speed and distance information about each trip. This was a critical step in data reduction, in which the researchers applied adjustments to compensate for several technical difficulties encountered during data collection (see Staplin et al., 2019). Among the adjustments was filtering out trips less than 0.1 miles as well as those less than 1 minute. Because GPS and video data were collected using separate devices, the only link between the two separate sets of data was the timestamp. Not all data could be matched. This resulted in a lower count of trips with videos linked to GPS (3,040 trips in the video file versus 2,777 trips in the GPS file). The GPS system failed to record data for one treatment group participant, whose video data recorded 68 trips. For the remaining 29 participants, GPS data were matched for 93.4% of the total video trips (ranging across participants from 72.3% to 99.2%). Video trip counts and trip durations (length of time) were accurate; therefore, results reporting trip counts and durations are based on the video data. However, because only the GPS recorded mileage and speed, results reporting these data are based on the matched GPS-video data (a subset of the video trips).

The 30 participants drove a total of 623 hours, logged 16,022 miles, and made 3,040 trips. Table 8 summarizes these characteristics, by group. T-tests found no significant differences between the treatment and control group at pre-intervention in number of trips, driving time, or mileage.

Table 8. Time and Distance Driven During Pre-Intervention

Measure	Treatment Group (n=20)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Number of Trips	100.3	104.0	41-163	36.0	103.5	89.5	63-212	47.1
Driving Hours	21.1	10.0	11.3–38.2	8.2	20.0	19.8	8.4-30.5	6.3
Distance (miles)	548.4	461.5	149.9–1,124.1	300.8	560.2	523.4	252.7–1,286.9	288.1

Trip distance and duration. Table 9 summarizes trip distance (miles driven per trip) based on the minimum, maximum, and average trip distance for each of the 19 treatment and 10 control participants for which GPS data were recorded. These statistics show a large range in the longest trip made by drivers in each group. The All Trips row represents the calculations across the 1,829 trips taken by the treatment participants and the 948 trips taken by the controls. Table 10 shows trip duration in minutes, calculated as described above for the trips recorded in the video data (2,005 treatment group trips and 1,035 control group trips), and again, shows a large range in the duration of the longest trip made between drivers in each group). Average trip time and distance (All Trips rows) were similar for treatment and control group drivers.

Table 9. Trip Distance, by Driver and Group During Pre-Intervention

Trip Distance (Miles)	Treatment Group (n=19)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Minimum trip distance per driver	0.2	0.1	0.1–0.4	0.1	0.1	0.1	0.1–0.3	0.1
Maximum trip distance per driver	49.7	27.0	6.9–175.3	49.1	74.2	35.5	20.6–328.2	93.1
Average trip distance per driver	6.1	5.5	1.9–12.1	2.9	7.1	5.7	2.0–21.8	5.6
All Trips	**5.7**	**3.0**	**0.1–175.3**	**10.4**	**5.9**	**2.2**	**0.1–328.2**	**16.3**

Table 10. Trip Duration, by Driver and Group During Pre-Intervention

Trip Duration (Minutes)	Treatment Group (n=19)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Minimum trip time per driver	1.0	1.0	1.0– 2.0	0.0	1.0	1.0	1.0 - 2.0	0.0
Maximum trip time per driver	72.0	53.0	28.0–209.0	47.0	96.0	67.0	33.0–328.0	89.0
Average trip time per driver	13.1	12.5	9.0–19.9	3.4	13.1	12.5	6.2–29.1	6.5
All Trips	**12.6**	**7.0**	**1.0–209.0**	**13.3**	**11.6**	**10.0**	**1.0–328.0**	**17.9**

Table 11 presents the proportion of trips taken by each study group based on trip distance, with this measure binned into six categories ranging from less than one mile to over 20 miles. Control participants were more likely than treatment group participants to make trips of 1 mile or less, while treatment group participants were more likely than control group members to make trips between 2.5 and 5 miles. There were only slight differences between groups at the remaining four distance bins. A 2 x 6 chi-square test found that the treatment and control groups differed significantly ($\chi^2[5]=71.2$, $p=0.00$) in how the overall proportions of their trips were distributed by distance.

Table 11. Percentage of Trips by Distance and Group During Pre-Intervention

Percent of Trips	Treatment Group (n=19)				Control Group (n=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
≤ 1 Mile	18.2%	14.8%	4.5% - 40.9%	11.5%	28.2%	25.5%	6.7% - 71.9%	21.4%
>1 and ≤2.5 Miles	23.7%	22.7%	5.4% - 46.9%	12.0%	20.6%	18.9%	9.4% - 42.5%	9.5%
>2.5 and ≤ 5 Miles	25.9%	26.3%	3.9% - 48.0%	11.5%	15.8%	19.2%	6.3% - 22.8%	7.1%
>5 and ≤ 10 Miles	15.9%	14.2%	1.0% - 41.8%	11.3%	18.9%	15.3%	2.4% - 40.4%	16.0%
>10 and ≤20 Miles	10.1%	7.9%%	0.0% - 36.4%	9.8%	11.3%	7.0%	0.0% - 31.2%	11.6%
>20 Miles	6.2%	6.3%	0.0– 26.3%	6.8%	5.1%	3.7%	1.0% - 13.6%	4.3%

Trip speed. The GPS sampled speed almost every second, with some intermittent 2-second samples. The researchers filtered out trip speeds less than 3 mph so that average speed would not be skewed by zeroes that occurred in the data before the vehicle was set in motion. The researchers then averaged the speed across all GPS data points within a trip and identified the maximum speed within each trip. Researchers used average trip speed and maximum trip speed for analysis (see Table 12). T-tests found no significant differences in averages between groups at pre-intervention.

Table 12. Trip Speed Summary, by Group, at Pre-Intervention

Trip Speed (mph)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Maximum trip speed per driver	76.4	79.5	45.4–88.9	11.6	77.4	78.9	62.8–86.4	7.7
Minimum of average trip speed per driver	8.6	7.5	4.3–15.5	3.4	8.1	9.0	3.7–11.2	2.3
Maximum of average trip speed per driver	53.9	55.3	28.6–67.7	11.8	53.2	51.6	42.3–63.4	7.1
Average of average trip speed per driver	28.1	26.7	17.9–40.6	5.7	27.7	29.7	17.6–34.0	5.7
All Trips: Max trip speed	**47.5**	**45.4**	**9.3–88.9**	**14.3**	**45.6**	**42.9**	**8.1–86.4**	**15.3**
All Trips: Average trip speed	**27.7**	**26.1**	**4.3–67.7**	**10.9**	**26.7**	**25.5**	**3.7–63.4**	**11.6**

Trips in adverse weather, nighttime, and rush hour. If any part of a trip was driven in fog or rain, or if the pavement was wet, the video coder coded the trip as an adverse weather trip; use of windshield wipers was a key indicator of adverse weather conditions. The video coder coded nighttime trips if any part of the trip occurred during darkness. Rush hour trips began between 6and 9 a.m. and between 4 and 7 p.m.. For both groups, most trips were conducted in dry weather with dry pavement, during the day, and not during rush hour. Across all 2,005 trips made by treatment group participants, 8% were made in adverse weather, 4% were at night, and 23% at rush hour. Similarly, across the 1,035 trips made by control participants, 8% were made in adverse weather conditions, 4% were at night, and 23% during rush hour. Table 13 presents the proportion of trips made in adverse weather, at night, and during rush hour, for the 20 treatment and 10 control group drivers. T-tests found no significant group differences in the average proportions of adverse weather, nighttime, or rush-hour trips.

Table 13. Proportion of Trips Made During Adverse Weather Conditions, at Night, and During Rush Hour, by Group, During Pre-Intervention

Weather and Adverse Conditions (% of Trips)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Adverse weather trips per driver	8.0%	7.6%	0.0 %– 26.5%	5.3%	7.8%	9.1%	1.2% - 13.7%	4.3%
Nighttime trips per driver	3.7%	2.9%	0.0% - 15.8%	4.0%	5.2%	3.5%	0.7% - 14.3%	5.2%
Rush hour trips per driver	22.4%	23.1%	4.1% - 34.0%	7.4%	23.0%	21.8%	15.9% - 33.3%	5.3%

Trip time of day. As shown in Table 14, approximately half the trips made by participants in both groups were between 10 a.m. and 3 p.m. and nearly one-third were between 3 p.m. and 8 p.m. A chi-square test found no significant difference between groups in the distribution of their trips by time of day.

Table 14. Proportion of Trips Made at Various Time-Of-Day Bins, by Group, During Pre-Intervention

Time of Day (% of Trips)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
6 a.m. to 10 a.m.	12.3%	11.6%	1.3% - 29.7%	6.8%	13.2%	12.3%	4.3% - 30.2%	7.8%
10 a.m. to 3 p.m.	53.1%	56.2%	17.1% - 66.2%	11.6%	49.6%	51.7%	37.9% - 59.0%	6.7%
3 p.m. to 8 p.m.	30.8%	29.9%	14.4% - 61.0%	12.0%	30.8%	29.4%	17.5% - 48.5%	8.5%
8 p.m. to 6 a.m.	3.8%	3.3%	0.0% - 14.2%	4.2%	6.3%	4.7%	1.3% - 19.0%	5.7%

Pre-Intervention Correlations Between Physical Activity, Functional Ability, Driving Performance, and Driving Exposure

The researchers performed correlations between the measures of physical fitness/activity level, functional ability, and driving performance; between physical fitness/activity level, functional ability and driving exposure; and between driving performance and driving exposure. The researchers reported the strength of the positive and negative correlations using the Evans (1996) guidelines.

- very weak = 0.00 - 0.19
- weak= 0.20 - 0.39
- moderate= 0.40 - 0.59;
- strong = 0.60 - 0.79
- very strong = 0.80 - 1.0

Correlations ranged from very weak to moderate, and are coded in the following three tables, with underline indicating weak and bold text indicating moderate correlations.

As Table 15 shows, higher levels of self-reported physical activity (higher Phone -FITT scores) were weakly associated with better tactical skill performance and better overall on-road driving performance. Counter-intuitively, inability to turn one's head/neck/trunk was associated with better operational skill performance on the road test. In terms of functional abilities, poorer performance on the maze tests was weakly associated with poorer strategic skill performance during the on-road evaluation.

As Table 16 shows, higher levels of physical activity were weakly associated with lower proportions of trips started at rush hour, lower trip counts, and lower driving speeds (i.e., more self-regulation). Better physical fitness (measured with the VO_2 max questionnaire) was weakly associated with larger proportions of trips begun at rush hour and moderately associated with larger proportions of short trips (2.5 to 5 miles). Poorer performance on many of the functional ability measures was weakly associated with self-regulating driving exposure, for example fewer night time and rush hour trips, shorter trip durations (minutes and miles), and slower speeds. Poorer performance on several measures of functional ability showed weak to moderate associations with larger proportions of low mileage trips and smaller proportions of high mileage trips.

In terms of the associations between driving performance and driving exposure, poorer operational skill performance was moderately associated with larger numbers of trips and weakly associated with larger proportions of trips in adverse weather and at higher speeds. Poorer tactical skills performance was associated with increased proportions of adverse-weather trips, but lower proportions of trips at night. Poorer strategic skills performance was weakly associated with shorter trip times and distances, lower driving speeds, more trips that were less than 1 mile and fewer trips of 10 to 20 miles (see Table 17).

Table 15. Correlations Between Measures of Functional Ability/Physical Activity and Driving Performance at Pre-Intervention

Functional Measures and Measures of Physical Activity	**On-Road Performance (Higher Scores = Poorer Performance)**			
	Operational Points Off	**Tactical Points Off**	**Strategic Points Off**	**Road Total Points Off**
VO_2 max Score (Higher Score = Better Performance)	0.07	0.10	0.00	0.11
Phone-FITT Total (Higher Score = Better Performance)	-0.06	-0.23	0.01	-0.23
Head/Neck/Trunk Rotation (Higher Score = Poorer Performance)	-0.31	-0.09	-0.04	-0.11
Walk Time (Higher Score = Poorer Performance)	-0.03	0.18	0.06	0.18
Trails A (Higher Score = Poorer Performance)	-0.15	0.00	0.03	0.00
Trails B (Higher Score = Poorer Performance)	-0.15	-0.04	-0.08	-0.06
Maze 1 (Higher Score = Poorer Performance)	-0.12	0.07	0.20	0.08
Maze 2 (Higher Score = Poorer Performance)	0.00	0.02	0.39	0.07
Maze Total (Higher Score = Poorer Performance)	-0.08	0.05	0.31	0.08

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Table 16. Correlations Between Measures of Functional Ability/Physical Activity and Driving Exposure at Pre-Intervention

Functional Measures and Measures of Physical Activity	Driving Exposure Measures																
	Total Number of Trips	**% Night Trips**	**% Adverse Weather Trips**	**% Rush Hour Trips**	**Total Driving Time**	**Average Trip Time**	**Daily Trip Count**	**Total Driving Distance**	**Average Trip Distance**	**Maximum Speed**	**Average Trip Speed**	**% Trips Under 1mi**	**% Trips 1-2.5mi**	**% Trips 2.5-5mi**	**% Trips 5-10mi**	**% Trips 10-20mi**	**% Trips Over 20mi**
VO_2 max	0.01	-0.11	-0.17	0.21	0.08	0.11	-0.03	0.11	0.09	-0.04	0.14	-0.28	-0.01	**0.40**	-0.07	-0.01	0.19
Phone-FITT	-0.15	-0.15	0.16	-0.21	-0.16	0.02	-0.22	-0.17	-0.05	-0.21	-0.25	-0.12	0.32	0.26	-0.09	-0.28	-0.08
Head Neck	0.03	-0.04	0.33	0.32	-0.34	**-0.41**	0.13	**-0.45**	-0.36	-0.22	-0.29	0.16	**0.41**	0.01	-0.28	-0.27	-0.16
Walk Time	0.08	-0.17	0.05	-0.16	-0.12	-0.27	0.20	-0.32	-0.36	**-0.42**	**-0.40**	0.20	0.22	0.05	-0.11	-0.21	**-0.42**
Trails A	0.13	-0.25	-0.12	0.14	-0.18	-0.33	0.19	-0.26	-0.28	-0.23	-0.31	0.18	**0.45**	0.19	**-0.43**	-0.35	-0.13
Trails B	-0.13	-0.22	-0.11	-0.15	-0.10	0.09	-0.07	-0.04	0.10	-0.15	-0.04	-0.09	0.14	0.17	-0.02	-0.20	0.03
Maze 1	-0.10	-0.20	-0.05	-0.22	-0.27	-0.18	-0.04	-0.33	-0.22	-0.05	-0.14	0.02	-0.09	0.17	0.11	-0.19	-0.10
Maze 2	-0.02	-0.06	-0.03	-0.03	-0.13	-0.13	-0.06	-0.20	-0.16	-0.04	-0.06	-0.15	-0.04	0.31	0.22	-0.31	-0.04
Mazes Total	-0.07	-0.15	-0.04	-0.15	-0.23	-0.17	-0.05	-0.30	-0.21	-0.05	-0.11	-0.06	-0.07	0.25	0.17	-0.26	-0.08

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Table 17. Correlations Between Driving Performance and Driving Exposure at Pre-Intervention

Measures of Driving Exposure	On-Road Performance (Higher Scores = Poorer Performance)			
	Operational Points Off	Tactical Points Off	Strategic Points Off	Road Total Points Off
Total Number of Trips	**0.52**	-0.07	-0.13	-0.06
Percent Night Trips	-0.18	-0.22	-0.10	-0.24
Percent Adverse Weather Trips	0.20	0.20	-0.08	0.20
Percent Rush Hour Trips	-0.05	-0.03	-0.10	-0.04
Total Driving Time	0.33	0.17	-0.31	0.15
Average Trip Time	-0.09	0.20	-0.29	0.16
Daily Trip Count	0.33	-0.18	-0.10	-0.17
Total Driving Distance	0.15	0.11	-0.33	0.08
Average Trip Distance	-0.09	0.07	-0.28	0.04
Maximum Speed	0.21	0.08	-0.20	0.07
Average Trip Speed	-0.25	0.02	-0.32	-0.03
Percent of Trip Under 1mi	0.29	-0.18	0.34	-0.12
Percent of Trips 1 - 2.5 mi	-0.23	-0.34	-0.11	-0.36
Percent of Trips 2.5–5 mi	0.09	**0.40**	-0.12	0.39
Percent of Trip 5–10 mi	-0.04	0.17	0.01	0.16
Percent of Trips 10–20 mi	-0.18	-0.13	-0.25	-0.16
Percent of Trips Over 20 mi	-0.10	0.22	-0.10	0.20

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Group Functional Status at Post-Intervention

Analysis showed no group difference in the percentage of participants who passed the head/neck/trunk flexibility measure at post-intervention. Table 18 shows that in both groups, 10% fewer participants passed the test at post-intervention. Of the 20 treatment group participants, 16 showed no change in performance from pre- to post-intervention, 1 showed better performance, and 3 showed poorer performance. Of the 10 control group participants, 9 showed no change and 1 showed poorer performance.

Table 18. Head/Neck Flexibility Test Performance by Group and Study Phase

Study Phase	Number and % Passing	
	Treatment Group	Control Group
Pre-Intervention	8 (40%)	4 (40%)
Post-Intervention	6 (30%)	3 (30%)

Table 19 presents the performance of both groups on the remaining functional measures following the exercise intervention. The groups did not differ significantly on any of the tests of physical or cognitive function at post-intervention, as described below. Appendix F shows the average change scores for each measure by group, the t-statistic, and probability level.

Table 19. Performance on Functional Status Tests by Group at Post-Intervention

Functional Status Test	Completion Time (seconds)							
	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Rapid Pace Walk	6.5	6.7	3.8–10.3	1.7	6.2	6.3	4.8–7.8	0.9
Maze 1	24.7	20.8	4.6–99.2	23.4	24.2	11.9	4.9–74.9	26.3
Maze 2	25.5	17.0	9.6–120.4	27.1	15.0	14.3	8.0–25.0	4.7
Maze Total	49.9	36.1	14.9–143.3	39.1	39.2	29.5	12.9–91.5	28.2
Trails A	37.5	34.5	19.9–60.7	12.0	33.5	33.1	22.6–45.5	8.8
Trails B	112.0	99.3	52.7–322.4	63.4	103.5	93.1	55.8–182.6	42.9

Group Physical Activity and Cardiovascular Fitness Levels at Post-Intervention

Table 20 presents measures of central tendency, by group, for the Phone-FITT and VO_2 max questionnaires following the exercise intervention. Not surprisingly, the treatment group showed increases in the proportion of participants who lifted weights to strengthen their legs and arms (categories G and I) and the proportion who participated in other aerobic exercises (category N) (see Table 21). The average change score for the treatment group was 8.29 (SD = 15.5) and the average change score for the control group was -1.7 (SD=11.08). A t-test using the change scores found a significant difference between groups as a result of the exercise intervention ($t[28]=1.81$, $p=0.04$).

Table 20. Performance on Measures of Physical Activity by Group at Post-Intervention

Physical Activity Measure	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Phone-FITT	47.5	47.5	14.0–70.5	16.0	35.6	34.5	15.0–62.0	14.2
VO_2 max	28.2	27.6	18.8–39.2	5.6	23.9	24.4	19.2–27.1	2.9

Table 21. Responses to Phone-FITT Activities, by Group at Post-Intervention

Activity	Group	
	Treatment (n=20)	Control (n=10)
	% Yes	% Yes
A. Light housework such as tidying, dusting, laundry, or ironing	80%	100%
B. Making meals, setting and clearing the table, and washing dishes	100%	90%
C. Shopping (for groceries or clothes, for example)	100%	90%
D. Heavy housework such as vacuuming, scrubbing floors, mopping, washing windows, or carrying trash bags.	65%	50%
E. Home maintenance such as painting, cutting grass, or other yardwork.	50%	30%
F. Caring for another person (such as pushing a wheelchair or helping a person in or out of a chair or bed)	5%	30%
G. Lifting weights to strengthen your legs	30%	0%
H. Other exercises designed to strengthen your legs (such as standing up/sitting down several times in a chair or climbing stairs)	50%	30%
I. Lifting weights to strengthen your arms or other exercises to strengthen your arms (such as wall push-ups)	45%	20%
J. Walking for exercise	65%	70%
K. Dancing	25%	10%
L. Swimming	5%	0%
M. Bicycling (either outdoors or indoors on a stationary bike)	5%	10%
N. Other aerobic exercise (includes programs used in this study, elliptical, rowing, stair stepper, etc.)	100%	0%
O. Stretching or balance exercises, including activities such as yoga and tai chi	40%	30%
P. Play golf (Use cart)	5%	0%
Q. Play tennis (singles or doubles)	0%	0%
R. Gardening	35%	40%
S. Other	25%	20%

Figure 5 shows the proportion of participants within the treatment group who scored at each VO_2 max fitness category before and after the exercise intervention. VO_2 max scores increased significantly for the treatment group from pre-to post-intervention (t[19]=-3.48, p=0.001), but not for the control group. However, a t-test using the change scores found no differences between groups.

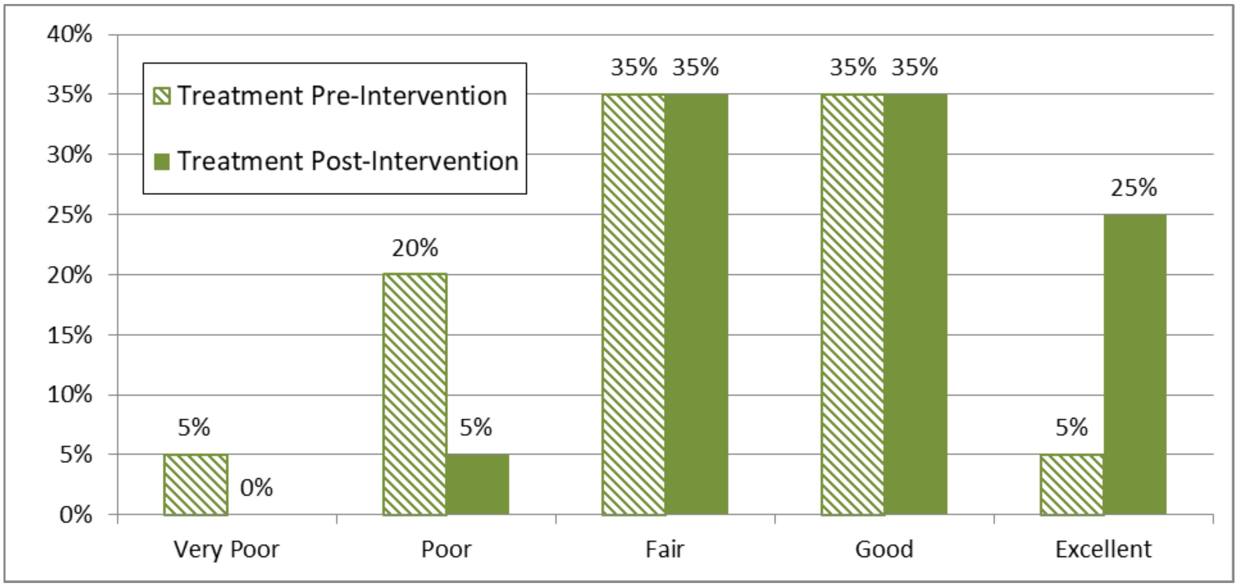

Figure 5. Categorization of VO_2 max scores (very poor to superior), for the treatment group at pre- and post-intervention

Group Road Test Performance at Post-Intervention

Table 22 presents summary statistics, by group, for the number of road test points off (i.e., error score) for each driving skills subset and the total error score. Appendix E shows the score sheet, provides the total number of participants who made each error, the total error score across participants for each task, and totals by subscore. Two-sample t-tests assuming equal variances (based on two-sample F-tests for variances) found no significant differences between groups on any skill subset score or total road test score (see Appendix F).

Table 22. Road Test Scores by Group at Post-Intervention

	Road Test							
Road Test Subscore	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Operational Skills	0.25	0	0 - 5	1.1	0.3	0	0 - 3	1.0
Tactical Skills	28.0	20.0	0 - 106	27.3	18.5	16	5 - 41	11.7
Strategic Skills	1.8	0	0 - 10	2.9	1.0	0	0 - 5	2.1
Overall	30.0	21	5 - 116	28.7	19.8	16	5 - 46	12.4

Figure 6 presents road test performance by group following the exercise intervention. Collapsing across both "passing" score categories, 75% of the treatment group and 100% of the controls received passing grades. The major difference in post-intervention scores for the treatment group was a slight reduction in the proportion of participants who failed, and a slight increase in the percentage who improved from a B to an A. The treatment group participant who failed both road tests drove aggresively, without regard to best driving practices such as communicating and signals, maintaining a safe space cushion, and making full stops. Since the underlying cause of the large driving error score appeared to be attitudinal rather than a deficit in functional ability or fitness, it was unlikely that exercise would improve this participant's driving ability.

Interestingly, with respect to the error scores presented in Appendix E, treatment participants reduced their visual skills errors within the tactical skills subset from 40 in the pre-intervention drive to zero in the post-intervention drive. The control group had no visual skills errors on either drive. Another area of improvement for the treatment group was in the vehicle positioning subset of tactical skills, which improved from 130 points at pre-intervention to 115 at post-intervention. The control group showed an increase from 25 to 35 in this subset of skills. Errors in lane changing decreased from 104 pre-intervention to 70 post-intervention for the treatment group and much more slightly from a low baseline of 10 to 5 in the control group. This category includes scanning to assess blind spots and using mirrors; again, scanning behaviors might improve as a direct consequence of exercise.

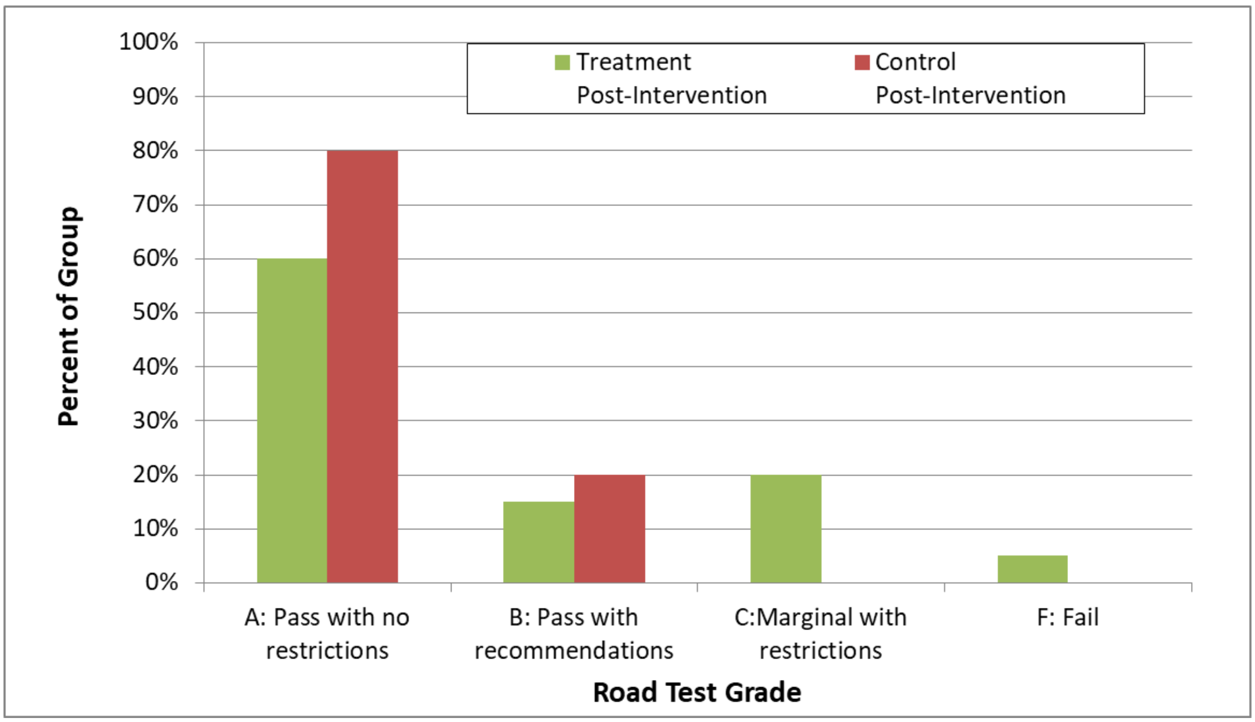

Figure 6. Road test performance by study group, at post-intervention

Driving Exposure Post-Intervention

The post-intervention exposure period was September to December 2018. Table 23 summarizes the number of days participants' vehicles were instrumented during the post-intervention exposure period, by study group. A t-test found no significant difference between groups in the length of their exposure period.

Table 23. Days in Post-Intervention Exposure Period, by Study Group

Measure	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Vehicle Instrumentation Days	31.9	31	24-59	7.4	28.9	28	23-34	3.1

Because GPS and video data were collected using separate devices, analysts matched data from the two sources. They matched 86.1% of the video trips to GPS data (ranging across participants from 43.5% to 100%). Analysts filtered out trips less than 0.1 mile and those less than 1 minute to obtain speed and distance information about each trip. The resulting data set included trip counts and durations (in minutes) for all 2,711 trips. Data on mileage and speed are based on the 2,335 trips for which GPS data were available. The 30 participants made 2,711 trips, drove a total of 598 hours, and logged 14,353 miles. Table 24 summarizes trip counts, driving time, and total mileage by group following the exercise intervention. T-tests using the change scores found no group differences on these measures (see Appendix F).

Both groups showed a reduction in trips, mileage, and driving time during the post intervention period. This could be the result of seasonal differences in weather or reasons for driving, such as for summer vacations or seasonal work, during the pre-intervention period. The post-intervention period spanned September through December, whereas the pre-intervention period spanned March through July. The Bureau of Transportation Statistics reports that vehicle miles traveled (VMT) are at their lowest in February, rise sharply in March and continue to rise through the summer months until peaking in August. VMT decline through the fall and winter (Bureau of Transportation Statistics, n.d.).

Table 24. Time and Distance Driven During Post-Intervention

Measure	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Number of Trips	90.5	84	30-158	30.5	90.1	84	48-152	32
Driving Hours	20.8	21.7	6.6-34.8	7.7	18.1	17.6	6.4-39.8	9.6
Distance (miles)	473.6	413.5	24.5-1,426.8	317.4	488.0	430.7	107.5-1,028.9	337.1

Trip distance and duration. Table 25 summarizes trip distance (in miles) based on the minimum, maximum, and average trip distance for each driver. The "All Trips" row represents the calculations across the 1,531trips taken by the treatment participants and the 804 trips taken by the controls.

Table 25. Trip Distance, by Driver and Group During Post-Intervention

Trip Distance (Miles) per driver	Treatment Group (N=20)				Control Group (N=10)			
	Average	Median	Range	SD	Average	Median	Range	SD
Minimum	0.2	0.2	0.1–0.4	0.1	0.2	0.1	0.1–0.3	0.1
Maximum	45.3	30.8	5.8–229.5	51.1	45.3	24.0	5.1–128.0	44.2
Average	6.5	5.8	1.4–24.6	4.9	6.9	4.9	1.7–24.5	6.7
All Trips	**6.2**	**3.2**	**0.1–229.5**	**13.1**	**6.1**	**2.7**	**0.1–128.0**	**10.3**

Table 26 presents the proportion of trips with distances binned into six categories ranging from less than one mile to over 20 miles, and it shows a similar pattern of results as during the pre-intervention exposure phase. As during pre-intervention, a chi-square test found that the treatment and control groups differed significantly ($\chi^2[5]$ =76.8, p=0.00) in how the overall proportions of their trips were distributed across the indicated distance bins; however, the differences mirrored those demonstrated before the intervention and cannot be attributed to a treatment effect.

Table 26. Percentage of Trips by Distance and Group During Post-Intervention

Percent of Trips	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
≤1 Mile	15.8%	14.1%	5.2% - 58.8%	11.3%	25.2%	18.8%	2.4% - 50.0%	17.8%
>1 and ≤2.5 Miles	24.9%	24.2%	0.0% - 51.2%	11.8%	21.7%	19.3%	7.1% - 47.2%	12.2%
>2.5 and ≤ 5 Miles	24.4%	26.8%	0.0% - 42.5%	13.3%	14.3%	14.3%	4.8% - 29.5%	8.1%
>5 and ≤10 Miles	17.1%	16.7%	3.7% - 38.6%	10.9%	17.1%	14.1%	1.4% - 46.7%	13.1%
>10 and ≤20 Miles	13.0%	6.6%	0.0% - 40.4%	13.4%	15.2%	14.8%	0.0% - 35.9%	13.8%
>20 Miles	4.7%	2.6%	0.0% - 22.4%	5.5%	6.5%	1.6%	0.0% - 42.9%	13.2%

Table 27 shows trip duration in minutes, calculated as described above for the trips recorded in the video data (1,810 treatment group trips and 901 control group trips), and again, shows a large range in the duration of the longest trip made between drivers in each group). Inspection of the "All Trips" rows for these two tables indicates that average trip time and distance were similar for treatment and control group drivers during the post-intervention period.

T-tests using the change scores found no differences between groups in average trip duration or distance or for the longest trip durations and distances (see Appendix F).

Table 27. Trip Duration, by Driver and Group During Post-Intervention

Trip Duration (Minutes)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Minimum trip time per driver	1.5	1	1.0–3.0	0.7	1.6	1.5	1.0–3.0	0.7
Maximum trip time per driver	75.5	57.0	25.0–240.0	51.8	56.4	26.9	26.0–122.0	26.9
Average trip time per driver	14.4	13.1	8.5–32.6	5.4	12.5	12.5	5.2–21.7	5.6
All Trips	**13.8**	**10.0**	**1.0–240.0**	**16.2**	**12.0**	**8**	**1.0–122.0**	**12.6**

Trip speed. As at pre-intervention, researchers averaged the speed across all GPS data points within a trip, identified the maximum speed within each trip, and used average trip speed and maximum trip speed for analysis (see Table 28). T-tests conducted on the change scores found no significant difference between groups (see Appendix F).

Table 28. Trip Speed Summary, by Group, at Post-Intervention

Trip Speed (mph)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Maximum trip speed per driver	74.3	77.1	45.4–90.1	11.8	71.2	69.0	46.0–93.2	13.3
Minimum of average trip speed per driver	7.7	7.5	3.1–11.8	2.1	8.1	8.1	5.6–12.4	2.1
Maximum of average trip speed per driver	50.8	54.7	28.0–66.5	11.0	48.7	48.5	34.2–61.5	9.2
Average of average trip speed per driver	27.6	27.0	16.0–38.3	5.5	27.1	28.9	19.5–35.2	6.1
All Trips: Max trip speed	**48.3**	**46.0**	**7.5–90.1**	**13.6**	**46.9**	**44.7**	**9.9–93.2**	**15.6**
All Trips: average trip speed	**27.5**	**26.7**	**3.1–66.5**	**10.0**	**26.7**	**25.5**	**5.6–61.5**	**11.2**

Trips in adverse weather, nighttime, and rush hour. For both groups, most trips were conducted under dry weather and pavement conditions, during the day, and non-rush hour periods. Across all 1,810 trips made by treatment group participants, 11% were made during adverse weather conditions, 9% were conducted at night, and 19% at rush hour. Similarly, across the 901 trips made by control participants, 11% were made under adverse weather conditions, 14% were at night, and 20% during rush hour. Table 29 presents the proportion of trips made during adverse weather conditions, at night, and during rush hour, for the 20 treatment and 10 control group drivers.

T-tests conducted on the change scores found no significant difference between groups (see Appendix F). Increases observed for proportion of night trips between pre- and post-intervention are likely the result of daylight savings time during the pre-intervention period and fewer daylight hours in the post-intervention period.

Table 29. Proportion of Trips Made During Adverse Weather Conditions, at Night, and During Rush Hour, by Group, During Post-Intervention

Weather and Adverse Conditions (% of Trips)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
Adverse weather trips per driver	10.9%	9.3%	0.0% - 25.3%	7.5%	11.1%	10.2%	6.8% - 18,4%	3.9%
Nighttime trips per driver	8.0%	7.7%	0.0% - 21.9%	6.6%	13.4%	12.4%	2.5% - 27.4%	8.9%
Rush hour trips per driver	17.9%	19.6%	2.6% - 29.1%	7.6%	20.3%	18.4%	13.6% - 32.7%	6.8%

Trip time of day. The researchers grouped trips into four time-of-day bins, as shown in Table 30. Like the distribution at pre-intervention, approximately half the trips made by participants in both groups were between 10 a.m. and 3 p.m. and approximately one-third of the trips made by both groups were between 3 p.m. and 8 p.m. However, unlike at pre-intervention, the results of a chi-square test found a significant difference between groups ($\chi^2[3] = 24.0$, $p=0.00$). A larger proportion of treatment group drivers had trips between 10 a.m. and 3 p.m. compared to control group drivers (56% and 50%, respectively). Larger proportions of control group drivers had trips between 3 p.m. and 8 p.m. compared to treatment group drivers (33% and 29%, respectively), and between 8 p.m. and 6 a.m. (5% and 2%, respectively).

Table 30. Proportion of Trips Made at Various Time-Of-Day Bins, by Group, During Post-Intervention

Time of Day (% of Trips)	Treatment Group				Control Group			
	Average	Median	Range	SD	Average	Median	Range	SD
6 a.m. to 10 a.m.	12.3%	10.6%	3.7% - 29.7%	8.0%	14.4%	12.2%	1.8% - 43.8%	11.8%
10 a.m. to 3 p.m.	56.7%	55.0%	43.8% - 77.6%	8.5%	49.0%	47.5%	38.1% - 63.8%	8.6%
3 p.m. to 8 p.m.	29.1%	33.0%	6.6% - 43.9%	10.1%	30.2%	30.2%	10.4% - 54.0%	13.2%
8 p.m. to 6 a.m.	1.9%	1.0%	0.0% - 6.7%	2.3%	4.5%	4.1%	0.0% - 11.7%	3.2%

Post-Intervention Correlations Between Physical Activity, Functional Ability, Driving Performance, and Driving Exposure

The researchers performed correlation analyses between the measures of physical fitness/activity level (VO_2 max and Phone-FITT questionnaires), functional ability, and driving performance; between physical fitness/activity level, functional ability and driving exposure; and between driving performance and driving exposure. Correlations ranged from very weak to moderate, and are coded below using underline for weak (0.20 to 0.39) and bold text for moderate (0.40 to 0.59).

Physical fitness and activity level were not associated with road test performance (see Table 31), but they were weakly or moderately associated with driving exposure (see Table 32). Specifically, better VO_2 max performance was associated with more total driving time and distance during the post-intervention phase, as well as longer average trip distances. Higher activity levels were associated with more frequent trips during wet weather. These associations were not observed prior to the exercise intervention.

In terms of functional abilities, faster walk time was moderately associated with better on-road performance (fewer tactical errors and fewer total errors on the driving assessment). This association was not evident prior to the exercise intervention. Slower walk time showed weak associations with less total driving distance, shorter trip distances, and lower average driving speeds, similar to prior to the intervention. Ability to turn one's head/neck upper body to look over the shoulder at post intervention was weakly associated with better strategic skill performance on the road test. Less head/neck upper body flexibility was associated with *more* total trips and *more* night and adverse weather trips, but shorter trip times, distances, and lower speeds. Similarly, poorer performance on Trails A and the Maze 2 tests was associated with more total errors on the road test, more total trips and more wet weather trips, but shorter average trip distances and slower speeds.

In terms of the associations between driving performance and driving exposure (see Table 33), poorer overall road test performance was moderately associated with a smaller proportion of trips at night, and weakly associated with fewer rush hour trips and fewer trips per day.

Table 31. Correlations Between Measures of Functional Ability/Physical Activity and Driving Performance at Post-Intervention

Functional Measures and Measures of Physical Activity	**On-Road Performance (Higher Scores = Poorer Performance)**			
	Operational Points Off	**Tactical Points Off**	**Strategic Points Off**	**Road Total Points Off**
VO_2 max Score (Higher Score = Better Performance)	0.00	0.05	-0.18	0.03
Phone-FITT Total (Higher Score = Better Performance)	0.00	-0.10	-0.15	-0.11
Head/Neck/Trunk Rotation (Higher Score = Poorer Performance)	-0.18	-0.06	<u>0.24</u>	-0.04
Walk Time (Higher Score = Poorer Performance)	0.09	**0.47**	<u>0.34</u>	**0.49**
Trails A (Higher Score = Poorer Performance)	<u>-0.28</u>	<u>0.29</u>	0.15	<u>0.28</u>
Trails B (Higher Score = Poorer Performance)	<u>-0.20</u>	0.15	0.04	0.14
Maze 1 (Higher Score = Poorer Performance)	<u>-0.20</u>	-0.02	<u>0.30</u>	0.00
Maze 2 (Higher Score = Poorer Performance)	-0.05	<u>0.28</u>	<u>0.17</u>	<u>0.29</u>
Maze Total (Higher Score = Poorer Performance)	-0.17	0.18	<u>0.28</u>	0.19

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Table 32. Correlations Between Measures of Functional Ability/Physical Activity and Driving Exposure at Post-Intervention

Functional Measures and Measures of Physical Activity	Driving Exposure Measures																
	Total Number of Trips	% Night Trips	% Adverse Weather Trips	% Rush Hour Trips	Total Driving Time	Average Trip Time	Daily Trip Count	Total Driving Distance	Average Trip Distance	Maximum Speed	Average Trip Speed	% Trips Under 1mi	% Trips 1-2.5mi	% Trips 2.5-5mi	% Trips 5-10mi	% Trips 10-20mi	% Trips Over 20mi
VO_2 max	0.09	-0.16	0.12	-0.04	0.27	0.28	0.02	0.28	0.21	0.08	0.17	-0.32	-0.03	**0.47**	-0.10	-0.05	0.08
Phone-FITT	-0.10	-0.19	0.28	-0.04	0.13	0.16	-0.13	0.06	-0.01	-0.15	-0.09	-0.11	0.12	0.21	0.20	-0.26	-0.15
Head Neck	0.36	0.29	0.30	0.04	0.04	-0.28	0.26	-0.20	-0.32	-0.18	**-0.42**	0.39	**0.51**	0.03	-0.35	**-0.45**	-0.24
Walk Time	0.16	-0.19	-0.04	-0.07	0.04	-0.11	0.09	-0.21	-0.24	-0.17	-0.39	0.22	0.22	0.07	-0.22	-0.20	-0.16
Trails A	-0.01	-0.19	0.14	-0.04	0.14	0.10	-0.14	0.14	0.09	0.18	0.14	-0.32	0.00	0.31	-0.01	-0.01	0.10
Trails B	-0.19	-0.19	-0.10	-0.09	0.01	0.17	-0.13	0.08	0.15	0.00	0.13	-0.23	-0.06	0.06	0.03	0.15	0.09
Maze 1	0.06	0.03	0.24	-0.03	0.03	-0.06	0.06	-0.11	-0.16	-0.25	-0.19	-0.02	0.41	0.16	-0.28	-0.10	-0.20
Maze 2	0.24	-0.04	0.28	0.01	0.01	-0.17	-0.04	-0.14	-0.19	-0.13	-0.17	-0.06	0.22	0.27	0.00	-0.28	-0.16
Mazes Total	0.19	-0.03	0.32	-0.03	-0.01	-0.18	0.00	-0.19	-0.25	-0.32	-0.27	-0.06	0.46	0.30	-0.22	-0.28	-0.25

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Table 33. Correlations Between Driving Performance and Driving Exposure at Post-Intervention

Measures of Driving Exposure	On-Road Performance (Higher Scores = Poorer Performance)			
	Operational Points Off	**Tactical Points Off**	**Strategic Points Off**	**Road Total Points Off**
Total Number of Trips	0.14	-0.07	0.03	-0.06
Percent Night Trips	-0.18	**-0.42**	-0.04	**-0.41**
Percent Adverse Weather Trips	-0.02	-0.06	0.12	-0.05
Percent Rush Hour Trips	<u>-0.26</u>	<u>-0.37</u>	<u>0.23</u>	<u>-0.34</u>
Total Driving Time	-0.06	0.00	0.04	0.00
Average Trip Time	-0.13	0.02	-0.02	0.01
Daily Trip Count	<u>0.21</u>	<u>-0.21</u>	-0.06	<u>-0.20</u>
Total Driving Distance	-0.19	-0.09	-0.02	-0.09
Average Trip Distance	-0.18	-0.11	-0.11	-0.12
Maximum Speed	<u>-0.28</u>	-0.07	0.11	-0.07
Average Trip Speed	<u>-0.35</u>	-0.09	0.04	-0.09
Percent of Trip Under 1mi	0.16	0.02	-0.17	0.01
Percent of Trips 1 - 2.5 mi	-0.04	-0.03	<u>0.23</u>	0.00
Percent of Trips 2.5–5 mi	<u>0.27</u>	-0.01	0.15	0.02
Percent of Trip 5–10 mi	-0.07	0.09	-0.14	0.07
Percent of Trips 10–20 mi	<u>-0.23</u>	0.00	-0.03	-0.02
Percent of Trips Over 20 mi	-0.15	-0.10	-0.04	-0.10

Note: No underline nor bold text = very weak correlation (0.00 to 0.19)
Underline = weak correlation (0.20 to 0.39)
Bold text = moderate correlation (0.40 to 0.59)

Pre-Post Comparisons Using Hauer's Method for Analyzing Frequency Count Data

Key dependent measures in this study involved count data, including errors during road tests and various exposure measures (e.g., number of trips, miles driven). Following the planned analyses, the research team conducted further, exploratory analyses using an approach advanced by Hauer (1997) to evaluate the safety effect of engineering treatments based on "before" and "after" event counts at sites where the safety treatments were implemented as an alternative method of comparing the pre- and post-intervention data.

This method essentially estimates the *expected* number of counts[2] during the "after" period had the treatment not been implemented and compares that with the *actual* number of counts in the "after" period. In estimating the expected number of counts in the "after" period, this method uses the change in the number of counts from the "before" to the "after" period, and includes a parameter denoting the variance of the odds ratio (ω), which is a measure of the similarity of the treatment and comparison groups. In before-after analysis of engineering treatments, the trends in the crash counts in the "before" and "after" periods at the treatment and comparison sites is used to estimate ω. In before-after comparisons where such information is not applicable, as in the present case, Hauer (1997) recommends assuming a value between 0.001 and 0.01. A lower value for ω implies that the treatment and comparison groups are more similar to each other; a higher value assumes they are more disparate. In this evaluation, ω was assumed to be 0.01 (the higher end of the range) leading to a more conservative hypothesis testing result, i.e., making it less likely that the null hypothesis will be rejected.[3]

This analysis method produces two outcome measures. The first is the difference between the expected counts in the "after" period and the actual counts (called δ). If the difference is positive, then the treatment was associated with an increase in counts, and if the difference is negative, the treatment was associated with a decrease in counts. The standard deviation of this difference can be used to test whether the difference is statistically different from 0.

The second is the index of effectiveness (θ), which is the measure of the ratio of the actual counts to the expected counts. If this ratio is greater than 1, then the treatment was associated with an increase in counts, and if it is less than 1, the treatment was associated with a decrease (e.g., θ = 1.2 represents a 20% increase, and θ = 0.8 represents a 20% decrease). The standard deviation of this difference can be used to test whether the index of effectiveness is statistically different from 1.

The following measures were investigated using the comparison group method from Hauer (1997).

Driving evaluation measures[4]

- Tactical driving performance points off
- Strategic driving performance points off
- Road test total points off

Exposure measures

- Total trips and trips per day
- Total miles and miles per day
- Total minutes and minutes per day

For each of the measures, the analysis first included all the treatment and control group participants, followed by a second analysis that excluded two treatment group participants who were

[2] This method has traditionally been used with crash counts, but can be extended to any kind of count data.
[3] One reason for using the higher value is that the participants in the treatment group had on average poorer driving performance in the "before" period even after removing two outliers.
[4] Operational driving performance scores had too many zeros to provide any meaningful comparisons.

considered outliers. The researchers defined outliers as values more than three standard deviations from the group mean; and in one of these cases, the participant stated that he intentionally drove in a risky fashion during the on-road evaluation. Table 34 shows the total counts in the before and after periods for the treatment and control groups for all selected measures, and per-day counts for the exposure measures, along with δ, standard deviation of δ, θ, the standard deviation of θ, and the p-value for statistical significance (0.05, 0.10, or n.s.).

Table 34. Before-After Comparisons of Selected Measures for Treatment and Control Groups

Measure	Treatment Group		Control Group		δ	SD of δ	p-value	θ	SD of θ	p-value
	Pre-Intrvn	Post-Intrvn	Pre-Intrvn	Post-Intrvn						
Tactical pts off	743	560	173	185	-230.0	120.9	0.10	0.693	0.106	0.05
Tactical pts off w/o outliers	462	399	173	185	-92.2	77.7	n.s.	0.794	0.125	0.10
Strategic pts off	45	35	25	10	17.7	9.3	0.10	1.725	0.659	n.s.
Strategic pts off w/o outliers	45	25	25	10	7.7	8.8	n.s.	1.232	0.484	n.s.
Road test total pts off	793	600	207	198	-154.9	112.5	n.s.	0.778	0.115	0.10
Road test total pts off w/o outliers	507	429	207	198	-53.6	74.3	n.s.	0.870	0.132	n.s.
Total trips	1937	1725	1035	901	40.4	193.5	n.s.	1.011	0.115	n.s.
Total trips w/o outliers	1759	1538	1035	901	8.2	176.4	n.s.	0.993	0.113	n.s.
Total minutes	24594	24065	12018	10835	1893.8	2246.3	n.s.	1.074	0.108	n.s.
Total minutes w/o outliers	21403	20694	12018	10835	1399.4	1956.1	n.s.	1.062	0.107	n.s.
Total miles	10420	9088	5602	4880	12.5	933.9	n.s.	0.991	0.101	n.s.
Total miles w/o outliers	8826	7474	5602	4880	-213.6	792.4	n.s.	0.962	0.098	n.s.
Minutes per day	764.5	775.4	376.6	368.9	28.5	100.4	n.s.	1.021	0.135	n.s.
Minutes per day w/o outliers	684.9	659.6	376.6	368.9	-9.6	90.5	n.s.	0.969	0.129	n.s.
Trips per day	61.1	55.3	32.7	31.0	-1.0	18.4	n.s.	0.902	0.271	n.s.
Trips per day w/o outliers	56.6	48.9	32.7	31.0	-3.3	17.2	n.s.	0.860	0.263	n.s.
Miles per day	320.6	295.6	173.4	171.0	-18.6	52.3	n.s.	0.918	0.150	n.s.
Miles per day w/o outliers	280.7	240.3	173.4	171.0	-34.9	46.3	n.s.	0.852	0.142	n.s.

The results presented in Table 34 indicate the index of treatment effectiveness was significant at $p = .05$ in the before-after comparison only for tactical points off on the road test; this comparison remained marginally significant ($p = .10$) when two outliers were removed from the data set. None of the comparisons involving exposure measures changed significantly from the pre- to post-treatment periods.

Conclusions and Discussion

This research hypothesized that participation in a structured exercise program for 23 weeks by older adults whose lifestyle was characterized by a relatively low level of physical activity would result in improved performance on a road test and would increase their driving exposure. The researchers randomly assigned participants to an exercise (treatment) group or to a control group, comprised of similarly-aged peers who participated in group activities involving little or no physical activity over the same time span.

An impetus for this study was prior research showing a relationship between cardio-vascular health and cognitive function in older adults. Most notable for driving performance and safety, this includes *executive function* (Brown et al., 2010; Bugg et al., 2012; Netz et al. 2011); *attention* (Netz et al., 2011); and *processing speed* (Brown et al., 2010; Bugg et al., 2012). Thus, if a program of regular exercise—in this case, a treatment group mean of 1.5, 45-minute sessions per week—could increase cardiovascular fitness (VO_2 max) and self-reported activity (Phone-FITT), gains in functional status promoting better performance or increased driving might also be anticipated.

Not surprisingly, pre-post "change scores" on responses to the Phone-FITT questionnaire indicated significantly greater participation by treatment group members in multiple physical activities "in a typical week in the last month," compared to the control group. While change scores for the VO_2 max measure were in the predicted direction, treatment-control differences were not significant. With regard to pre-post changes in functional status indicators, neither measures of leg strength/mobility (rapid pace walk) nor visual search with divided attention (Trail-Making) demonstrated significantly greater gains for the treatment group.

The effects of the treatment on driving performance and exposure outcomes in this study were correspondingly weak. Inferential statistical tests found no significant differences between groups in terms of changes in their scores from before to after the intervention on any driving skill subset score or on total road test score. Pre-post comparisons using the method described by Hauer (1997) found a significant improvement for the treatment versus control group on a single measure, tactical driving skill. Analyses of between-group differences on the considerable number of exposure measures included in this study uniformly failed to reach statistical significance at conventional levels, across all methods.

Absent the limitations and methodological challenges to completing this study, more robust findings may have emerged. The most serious limitation was the small sample size; while the planned sample size was 90 participants, the research team was only able to recruit 30 despite early indications of interest, and on-going efforts by team members at each site. Sample recruitment was hindered by not only the natural reluctance of aging drivers to undergo formal drivng evaluations that could, in extreme cases, lead to their being reported to the licensing authority, but also by the 23-week commitment required for study participation.

Related challenges during the road tests included inadvertent discovery by the CDRS of group assignment, and foreknowledge of test route characteristics and specific driving task requirements by study participants. In the first case, it was not uncommon for participants to make spontaneous, unsolicited remarks to the CDRS about the activities they had been engaged in during the intervention phase. While the CDRS discouraged this, it was not possible for the CDRS to remain blind to group assignment for the entire sample. While not suggesting a bias; this methodological shortcoming should be acknowledged. In the second case, when the friend or spouse of a participant completed the road test first, they sometimes shared details of the procedure to participants who had not yet completed the test.

In spite of the theoretical justification, there is reason for skepticism that an increase in physical activity will lead to an increase in older persons' driving exposure. Preceding NHTSA research (Staplin et al., 2019) led to the conclusion that reliable measures of older persons' choices about when, where, and how often they drive primarily reflect habits acquired from many years of experience grounded in varied connections to the community, rather than an individual's momentary physical activity/fitness level.

Older adults' continuing dependence upon travel by personal automobile to remain independent in their communities places a premium on understanding individual differences that influence one's ability to keep driving safely. The prevalence of age-related functional decline, and evidence linking such declines with poorer performance and an associated risk of crash involvement, reinforce the notion that safe mobility may be buttressed by maintaining fitness with advancing age. The present findings provide only limited support for the hypothesis that increasing a previously sedentary older individual's level of physical activity may translate to better on-road performance, a surrogate for safety. While the use of increased physical activity as a traffic safety countermeasure was not supported by this research, the present findings underscore the need for continuing research aimed at identifying countermeasures to preserve older adults' independent mobility.

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Appendix A: Participant Recruitment Materials

Physical Fitness and Driving Study–Phase 2
Talking Points for Presentations or Gatherings

Funding Agency: National Highway Traffic Safety Administration, U.S. Department of Transportation

Performing Organizations:

UNC Highway Safety Research Center

TransAnalytics, LLC

Driver Rehabilitation Services (Cyndee Crompton, OT performing driving evaluations)

Overall Goals of the Study: Two main questions seeking to answer:

1. Do adults ages 70 and older who participate in regular physical activity perform better in a driving evaluation and/or drive more than do healthy, sedentary drivers of similar age?
2. If sedentary older drivers participate in a fitness training program including regular, documented physical activities, will their driving performance improve or driving exposure increase?

Importance of the Study:

Regular physical activity is associated with numerous health benefits, including improvements in many cognitive and physical abilities demonstrated to be important to driving. Phase 2 of Physical Fitness and Driving Study will directly test the hypothesis that becoming physically active will lead to improved driving performance. If so, more older adults might be motivated to increase their physical activity levels in order to remain healthy as well as retain their driving abilities and privileges longer.

Description of Planned Activities:

This project is being carried out in two Phases to address its two primary research questions.

Phase I was conducted at Galloway Ridge and Fearrington Village. The 67 volunteers for this initial phase of the project represented a cross-section of physical activity levels, and their data is currently being analyzed by the researchers to answer Research Question #1 above.

For **Phase** 2 of the research project, we hope to recruit 90 adults ages 70+ who do not currently engage in regular physical activities. Participants will be asked to complete the following steps twice: once before and once after a six-month intervention:

1. Meet with a member of the research team to complete a brief physical activity questionnaire and a few physical and cognitive assessments. (Time required–1 hour)

2. Wear a lightweight, unobtrusive activity tracker during the time equipment is installed in their vehicle and during a 3-4 week period mid-intervention
3. Allow the researchers to install equipment in their vehicle to automatically record how often and how much they drive over a period of about a month. (During 1-hour meeting above)
4. After going about their normal daily activities for this one-month period, schedule a one-hour meeting with a Certified Driver Rehabilitation Specialist to have their driving skills professionally evaluated. Also at this time, the equipment that was installed in their vehicle will be removed by a member of the research team.

After completing the above activities the first time, participants will be randomly assigned to either a physical activity intervention, or to a control group that will offer alternative, non-physical activities. Participants in the exercise group will be allowed to choose which of the available classes they want to attend, and will be encouraged to attend the classes at least two to three times per week for the duration of the 6-month intervention period. At the conclusion of the exercise (or control group) classes, participants will again be asked to complete Steps 1-4 above.

Analyses will be carried out to determine whether older adults who become more physically active improve their driving performance or expand their driving exposure (Research Question 2 above).

Confidentiality Reassurance:

Any information that could identify individuals as participants in the study will be kept confidential. The researchers will not make any identifiable data available to their study sponsor, the NHTSA, and will not pass along any information to the NC DMV. Study participants will be identified only by a 3-digit number assigned to them at the beginning of their participation in the study.

Compensation:

Individuals who complete the study will receive a total of $250 in Visa gift cards. These include a $75 gift card after completing the first on-road evaluation and having the equipment removed from their vehicle; another $75 gift card midway through the intervention; and a $100 gift card after completing the second and final on-road evaluation.

Participants will also receive feedback on their driving from the driving evaluation (normally $350, but there will be no charge to participants in the study) and free participation in the exercise classes or control group activities.

Project Timeline:

Phase I–Completed.

Phase 2 –January 2018 through September 2018, with data analysis and report preparation to follow.

Newsletter or Newspaper Announcement

Senior Drivers Needed for Physical Fitness and Driving Study

Burlington/Efland is one of two sites participating in a national study conducted by researchers at the UNC Highway Safety Research Center. The goal of the study is to learn whether becoming physically active improves driving performance of older adults. This research study involves having equipment installed in your car to collect information about your driving, having your driving evaluated by a driving rehabilitation specialist, and participating in regular exercise classes (or other group activities) over a period of 6 months. Rewards include $250 in Visa gift cards, professional feedback on your driving, and small incentives to keep you motivated and involved during the intervention period. If you are age 70+, drive, and do not currently engage in regular physical activity, please consider volunteering for this important research study. For more information or to sign up, contact Kristel Robison at the UNC Highway Safety Research Center. Call **[Redacted]** or send an email to **[Redacted].**

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Flyer

Physical Fitness and Driving
A Research Study Funded by the National Highway Traffic Safety Administration

We all know that being physically active is good for us. But is becoming more physically active also good for our driving?

That is the question researchers at the UNC Highway Safety Research Center hope Chapel Hill/Burlington/Efland area seniors will help them answer. Volunteers for the study must be licensed drivers age 70 or older with access to a car and not already engaged in a program of regular physical activity.

Volunteering in this research study requires two one-hour meetings with members of the research team before and after a six-month intervention period. For the intervention, participants will be randomly assigned to either an exercise group or a non-exercise control group. Participants will be asked to wear an activity tracker to record their daily steps, and to allow researchers to install special equipment in their car to record information about their driving. They will also have their driving evaluated by a certified driving rehabilitation specialist.

Participants will receive three Visa gift cards totaling $250 for their participation in the study. They will also receive professional feedback on their driving to help them continue driving safer, longer.

To learn more about the study, or to find out if you qualify to participate, call
Kristel Robison at [Redacted], or email her at [Redacted].

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Alamance seniors asked to do driving study

By Kate Croxton
Posted Jan 25, 2018 at 6:04 PM
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Driving habits, abilities monitored; $250 gift cards the reward

Driving Rehabilitation Services is pairing up with the National Highway Traffic Safety Administration to provide senior citizens a unique driving experience.

In 2010, NHTSA completed a study that looked at whether exercise helped senior citizens enhance their driving skills. The goal of the study was to address how to keep seniors driving as long as possible and as safely as possible.

"With the rise in the baby boomers and the growing population of the aging, if you are automatically taking people off the road, you have another crisis that you are dealing with in terms of depression and how do you keep people engaged and productive and happy," said Cyndee Crompton, an occupational therapist with Driving Rehabilitation Services. "If you can say, 'Research shows that if you are physically active, if you increase your activity level from inactive to moderately active, your driving skill performance goes up,' that is a pretty good benefit. It is to help keep the roads safe, the seniors active and safe and independent as long as they can be."

The study produced positive results, and NHTSA is launching phase two.

Crompton, who has been a therapist for 25 years, joined the NHTSA-funded research study because of her background and her ability to look at how a person performs behind the wheel of a vehicle. She is asking for 90 seniors from Burlington, Efland and Chapel Hill to join the study. The requirements are that the seniors must be older than 70, they currently drive, and they do not participate in moderate or vigorous physical activities on a regular basis.

"I really believe that we have seniors in this community that have an opportunity to contribute to national research," Crompton said. "We, in Alamance County, have an opportunity to provide feedback that could potentially enhance generations of drivers and safety."

Tests and tasks

Seniors selected for the study will spend the first month completing several tasks. They will have a screening test completed by Kristel Robison with the UNC Highway Safety Research Center. The test will look at visual abilities, measures of flexibility, and self-reported activity levels. They also will have cameras with built-in GPS installed in their cars to collect information about their driving habits, such as where they go, how long it takes them and their driving speeds, as well as recording the driver.

"It is a little, nonintrusive camera that goes on their windshield right below the rear view mirror," Crompton said. "The reason it films them is only to identify that they are actually the driver. If somebody else is driving their car that day, we don't look at the data."

Each will then complete a 45-minute driving test with Crompton, who will score driving skills but will not provide feedback.

"The goal is to look at what is their performance in their natural skills without feedback," Compton said.

The next step is to split the seniors into two groups: a control group and an exercise group. Two-thirds of the seniors will be enrolled in the exercise group and will attend locally held exercise classes at the Holly Hill Mall two to three times a week for six months. The exercises will consist of Zumba Gold and Silver Sneakers that will be led by a certified senior instructor.

"We hope to have primarily the same instructor for the class that you are in," Crompton said. "When they sign up, they are going to build a relationship with that instructor, and that instructor is going to be able to advance their skills because they are going to start with them having not exercised, and grow them."

2 or 3 times a week

While the seniors will have the option between six classes a week split between the morning and afternoon to best fit their schedules, Crompton warned that any seniors who felt they could not commit to the two or three exercises a week should not join the study.

"If you are going on vacation for a week or two, understandable. Life happens," Crompton said. "We really want someone to commit to two to three times a week. If someone is only wanting to commit once a week, they are probably not the right fit."

The one-third not put in an exercise group will complete random, nonphysical activities throughout the six months.

At the end of the six months, all the seniors will redo the screening with Robison, they will have the cameras installed for another month, and they will have their driving evaluated again by Crompton, who will provide feedback on their driving skills.

Gift cards given

All seniors who participate in the study will received three Visa gift cards that are worth $250.

Interested seniors are asked to attend the information session from 10 to 11 a.m. Thursday, Feb. 8, at Studio 1 in Holly Hill Mall. Refreshments will be served, and there will be a drawing for a $25 gift card. Seniors also can contact Robison at 919-962-6404 or robison@hsrc.unc.edu.

The deadline to sign up is the end of February with the study beginning in March.

"We are recruiting hard and fast," Crompton said. "We want to get people signed up and get it going and meet deadlines."

Seniors who sign up will receive several benefits that they would not normally get, Crompton said.

"I think it is an opportunity to get professional feedback on their driving," she said. "I also think this could affect the safety of Alamance County. If we get a large population of seniors here that are enhancing their driving performance, then I think our county becomes safer."

The study also would provide community building among the seniors.

"You are contributing to a common goal with your peers, which is always fun, and doing it in a motivational way," Crompton said. "There is also the financial incentive.

"I think it would be fun," Crompton added. "If I was a senior, I think this is fun to have an opportunity to exercise, contribute to knowledge, have my skills evaluated, get good feedback and earn money."

Reporter Kate Croxton can be reached at kate.croxton@thetimesnews.com or 336-506-3078. Follow her on Twitter at @katecroxtonBTN.

Appendix B: Study Consent Form

University of North Carolina at Chapel Hill
Consent to Participate in a Research Study
Adult Participants

Consent Form Version Date: March 3, 2018
IRB Study # 16-2167
Title of Study: Physical Fitness and Driving Performance (Phase 2)
Principal Investigator: Arthur Goodwin
Principal Investigator Department: Highway Safety Research Center
Principal Investigator Phone number: [Redacted]
Principal Investigator Email Address: [Redacted]
Funding Source and/or Sponsor: National Highway Traffic Safety Administration (NHTSA)

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may choose not to participate, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. Research studies may or may not benefit the individual participants in a study, and may also present risks to those participants. Details about the Physical Fitness and Driving Phase 2 Study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researcher named above, or staff members who may assist him, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to learn whether participation in a fitness training program affects driving performance in older adults. You probably have heard of the health benefits of regular physical activity and exercise. These benefits can include improved strength, flexibility, range of motion, and even improved cognitive function. This study will examine whether the benefits of becoming more physically active also extend to driving abilities and practices.

You are being asked to be in this study because you are an adult age 70 or older, you are a licensed driver, and you do not already engage in a regular physical fitness program.

Are there any reasons you should not be in this study?
You should not be in this study if you have been told by your doctor that you have a medical condition that can make it unsafe for you to drive or to participate in regular physical fitness classes. You should also not participate in the study if you require special equipment in your car (such as hand controls or pedal extensions) in order to drive.

How many people will take part in this study?
A total of approximately 90 adults will be recruited to take part in this study.

How long will your part in this study last?
If you choose to participate in this research study, your total time commitment will be 8-9 months, which includes a 6-month-long exercise (or control) intervention as well as pre and post assessment periods. During the pre and post months, you will be asked to participate in two one-hour meetings with a member of the research staff (a total of 4 hours altogether). If selected for one of the two exercise interventions, you will also be expected to attend two or three 45-60 minute exercise classes per week for approximately 6 months.

What will happen if you take part in the study?
If you agree to take part in this study, there are a few things we will be asking you to do for us today before you leave. They include:

- Complete a brief physical activity questionnaire that will ask whether you engage in various types of physical activities, and how often you do so;
- Answer a few questions that will allow us to estimate your "fitness age";
- Complete some simple exercises on a laptop computer to evaluate how quickly you're able to process visual information, how well you perceive spatial relationships among objects, and other skills that have been identified as important to driving;
- Complete two very simple physical assessments, one to check your head and neck flexibility, and the other your leg strength.

Also before you leave today, we will be giving you a pedometer-type device designed to fit around your ankle that we will want you to wear until we meet again in about a month (except when bathing, showering, or swimming). In addition, we will be installing some equipment in your car that will use GPS (global positioning system) technologies to automatically record information about your driving for a period of about a month. This will include information such as how many trips you make each week, the number of miles you drive, the speeds you travel, etc. The equipment will include a small video camera to provide us additional information about your driving, but we will not be capturing any audio. Because we are capturing video data, however, we are required to tell you that if in reviewing the video we observe any instances of suspected abuse of a child or disabled elder, we will need to report this to the proper authorities.

Before leaving today, we will randomly assign you to either the exercise intervention or control group. This will be done based on a number sequence randomly generated by a computer, so that even the research team does not have any control over which group you will be assigned to. Since we have two exercise groups and one control group, the computer will be assigning two-thirds of our study participants to the exercise group, and one-third to the control group.

In a few weeks, you will be contacted to schedule an appointment to meet with a certified driver rehabilitation specialist (CDRS) to have your driving skills evaluated. The individual conducting this evaluation is an occupational therapist with specialized training in driver assessment, training, and rehabilitation. Your driving evaluation will take place in the instructor's vehicle and will last about an hour, starting and ending at a nearby location. While you are out with the instructor, we will remove the equipment we've installed in your own vehicle. If we are unable to schedule the removal of the equipment on the same day as your driving evaluation, we will ask you to schedule a separate 15-minute appointment to have the equipment removed.

If you are randomized to one of the exercise groups, the exercise classes will be starting shortly after your initial driving evaluation. We will be offering two classes. Both have been specifically developed to benefit older adults. During the first week you will be invited to "try out" both classes; thereafter, we will ask you to choose just one of the classes and to attend it 2-3 times a week for the 6-month duration of the intervention period. If you are randomized to the control group, we will be offering a variety of "non-exercise" alternative activities over this same time period that we would like for you to attend.

A couple months into the 6-month intervention, we will ask you to once again wear the activity tracker to record your steps over a 3-4 week period. Towards the end of the 6-month intervention period, we will contact you to schedule a repeat one-on-one meeting to complete the same questionnaires and cognitive and physical assessments we will be doing today. We will re-install the vehicle monitoring equipment in your car and ask you to wear the activity monitor one last time while the equipment is in your vehicle. After you have gone about your normal driving for a second 3-4 week period, we will contact you to schedule a repeat evaluation of your driving. At this second evaluation, we will be able to provide you more detailed verbal feedback on your driving performance. We will retrieve the activity monitor device, and all equipment will be removed from your vehicle.

In order to be included in this study, you will need to agree to participate in all of these activities. However, you can choose not to answer specific questions on any of our questionnaires, and you always have the right to end your participation in the study at any time.

<u>What are the possible benefits from being in this study?</u>

Research is designed to benefit society by gaining new knowledge. The benefit to you from being in this study includes objective feedback on your driving offered by a certified driver rehabilitation specialist. You may also benefit from improved health and fitness from participation in the exercise classes offered, if you are randomized into the intervention group.

<u>What are the possible risks or discomforts involved from being in this study?</u>

Previously inactive older adults who start exercising regularly may be at increased risk for physical discomfort, pain, and injury. We have tried to minimize these risks by choosing exercise programs that are specifically designed for older adults. The programs are easily adaptable for individuals at varying levels of fitness, and can even be done while seated in a chair. The classes will be taught by certified instructors experienced in leading classes for older adults.

You may experience some psychological discomfort in having your driving abilities evaluated. However, the results of the evaluation will be completely confidential and will not be released to the DMV or to anyone else. We do not foresee any psychological or physical discomfort associated with your participation in any of the physical or cognitive tests required for the study.

There may always be uncommon or previously unknown risks. You should report any problems to the researcher.

What if we learn about new findings or information during the study?
You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will information about you be protected?
We will be asking for your name, address, phone number and an electronic mail (email) address if available. This information will only be used for scheduling meetings with project staff and for keeping you informed of any changes in exercise class or activity schedules. No information that could identify you as a participant in this research study will be included in our data analysis files. Instead, your name will be associated with a 3-digit number, and only this number will appear with the data. Your original driving exposure data containing video images of yourself as the driver will be stored in a secured location and destroyed at the conclusion of the project. Paper copies of any forms containing your name will be stored in a locked file at the UNC Highway Safety Research Center, and will only be accessible to designated members of the research team.

Each individual participant's data acquired in this research study may be fully accessed by our study sponsor (the National Highway Traffic Safety Administration). However, all data will remain in the custody of the UNC research team, and no information that could be used to identify you personally will be shared outside of the UNC research team. While the research data may be used by the agency in furtherance of highway safety purposes, in no case will it be linked to you personally by name or video. Participants will not be identified in any report or publication about this study. No video images of participants will be included in any presentations or publications.

Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, the research sponsor (NHTSA), or other government agencies (for example, the FDA) for purposes such as quality control or safety.

What will happen if you are injured by this research?
All research involves a chance that something bad might happen to you. This may include the risk of personal injury. In spite of all safety measures, there is a possibility that you could be involved in a motor vehicle crash, and be injured, while having your driving evaluated or while traveling to an exercise class or other project-related activity. You may also suffer an injury from participation in the exercise classes or other project activities. If such an event occurs, the researchers will help you get medical care, but any costs for the medical care will be billed to you and/or your insurance company. Neither the University of North Carolina at Chapel Hill nor the two sites assisting us in hosting this research study has set aside funds to pay you for any such injuries, or for the related medical care. You do not give up any of your legal rights by signing this form.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have experienced a medical event that prevents you from going about your normal daily activities (including driving),

have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
You will receive three Visa gift cards totally $250 for participating in all phases of this study. These include a $75 gift card after completing the initial on-road driving evaluation and having the in-vehicle equipment removed from your vehicle; a second $75 gift card midway through the exercise intervention; and a third $100 Visa gift card after completing the final on-road evaluation and again having the in-vehicle equipment removed from your vehicle. There will be no other pro-rated compensation to participants who do not complete these requirements. Your name, address, and social security number (SSN) are required to process payments and/or to report taxable income to the IRS. You will be asked to sign a separate Social Security Number Collection form. If you do not provide your SSN (or ITIN), we cannot issue you a payment for participation. However, you may still choose to participate in this study.

To maintain interest throughout the six month intervention period, we plan to offer refreshments and other small incentives to both exercise and control group participants.

Will it cost you anything to be in this study?
Your only cost to participating in this study will be any costs associated with driving your vehicle to a designated area at the study site for the four required meetings with members of the research staff, along with travel to the exercise class locations. All exercise classes and control group activities will take place at the study site.

Who is sponsoring this study?
This research is funded by the National Highway Traffic Safety Administration (NHTSA). This means that the research team is being paid by the sponsor for doing the study. TransAnalytics is a company involved in this research because they own the DrivingHealth Inventory software being used to measure the functional (cognitive) status of drivers in this study. In addition, Loren Staplin, a co-investigator on this study, has ownership in TransAnalytics, Should the use of this technology or approach prove beneficial at some point in the future, Loren Staplin may receive financial benefits.

A committee at the University of North Carolina at Chapel Hill has reviewed these arrangements. They concluded that the possible benefit to the person listed above is not likely to affect your safety or the scientific quality of the study. If you would like more information, please ask the researchers listed on the first page of this form.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researcher listed on the first page of this form. You may also call [Redacted], or e-mail her at [Redacted]u.

What if you have questions about your rights as a research participant?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you

would like to obtain information or offer input, you may contact the Institutional Review Board at [Redacted]or by email [Redacted].

Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

______________________________________ _______________

Signature of Research Participant Date

____

Printed Name of Research Participant

______________________________________ _______________

Signature of Research Team Member Obtaining Consent Date

____

Printed Name of Research Team Member Obtaining Consent

Appendix C: Phone-FITT Questionnaire

Modified Phone-FITT Physical Activity Interview Questionnaire

I'd like to ask you about some physical activities and find out how often you do them, and for how long. First, I'd like you to think about activities you did around your home **in a typical week in the last month.**

Interviewer: Ask about each activity listed in the following charts. If respondent answers 'yes' to engaging in the activity, ask the follow-up questions about frequency and duration; otherwise skip to the next activity. Record answers in charts.

Household Activities

Activity	Participated?	Frequency (times per week)	Duration (Mark one only)
In a typical week in the last month, did you engage in __		***How many times a week did you do this?***	***And about how much time did you spend on each occasion?***
A. Light housework such as tidying, dusting, laundry, or ironing	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
B. Making meals, setting and clearing the table, and washing dishes	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
C. Shopping (for groceries or clothes, for example)	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
D. Heavy housework such as vacuuming, scrubbing floors, mopping, washing windows, or carrying trash bags.	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
E. Home maintenance such as painting, cutting grass, or other yard work *(except for gardening which I'll ask about later.)*	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
F. Caring for another person (such as pushing a wheelchair or helping a person in or out of a chair or bed)	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +

Recreational and Conditioning Activities

Next I'd like to ask you about recreational or conditioning activities you may have engaged in, in a typical week in the last month.

Activity	Participated?	Frequency (times per week)	Duration (Mark one only)
In a typical week in the last month, did you engage in __		*How many times a week did you do this?*	*And about how much time did you spend on each occasion?*
G. Lifting weights to strengthen your legs	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
H. Other exercises designed to strengthen your legs (such as standing up/sitting down several times in a chair or climbing stairs)	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
I. Lifting weights to strengthen your arms or other exercises to strengthen your arms (such as wall push-ups)	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
J. Walking for exercise	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
K. Dancing	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
L. Swimming	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
M. Bicycling (either outdoors or indoors on a stationary bike)	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
N. Other aerobic exercise, (describe below)	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
O. Stretching or balance exercises, including activities such as yoga and tai chi (describe below)	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +

Seasonal Recreational and Other Physical Activities

Now I would like to ask you about a few specific activities that are seasonal, and about any other activities that you do.

Activity	Participated?	Frequency (times per week)	Duration (Mark one only)
In a typical week in the last month, did you ____		***How many times a week did you do this?***	***And about how much time did you spend on each occasion?***
P. Play golf □ Use cart □ Do not use cart	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
Q. Play tennis □ Singles □ Doubles	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +
R. Gardening	□ Yes □ No		□ 1-15 minutes □ 16-30 minutes □ 31-60 minutes □ 1 hour +

Do you participate in any **other regular physical activities** that I haven't asked about?

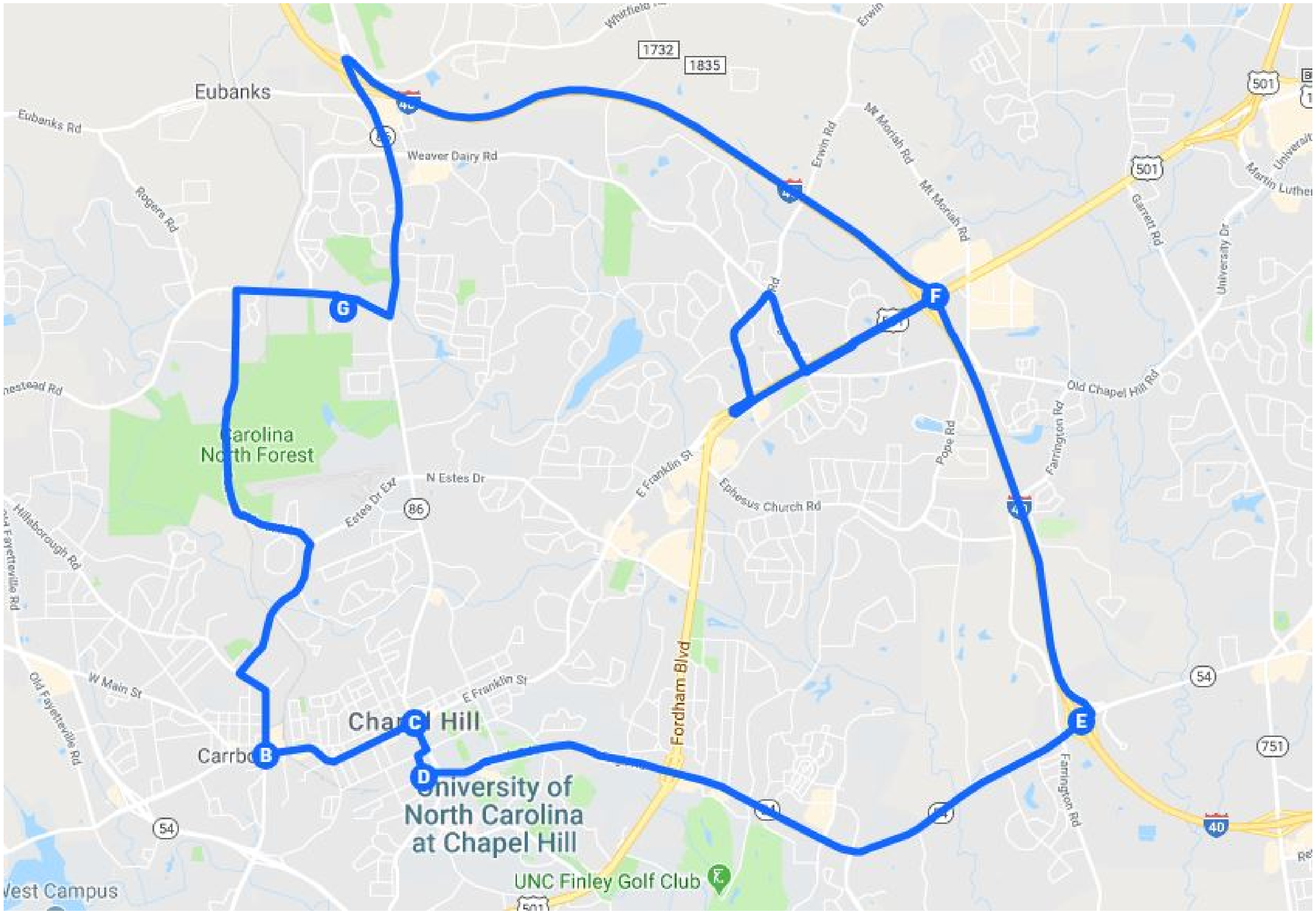
If 'yes,' ask what the activity is, followed by how frequently and for how long. Repeat for up to 3 additional activities, recording answers in chart.

Activity	Participated?	Frequency (times per week)	Duration (Mark one only)
S. Other *(write in below)*	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
T. Other *(write in below)*	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +
U. Other *(write in below)*	☐ Yes ☐ No		☐ 1-15 minutes ☐ 16-30 minutes ☐ 31-60 minutes ☐ 1 hour +

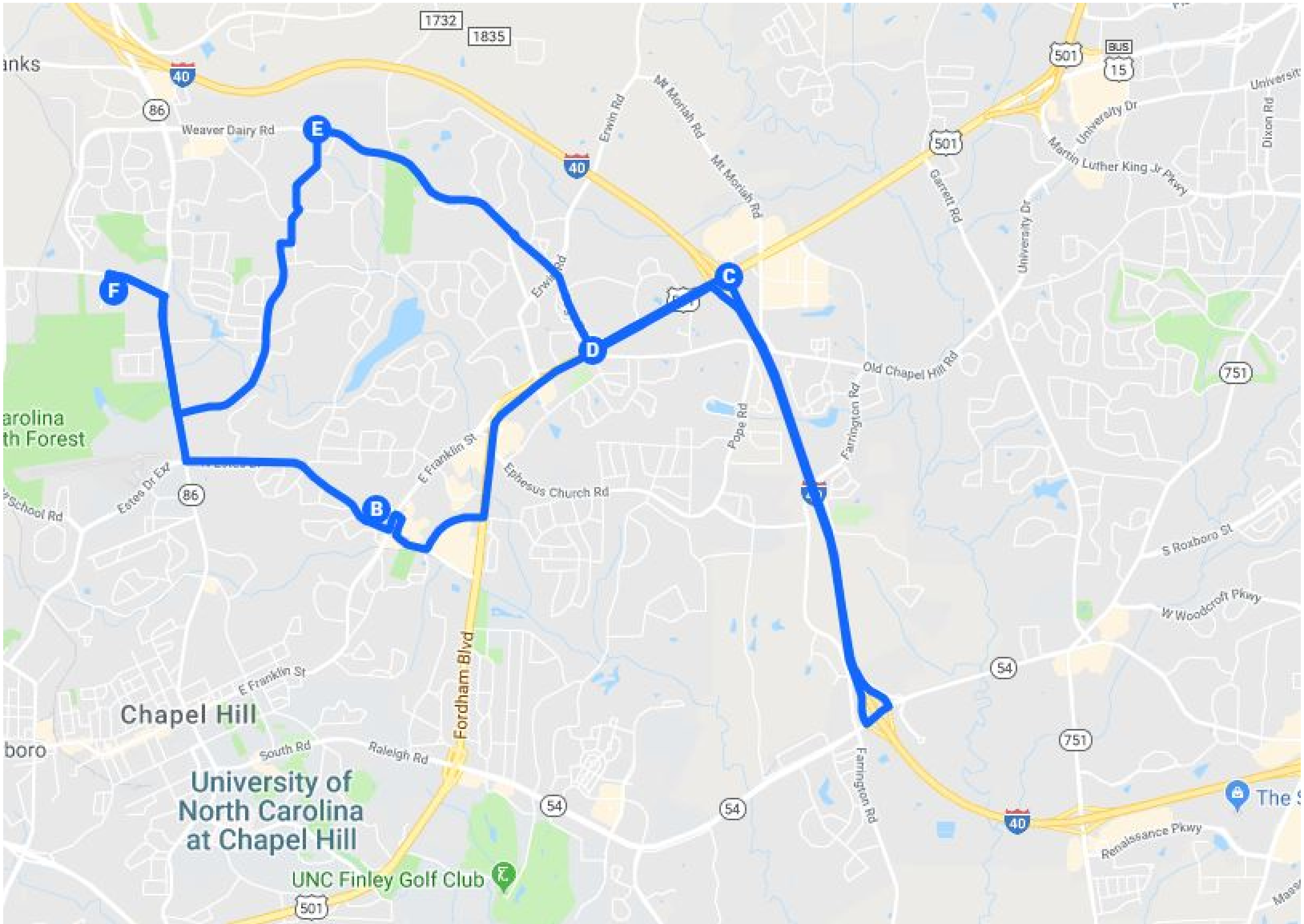
Thank you very much for taking the time to complete this interview.

Appendix D: Test Routes Used by CDRS for On-Road Assessment

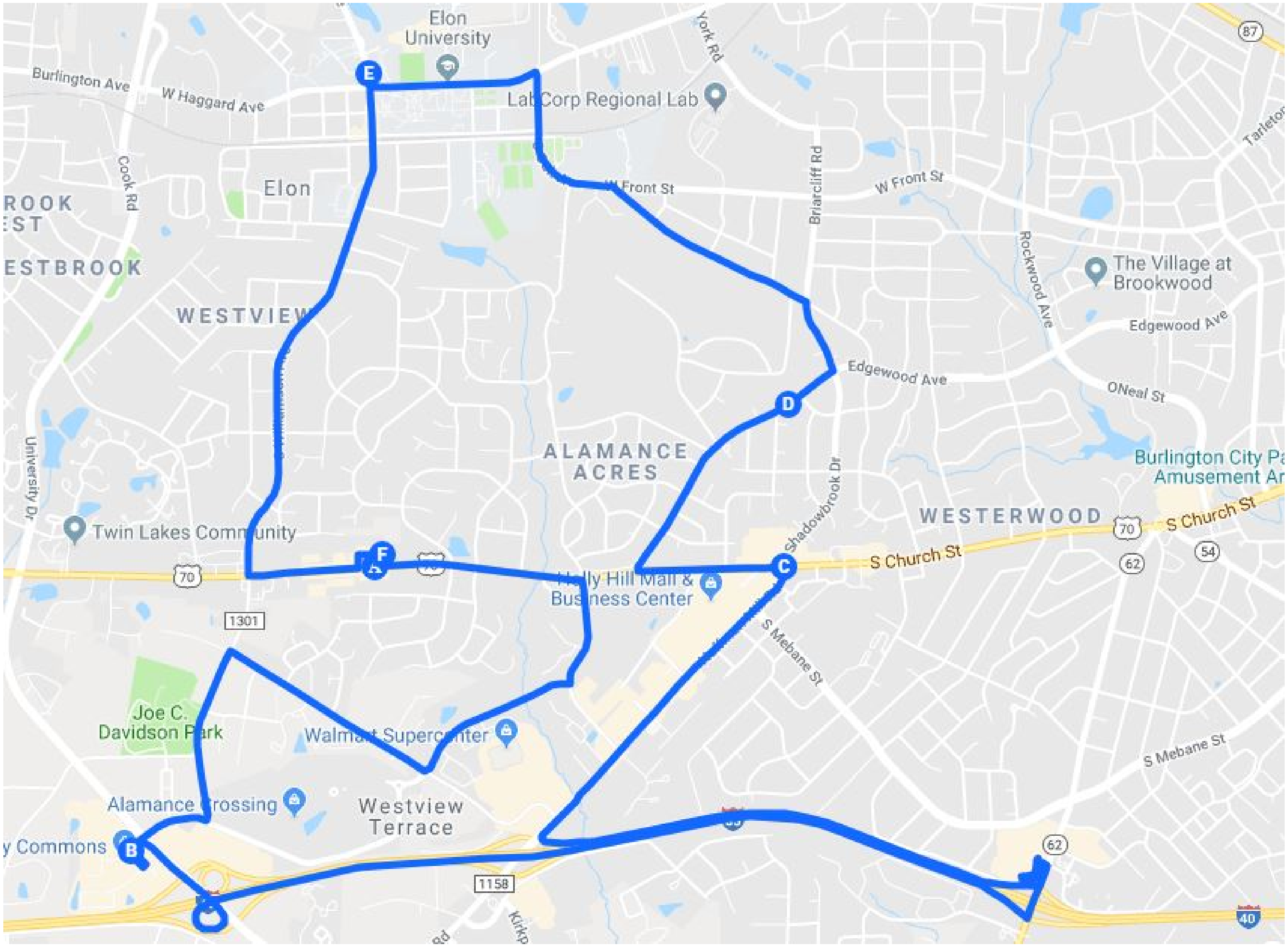
Chapel Hill Route 1: 22.9 miles, 55 minutes total time



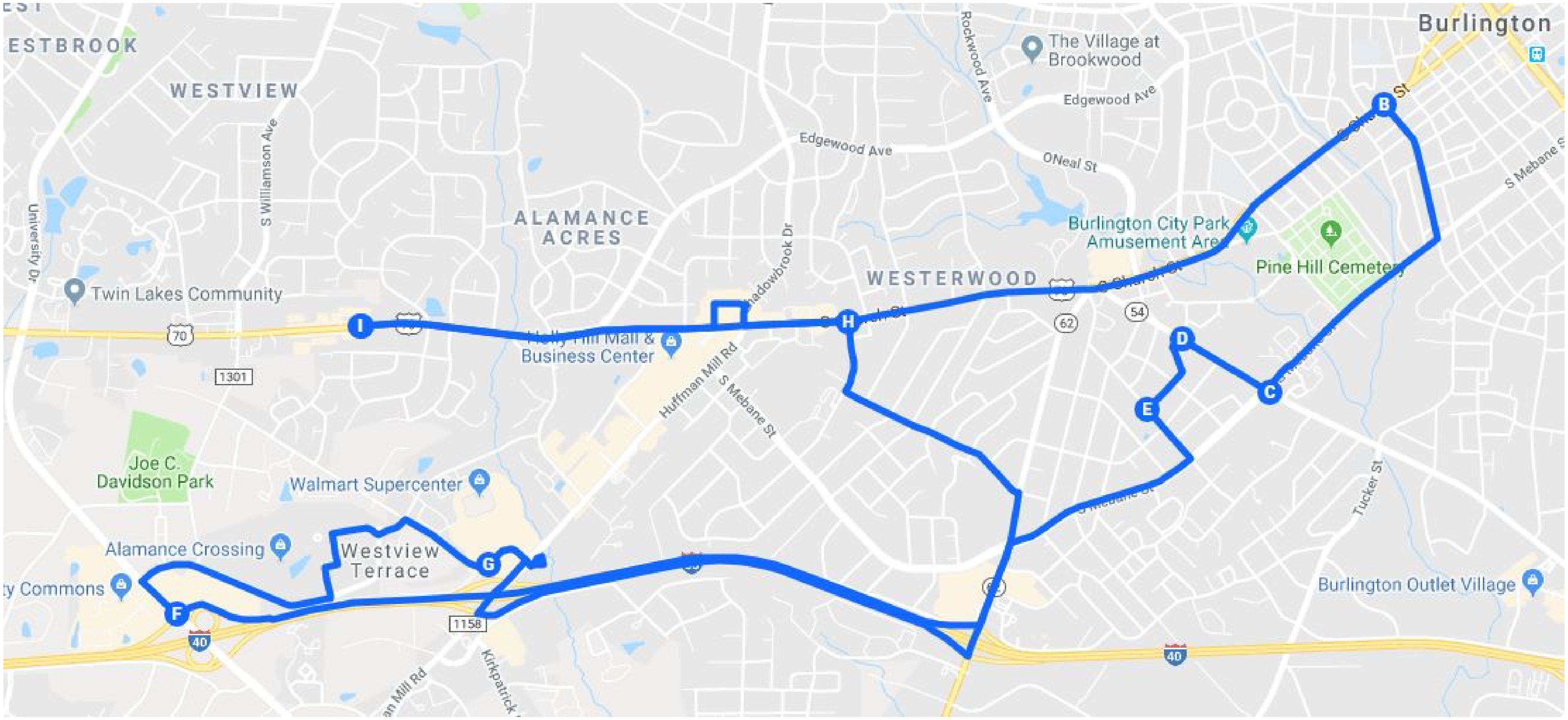
Chapel Hill Route 2: 18.6 miles, 50 minutes total time



Burlington Route 1: 15.1 miles, 50 minutes total time



Burlington Route 2: 17.5 miles, 50 minutes total time



Appendix E: On-Road Summary Scores by Group and Study Phase

Notes on Scoring and Summarizing Scores:

Scoring:

On each participant's score sheet, the CDRS made a vertical mark beside an item where an error occurred. The point value (i.e., error weight) of each item was shown in parenthesis. Each item may have several vertical marks beside it representing the errors that were committed more than one time. The CDRS multiplied the number of vertical marks times the point value in parenthesis to get the Points Off for that item (total).

Summarizing Scores:

Total error score for each skill may be greater that the product of the number of participants and the error weight due to multiple errors by a participant for a particular skill. For example, for lane maintenance/centered position under tactical skills for the treatment group: 3 participants made the error, but 1 of them made the error 4 times, so that person's lane maintenance score was 20 while the other 2 participants only did it once, so each of their error scores was 5. Error score = 20 + 5 + 5 = 30.

Total participants with operational, tactical, and strategic errors may add up to the number of participants with a specific error in each set, because a single participant may have made errors in multiple skills within the set. The total reflects the number of unique participants who had any errors in operational, tactical, and strategic skills.

TREATMENT GROUP (N=20)	Pre-Intervention		Post-Intervention	
Operational Skills	**Number of Partici-pants with Errors**	***Total Error Sum***	**Number of Partici-pants with Errors**	***Total Error Sum***
Independent access to vehicle (1)	0	0	0	0
Negotiation of driver door (1)	0	0	0	0
Seat adjustment (3)	0	0	0	0
Wheel adjustment (3)	0	0	0	0
Mirror adjustment (3)	0	0	0	0
Fastens seat belt (3)	0	0	0	0
Ignition Control (3)	0	0	0	0
Gear selection appropriate (3)	0	0	0	0
Brake pedal use (3)	0	0	0	0
Accelerator pedal use (3)	0	0	0	0
Steering (5)	0	0	0	0
Signal ability (5)	1	5	1	5
Adjusts Heating and Air/Radio if needed(5)	0	0	0	0
Turn Signal/Lights/Wiper/Cruise controls used if necessary (5)	0	0	0	0
Parking brake used if necessary (5)	0	0	0	0
Treatment Group Operational Points off	***1***	***5***	***1***	***5***
	Pre-Intervention		**Post-Intervention**	
Tactical Skills	**Number of Partici-pants with Errors**	***Total Er-ror Sum***	**Number of Partici-pants with Errors**	***Total Error Sum***
Visual Skills:				
Fails to scan environment/tunnel vision (10)	3	30	0	0
Awareness of signage (5)	2	10	0	0
Fails to check speedometer(5)	0	0	0	0
Vehicle Position:				
Lane maintenance/centered position (5)	3	30	3	20
Drives in proper lane (5)	5	30	5	30
Follow distance/Lateral Cushion (5)	3	20	1	15
Stopping position (5)	9	50	4	45
Response to other traffic (5)	0	0	1	5
Intersections/Turns *(Right)*				
Check Traffic (5)	0	0	0	0
Fails to signal (3)	1	3	1	6

TREATMENT GROUP (N=20)	Pre-Intervention		Post-Intervention	
Proper Lane (5)	5	30	6	45
Speed (3)	0	0	0	0
Safe gap selection/yield (10)	0	0	0	0
Fails to make complete stop, obvious roll but safe (5)	8	70	8	65
Fails to make complete stop, obvious roll and risky (10)	1	20	2	20
Fails to make complete stop/ Very near stop but vehicle does not settle back (3)	5	18	4	15
Runs red light (100)	0	0	0	0
Intersections/Turns *(Left)*				
Check Traffic (5)	2	10	0	0
Fails to signal (3)	1	3	1	6
Proper Lane (5)	10	60	7	55
Speed (3)	2	6	2	8
Safe gap selection/yield (10)	1	10	2	20
Fails to make complete stop, obvious roll but safe (5)	3	25	3	15
Fails to make complete stop, obvious roll and risky (10)	0	0	0	0
Fails to make complete stop/ Very near stop but vehicle does not settle back (3)	0	0	4	12
Runs red light (100)	1	100	0	0
Lane changes:				
Fails to signal (5)	3	50	5	45
Fails to use mirrors to check traffic (5)	2	15	0	0
Fails to perform necessary blind spot checks (5)	4	25	0	0
Position (3)	2	6	2	9
Speed (3)	1	3	1	6
Lane (5)	1	5	0	0
Safe gap selection/yield (10)	0	0	1	10
Merges on/off limited access hwy				
Judgment of space (5)	2	10	0	0
Signaling (5)	0	0	0	0
Speed regulation (5)	2	6	1	5
Visual scanning/Blind spot (5)	0	0	0	0
Vehicle Handling:				
Judge and regulate speed (5)	5	45	4	30
Smooth steering (5)	0	0	0	0
Smooth accelerator (5)	0	0	0	0
Smooth braking (5)	0	0	0	0
Appropriate use of signals (5)	0	0	0	0
Response to traffic signal (5)	0	0	0	0
Fails to make complete stop, obvious roll but safe (5)	8	50	6	45

TREATMENT GROUP (N=20)	Pre-Intervention		Post-Intervention	
Fails to make complete stop, obvious roll and risky (10)	0	0	1	10
Parking: Approach (3)	0	0	1	3
Position (3)	1	3	3	12
Speed (3)	0	0	0	0
Backing: Check Traffic (5)	0	0	0	0
Position (3)	0	0	1	3
Speed (3)	0	0	0	0
Safe/yield (10)	0	0	0	0
3-pt turn around (5)	0	0	0	0
U-Turn	0	0	0	0
Position (3)	0	0	0	0
Speed (3)	0	0	0	0
Safe/yield (10)	0	0	0	0
Traffic Circle (5)	0	0	0	0
Treatment Group Tactical Points Off	**19**	**743**	**19**	**560**
	Pre-Intervention		**Post-Intervention**	
Strategic Skills	**Number of Partici-pants with Errors**	***Total Er-ror Sum***	**Number of Partici-pants with Errors**	***Total Error Sum***
Correct and safe decisions				
Residential (5)	0	0	0	0
City (5)	0	0	0	0
Limited access hwy (5)	0	0	0	0
Route planning(5)	0	0	0	0
Route logically sequenced (5)	0	0	0	0
Remembers and executes the route in the preplanned order (5)	2	10	1	5
Maintains/regulates conversation appropriately (5)	0	0	0	0
Problems following rules of the road (5)	2	10	4	20
Fails to make decisions in advance of Maneuvers (5)	0	0	0	0
Separates hazards (5)	1	5	1	5
Fails to observe cues from other road users (5)	0	0	0	0
Fails to anticipate(5)	1	5	0	0
Attention deficit–"looked but didn't see" (5)	0	0	0	0
Decreased Processing speed(5)	0	0	0	0
Impaired following directions (5)	3	15	1	5
Treatment Group Strategic Points Off	6	45	6	35
Treatment Group Total Points Off	***20***	***793***	***20***	***600***

CONTROL GROUP (N=10)	**Pre-Intervention**		**Post-Intervention**	
Operational Skills	**Number of Partici-pants with Errors**	***Total Error Sum***	**Number of Participants with Errors**	***Total Error Sum***
Independent access to vehicle (1)	0	0	0	0
Negotiation of driver door (1)	0	0	0	0
Seat adjustment (3)	0	0	0	0
Wheel adjustment (3)	0	0	0	0
Mirror adjustment (3)	0	0	0	0
Fastens seat belt (3)	0	0	0	0
Ignition Control (3)	0	0	0	0
Gear selection appropriate (3)	1	9	1	3
Brake pedal use (3)	0	0	0	0
Accelerator pedal use (3)	0	0	0	0
Steering (5)	0	0	0	0
Signal ability (5)	0	0	0	0
Adjusts Heating and Air/Radio if needed(5)	0	0	0	0
Turn Signal/Lights/Wiper/Cruise controls used if nec-essary (5)	0	0	0	0
Parking brake used if necessary (5)	0	0	0	0
Control Group Operational Points off	***1***	***9***	***1***	***3***
	Pre-Intervention		**Post-Intervention**	
Tactical Skills	**Number of Partici-pants with Errors**	***Total Error Sum***	**Number of Participants with Errors**	***Total Error Sum***
Visual Skills:				
Fails to scan environment/tunnel vision (10)	0	0	0	0
Awareness of signage (5)	0	0	0	0
Fails to check speedometer(5)	0	0	0	0
Vehicle Position:				
Lane maintenance/centered position (5)	2	10	0	0
Drives in proper lane (5)	1	10	1	5
Follow distance/Lateral Cushion (5)	0	0	1	5
Stopping position (5)	1	5	4	25
Response to other traffic (5)	0	0	0	0
Intersections/Turns *(Right)*				
Check Traffic (5)	0	0	0	0

CONTROL GROUP (N=10)	Pre-Intervention		Post-Intervention	
Fails to signal (3)	1	3	1	3
Proper Lane (5)	2	10	2	10
Speed (3)	0	0	0	0
Safe gap selection/yield (10)	0	0	0	0
Fails to make complete stop, obvious roll but safe (5)	3	15	1	10
Fails to make complete stop, obvious roll and risky (10)	0	0	0	0
Fails to make complete stop/ Very near stop but vehicle does not settle back (3)	2	15	5	21
Runs red light (100)	0	0	0	0
Intersections/Turns *(Left)*				
Check Traffic (5)	0	0	0	0
Fails to signal (3)	1	3	0	0
Proper Lane (5)	2	15	3	15
Speed (3)	0	0	0	0
Safe gap selection/yield (10)	0	0	1	10
Fails to make complete stop, obvious roll but safe (5)	1	5	2	10
Fails to make complete stop, obvious roll and risky (10)	0	0	0	0
Fails to make complete stop/ Very near stop but vehicle does not settle back (3)	1	3	2	6
Runs red light (100)	0	0	0	0
Lane changes:				
Fails to signal (5)	1	5	0	0
Fails to use mirrors to check traffic (5)	1	5	0	0
Fails to perform necessary blind spot checks (5)	0	0	0	0
Position (3)	0	0	0	0
Speed (3)	0	0	0	0
Lane (5)	0	0	1	5
Safe gap selection/yield (10)	0	0	0	0
Merges on/off limited access hwy				
Judgment of space (5)	1	5	0	0
Signaling (5)	0	0	0	0
Speed regulation (5)	0	0	1	5
Visual scanning/Blind spot (5)	0	0	0	0
Vehicle Handling:				
Judge and regulate speed (5)	3	15	2	10
Smooth steering (5)	0	0	0	0
Smooth accelerator (5)	0	0	0	0

CONTROL GROUP (N=10)	Pre-Intervention		Post-Intervention	
Smooth braking (5)	0	0	0	0
Appropriate use of signals (5)	0	0	0	0
Response to traffic signal (5)	1	5	0	0
Fails to make complete stop, obvious roll but safe (5)	3	35	4	45
Fails to make complete stop, obvious roll and risky (10)	0	0	0	0
Parking : Approach (3)	1	3	0	0
Position (3)	2	6	0	0
Speed (3)	0	0	0	0
Backing: Check Traffic (5)	0	0	0	0
Position (3)	0	0	0	0
Speed (3)	0	0	0	0
Safe/yield (10)	0	0	0	0
3-pt turn around (5)	0	0	0	0
U-Turn				
Position (3)	0	0	0	0
Speed (3)	0	0	0	0
Safe/yield (10)	0	0	0	0
Traffic Circle (5)	0	0	0	0
Control Group Tactical Points Off	**10**	**173**	**10**	**185**
	Pre-Intervention		**Post-Intervention**	
Strategic Skills	**Number of Partici-pants with Errors**	***Total Error Sum***	**Number of Participants with Errors**	***Total Error Sum***
Correct and safe decisions				
Residential (5)	0	0	0	0
City (5)	0	0	0	0
Limited access hwy (5)	0	0	0	0
Route planning (5)	1	5	0	0
Route logically sequenced (5)	0	0	0	0
Remembers and executes the route in the preplanned order (5)	0	0	1	5
Maintains/regulates conversation appropriately (5)	0	0	0	0
Problems following rules of the road (5)	1	5	0	0
Fails to make decisions in advance of Maneuvers (5)	0	0	0	0
Separates hazards (5)	0	0	0	0
Fails to observe cues from other road users (5)	1	5	0	0
Fails to anticipate(5)	0	0	0	0
Attention deficit–"looked but didn't see" (5)	0	0	1	5

CONTROL GROUP (N=10)	Pre-Intervention		Post-Intervention	
Decreased Processing speed(5)	1	5	0	0
Impaired following directions (5)	1	5	0	0
Control Group Strategic Points Off	3	25	2	10
Control Group Total Points Off	***10***	***207***	***10***	***198***

Appendix F: Average Change Scores and T-Test Results, by Group, for Functional Measures, Physical Activity, and Cardiovascular Fitness, Road Test Performance, and Exposure Measures.

Measure		Average Change Score		T-Stat	P (one-tailed)
		Treatment	Control		
Functional Measures	Rapid Pace Walk	-0.28	-0.07	-0.56	0.29
	Maze 1	-4.28	10.88	-1.63	0.06
	Maze 2	1.40	-0.07	0.67	0.26
	Maze Total	-4.42	11.90	-1.61	0.06
	Trails A	0.26	1.70	-0.37	0.36
	Trails B	5.97	-0.98	0.44	0.33
Physical Activity & Cardiovascular Fitness	Phone-FITT	8.29	-1.7	1.81	0.04
	VO_2max	2.69	1.42	1.01	0.16
Road Test Performance	Operational Skills	0.0	-0.6	0.90	0.19
	Tactical Skills	-9.15	1.2	-1.14	0.13
	Strategic Skills	-0.50	-1.5	0.52	0.30
	Overall	-9.65	-0.9	-0.96	0.17
Driving Exposure	Average Trip Count	-9.75	-15.1	0.39	0.35
	Total Driving Time (mins)	-16.4	-118.3	0.45	0.33
	Total Mileage	-70.0	-72	0.02	0.49
	Average Trip Duration (mins)	1.3	-0.6	1.15	0.13
	Average Trip Distance (mi)	0.5	-0.2	0.59	0.28
	Longest Trip Duration (mins)	3.5	-39.4	-1.44	0.08
	Longest Trip Distance (mi)	-3.6	-28.8	0.95	0.18
	Maximum Speed (mph)	-2.5	-6.3	1.14	0.14
	Average Speed (mph)	-0.5	-0.6	0.08	0.47
	% Trips Adverse Weather	2.8	3.3	-0.16	0.44
	% Night Trips	4.3	8.2	-1.48	0.08
	% Rush Hour Trips	-4.5	-2.6	-0.64	0.26

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