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16. Abstract
This project explored the relationship between the fitness of older people – operationalized through multiple measures of physical activity level and cognitive status – and their driving performance and exposure. A certified driver rehabilitation specialist conducted on-road evaluations for a study sample (n=67; mean age=78.6) recruited from senior residential communities in the vicinity of Chapel Hill, NC. GPS and video recorders installed in study participants' own vehicles collected naturalistic driving data for approximately one month. Functional status assessments included measures of head/neck/torso flexibility; lower limb strength, balance, and proprioception; visual search with divided attention; and executive function. Activity levels were gauged through the Phone-FITT questionnaire; the VO_2max questionnaire and body measurements; and a pedometer that participants wore around their ankle for a month to record active minutes per day, steps per day, gait speed, and daily distance. Because of their complementary nature, the physical activity measures were combined into a single, continuous scale ranging from 1 (lowest level of physical activity) to 100 (highest level of activity), termed the Unified Physical Activity Index (UPAI). Subsequent correlations between UPAI scores and road test scores (operational, tactical, strategic, and total) showed that, while higher physical activity levels generally were associated with better road test performance, in all cases relationships were very weak, accounting for less than 3% of the variance in the performance evaluations. Similarly, UPAI scores failed to account for more than 1.5% of the variance in multiple measures of trip frequency, distance, or time, or of scanning behavior as characterized by frequency of side glances and over-the-shoulder checks. Correlations between functional status measures and performance and exposure also were very weak; the strongest (inverse) relationships, accounting for about 5% of variance, were between head/neck flexibility and shoulder checks per minute and between trails B score and minutes of driving per day. Logistic regression found that Trails B and Snellgrove Maze Test scores significantly predicted pass/fail outcomes on the road test, and a multiple regression model relating trails B (and other variables) to driving minutes per day indicated that the trails B relationship was statistically significant.

17. Key Words
older driver, physical fitness, 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. Ms. Crompton designed the test route and carried out the on-road driving evaluations in this study. She also assisted with participant recruitment, and made innumerable suggestions that improved our study methodology.
- Nancy Washburn, M.A., office manager, Driver Rehabilitation Services. Her support made Crompton's contributions possible.
- Dan Levitt, University of North Carolina-Chapel Hill, Highway Safety Research Center, was responsible for installing the instrumentation suite for naturalistic data collection in participants' cars, and later removing this equipment, while ensuring the integrity of the GPS and video data recorded for analysis by TransAnalytics.
- Kristel Robison, University of North Carolina-Chapel Hill, Highway Safety Research Center, assisted with participant recruitment and was responsible for enrolling and consenting study participants, performing the functional status assessments, and managing the distribution and supporting the use of the activity trackers that each participant was asked to wear for a month.

Executive Summary

This research examined the relationship between measures of older drivers' physical activity level, as well as selected measures of their functional status, and the results of a certified driver rehabilitation specialist (CDRS)-administered driving assessment plus an instrumented-vehicle log (GPS and video recordings) of naturalistic driving behavior. Researchers hypothesized that indices showing higher activity levels and higher cognitive status would relate significantly to better driving performance and greater exposure.

The study team recruited and consented 67 participants from a senior residential community in the Chapel Hill, NC, area including 37 males and 30 females ranging in age from 70 to 90, averaging 78.6. Inclusion criteria included being a currently NC-licensed driver, access to a vehicle the participant could drive, and age 70 or older. Exclusion criteria included reliance on adaptive vehicle controls to drive (e.g., steering knobs or pedal extensions) or self-report of a medical condition their doctor had indicated could affect their ability to drive safely. The Institutional Review Board (IRB) at the University of North Carolina, Chapel Hill, approved the study protocol, and the Office of Management and Budget approved the information collection (OMB No. 2127-0711).

Measures of physical activity included the Phone-FITT questionnaire; the VO_2max questionnaire and body measurements; and a record of active minutes per day, steps per day, gait speed, and daily distance using a pedometer that participants wore around their ankle for approximately one month. Because of their complementary nature, the physical activity measures were combined to derive a single, continuous scale termed the Unified Physical Activity Index (UPAI); values could range from 1 (lowest level of physical activity) to 100 (highest level of activity) on this scale.

Functional status assessments included measures of head/neck/torso flexibility; lower limb strength, balance, and proprioception; visual search with divided attention; and executive function. A researcher measured these abilities using a test requiring a seated participant to look over his/her shoulder to read the time on a clock; the rapid pace walk test; the Trail-Making Test Parts A and B; and the Snellgrove Maze Test (modified for computer administration), respectively.

A CDRS scored driving performance on a 34-mile standardized test route including suburban, urban, and commercial areas, with two-lane roads, four-lane arterials, and freeways. The CDRS was blind to participants' functional ability test results and physical activity level. The test protocol included operational, tactical, and strategic driving tasks. The CDRS scored the road test based on error counts and weights assigned to each error according to their seriousness for driving safety.

Researchers obtained driving exposure data by instrumenting participants' own vehicles, using a GPS logger and a miniature video camera, for a period averaging one month, in which they were asked to drive "as usual." These naturalistic data included the number and duration of trips, as well as vehicle speed. The data also permitted coding weather/visibility conditions (wet/dry, day/dusk/night), the presence or absence of passengers, and driver behaviors such as mirror checks, side glances, and over-the-shoulder checks, and confirming that the study participant was the driver on each trip.

The results of the analyses did not support hypotheses concerning the relationship between indicators of greater physical activity level and either safer driving performance, or greater driving exposure. Correlations were near zero for all measures. The strongest association was between a measure of physical function—head/neck flexibility—and a measure of driving performance (the frequency of over-the-shoulder checks); however, this functional status measure accounted for only 5% of the variance in this driver behavior.

Measures of cognitive status fared somewhat better in predicting differences in road test scores and exposure. Specifically, logistic regression analysis indicated that poorer performance on Snellgrove Maze 2 and Trail-Making Part B were associated with statistically significant lower odds of passing the road test.

Based on these results, it appears that the actions older drivers take when operating a motor vehicle primarily reflect habits acquired from years of experience; they are *not* directly influenced by their physical activity (i.e., "fitness") level, at least not within the range of individual differences observed in this study sample. Citing recent research that confirms a relationship between cardiovascular health and cognitive function in older adults, the study team suggests that the most plausible mechanism through which a higher level of fitness (operationalized in terms of physical activity level) can help preserve safe driving behavior is via an indirect effect of (moderate) physical activity to improve cardiovascular fitness.

Future studies of the link between exercise and driving may benefit by monitoring physical activity and indices of cardiovascular health over an extended period, rather than relying on relatively brief "snapshots" of these measures as obtained in this study. Researchers might then hypothesize that significant changes (gains) in such indices over the observation period will manifest in significant improvements in driving performance. Also, with respect to the selection of dependent variables, it may be less fruitful to examine idiosyncratic driver behaviors such as head or eye movements. Increased fitness may give older people greater *capacity* for a whole range of behaviors but may not override habits acquired over many decades of driving.

Introduction

Background

The potential to improve older adults' driving performance and safety through improvements in physical function resonates broadly among public health and injury prevention professionals. The population is aging, and – unless/until self-driving cars become widely available and affordable – people now in their 60s are expected to drive more miles, under more challenging conditions, and to postpone driving cessation until later than in previous generations. Current trends in fatality rates underlie a growing need to identify effective countermeasures to reduce crashes involving older drivers in the years ahead. Both the prevalence of age-related impairments in physical functioning, and evidence linking such declines with driving risk, reinforce the notion that gains in safe mobility may result from gains in fitness by older adults.

The physical capabilities (motor functions) needed for driving include strength, range of motion of extremities, trunk and neck mobility, and proprioception (Staplin, Lococo, Martell, & Stutts, 2012). National estimates of the prevalence of age-associated functional impairments for mobility are available from studies such as the *National Health Interview Survey* (Pleis & Lethbridge-Çejku, 2007), which reported on the percentage of people by age group who have difficulty in physical functioning in at least one of nine physical activities: walking a quarter of a mile; climbing 10 steps without resting; standing for 2 hours; sitting for 2 hours; stooping, bending, or kneeling; reaching overhead; grasping a handle or small object; lifting or carrying 10 pounds; and pushing or pulling large objects. Forty-eight percent of people 75 and older reported difficulty or inability in at least one of these activities. This compares to 30% for those 65 to 74, 17% of those 45 to 64, and 6% of those 18 to 44. Thus, there is ample evidence that aging is associated with decreasing physical function, as well as pain and discomfort.

The extent to which research has been able to link these age-related changes with decreased driving performance and safety is examined below.

Tuokko, Rhodes, and Dean (2007) found that people with spine and lower body symptoms (e.g., limited strength or movement, lack of feeling or sensation, stiffness, involuntary movement, or chronic pain) also reported difficulty performing some driving tasks. Respondents who were not physically active reported difficulty with driving tasks involving the spine, including shoulder checks, fastening seat belts, or bending to get into vehicles.

McCarthy and Mann (2006) assessed the ability to perform 20 strength tests (10 on each side) with or without resistance by the examiner. They found that the strength measures had no association with an on-road driving evaluation administered by a driver rehabilitation specialist. Only one of 50 participants failed the strength test. The authors concluded that strength might not be relevant to driving, given the decreased physical requirements of operating a modern car.

Marottoli, Cooney, Wagner, Doucette, and Tinetti (1994) found that the timed performance test involving the lower extremities most strongly associated with adverse events (traffic crash, violation, stopped by police) in the year following testing was the rapid-pace walk, the time required for the person to walk 20 feet. In the sample of 283 community-dwelling people 72 to 92 years old, those who required 7 or more seconds to perform this test were twice as likely to experience an adverse event as those who performed the test in less than 7 seconds. Twenty-one percent of the participants who walked less than one block per day had adverse driving events, compared to just 11% of those who walked one block or more each day. In a journal article about Maryland Pilot Older Driver Study, "MaryPODS revisited," (Staplin, Gish, & Wagner, 2003), the rapid pace walk was a significant predictor of at-fault crashes among drivers 55 and older, with an odds ratio of 3.23. The peak odds ratio for the rapid pace walk indicated a pass-fail cutpoint of 9 seconds.

Marottoli et al. (1998) explored head/neck range of motion in a study of 125 drivers 77 and older. The authors reported that, after adjusting for driving frequency, limited neck range of motion was associated with self-reported crashes, moving violations, or being stopped by the police (RR = 6.1, CI = 1.7-22.0). In the Maryland Pilot Older Driver Study (Staplin Lococo, Gish, & Decina, 2003), head-neck flexibility predicted at-fault crashes among drivers 55 and older, with an odds ratio of 2.56.

Ostrow, Shaffron, and McPherson (1992) found an exercise program to be effective in enhancing older drivers' performance of tasks that accentuate demands on the range of motion. The exercises consisted of chin flexion/extension, neck rotations, head side bending, chin tucks, rotating the shoulders backward, and trunk rotations. After the exercise program, participants completed a driving assessment on a 6.8-mile road test in traffic that lasted approximately 45 minutes. Those who received the range-of-motion training looked more frequently to the sides and rear of their vehicle than did drivers in a control group.

In another study of the effectiveness of a physical conditioning program, generally healthy, normally aging drivers 70 and older who drove at least 5 days per week, and who had at least two physical impairments were randomly assigned to either an intervention or a control group. Intervention group members received a weekly in-home visit by a physical therapist for 12 weeks. The therapist guided participants through a graduated exercise program targeting physical domains and abilities potentially relevant to driving. Following the intervention, the treatment group demonstrated significant improvements in road test scores compared to the control group (2.43 points) on a 72-point scale. Members of the treatment group with the poorest baseline driving evaluation scores showed the greatest improvement (Marottoli et al., 2007).

More recently, results in the NHTSA study *Validation of Rehabilitation Training Programs for Older Drivers* (Staplin, Lococo, Brooks, & Srinivasan, 2013) supported continuing work in this area. Though sample sizes were small (fewer than 20 subjects), a group that received eight hours of physical conditioning was better able than a control group to maintain a range of tactical driving skills (e.g., mirror checks, scanning the environment, blind spot checks, maintaining lane position, lane changes, appropriate speed and speed maintenance), and two strategic skills (anticipating hazards and planning ahead) 3 months after the treatment.

Colcombe and Kramer (2003) found that fitness training influenced a variety of cognitive processes, particularly the executive control processes. These processes support planning, scheduling, working memory, inhibitory processes, and multi-tasking—all important for safe driving. For example, Staplin et al. (2012) cited multiple researchers who reported significant correlations between diminished executive function and crash risk, and between diminished processing speed and crash risk. An increase in cardiovascular fitness achieved through moderate aerobic activity resulted in an increase in the heart's ability to deliver oxygen to working muscles. This may affect cognitive function through improved cerebral blood flow, changes in cerebral structure, or other factors (Netz, Dwolatzky, Zinker, Argov, & Agmon, 2011). Recent observational studies support this relationship between cardiovascular health and cognitive function in older adults (Brown et al., 2010; Bugg, Shah, Villareal, & Head, 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).

This potential for broader health benefits—in addition to maintaining or improving driving performance—highlights the appeal of fitness programs for seniors and underscores the timeliness of the present study.

Objective and Project Scope

The research question is: "Do drivers 70 and older who participate in regular physical activity perform better in a driving evaluation and/or drive more than do healthy, sedentary older drivers?" The research team designed a study to investigate the relationship between older drivers' physical activity level and their driving performance, and between activity level and driving exposure. Data included:

- Functional skills (cognitive and physical function) measured using clinically recognized instruments;
- Physical activity level based on a pedometer-type device and questionnaire responses;
- Driving performance demonstrated during a professional evaluation conducted by a driver rehabilitation specialist (DRS); and
- Driving exposure measures based on data collected using instrumentation installed in participants' own vehicles for approximately one month of naturalistic data collection.

The University of North Carolina at Chapel Hill's IRB approved the research (Office of Human Research Protections, IRB # 540). The study team received Office of Management and Budget approval to collect voluntary information from potential participants to determine their eligibility to participate in this study, as well as to collect the functional, driving performance, and driving exposure measures (OMB No. 2127-0711, expiration 12/31/2018).

[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).

Methods

Participant Recruitment

The study team recruited participants from the Fearrington Village and Galloway Ridge at Fearrington communities located adjacent to one another about 8 miles south of Chapel Hill, North Carolina. Fearrington Village is home to approximately 2,000 residents. This community included active retirees, young families, and working professionals who resided in their own (free-standing) homes. Galloway Ridge is a continuing care retirement community that is home to approximately 350 independent living residents residing in a mix of apartments and villas. All Galloway Ridge residents enjoyed membership in a large on-site fitness center named the Duke Center for Living and managed by Duke Health. The Duke Center for Living offered exercise equipment, an indoor lap pool, and a wide variety of fitness classes. Fearrington Village residents also had access to the Duke Center for Living, but they paid the general public rate to join the fitness center.

The researchers advertised the research opportunity in newsletters (Fearrington Village, Galloway Ridge, and Duke Center for Living), made formal presentations about the project at both Fearrington Village and Galloway Ridge, and posted flyers at various locations around both sites (see recruitment material in Appendix A).

Interested candidates telephoned the study coordinator, who asked several screening questions to determine eligibility for participation. Inclusion criteria included being a currently NC-licensed driver, access to a vehicle that they could drive, and 70 or older. Exclusion criteria included reliance on adaptive vehicle controls to drive (e.g., steering knobs or pedal extensions), self-report of a medical condition that their doctor had indicated could affect their ability to drive safely, or age younger than 70. The study coordinator 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, receive a physical activity tracker, and have their vehicle instrumented to collect the driving exposure data. These activities were all conducted at the Galloway Ridge site.

Functional Assessments

The study coordinator 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, which presented instructions, test stimuli, and timed responses. The study coordinator ensured that each participant understood the instructions for each measure prior to testing. The physical assessments consisted of head/neck/upper torso flexibility and the rapid pace walk:

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. Participants were not permitted to lift up 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 presented on the screen behind him or her) or fail (the participant could not turn far enough to identify the object).

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 marked spot 10 feet away, turned, and walked back to the starting point as quickly as possible. Those who took at least 7.5 and less than 9 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.

The cognitive measures were Trail-Making Parts A and B, and the Snellgrove Maze Test, modified for computer administration.

Snellgrove Maze Test. 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, Gish, Joyce, Lococo, and Sifrit (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 one or more crashes during the 18 months following assessment, than drivers scoring below this cutpoint. 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's group.

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 as well as output from an accelerometer to assess participants' general level of physical activity. This approach was previously used by a group of British researchers who set out to compare questionnaire, accelerometer, and pedometer approaches for measuring physical activity in older adults (Harris et al., 2009). Pedometers and accelerometers are the most frequently used measures to validate physical activity questionnaires.

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 of time may be compromised for some (Washburn, Smith, Jette, & Janney, 1993; Kowalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012; Harada, Chiu, King, & Stewart, 2006); thus, 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 (e.g., 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). It asks whether individuals participated in six household activities and 13 conditioning and recreational activities *in a typical week in the last month*. For affirmative responses, subjects provided the frequency (number of times per week) and duration (1-15, 16-30, 31-60 or more than 60 minutes). Total score was calculated according to Gill, Jones, Zou, and Speechley (2008) by assigning codes 0 to 4 to the duration responses, summing the frequency (times per week) and duration code (0-4) for each activity, and summing across all activities. The higher the score, the greater the activity level. The reliability and validity findings of Gill's group demonstrated very little gain by incorporating intensity into the summary scores, and suggested that the intensity measurement used in Phone-FITT does not fully capture the intensity of various activities performed by older adults. Thus the study team did not collect the intensity for each activity.

VO_2 max fitness questionnaire and measures. VO_2 max expresses how much oxygen is consumed while exercising to exhaustion. Most people consume between 30 and 60 milliliters of oxygen per minute per kilogram of body weight (ml/min/kg) (Davis, circa 2014). A higher value corresponds to better cardiovascular fitness.

The researchers employed a questionnaire, took several body measurements, and used a regression model developed by Nes et al. (2011) to describe cardiorespiratory fitness. The questionnaire obtained exercise frequency (almost never or less than once per week, once per week, 2 to 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. Responses were coded according to the Nes group 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.

The researchers calculated a physical activity index (PA index) as the product of frequency, duration, and intensity. The study coordinator measured height (cm), waist circumference (cm), and resting heartrate (beats per minute) using a fingertip pulse oximeter. Subjects self-reported their weight. The regression equation applied to males was:

*100 - (0.296 * age) – (0.369 * waist circumference) – (0.155 * resting heart rate) + (0.226 * PA Index)*

The regression equation applied to the data for females was:

*74.74 - (0.247 * age) – (0.259 * waist circumference) – (0.114 * resting heart rate) + (0.198 * PA Index)*

Nes and colleagues 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. The non-exercise regression model was accurate in predicting measured VO_2 max in Nes and colleagues' healthy population of 4,260 males and females (average age 48.4 years, R=0.78 for males, R= 0.75 for females), and they consider it a valid tool for a rough assessment of cardiovascular fitness.

Activity tracker. Participants wore an activity sensor[2] in a fabric band with a velcro closure around their ankle for the month of data collection. The device collected daily step counts, number of active minutes per day, gait speed, and distance per day. The device was selected for the study because it had no display to provide feedback to the participants about their activity, and because the batteries did not need to be charged or replaced during the data collection period. The study coordinator advised participants to take the pedometer off when bathing, showering, or swimming because the device was not meant to be worn in water. The study team enclosed each sensor in a small plastic zipper bag before placing it in the ankle band, for protection in the event a participant got the device wet. The activity data from the wearer's sensor was automatically retrieved by Bluetooth when the participant returned the device to the study coordinator and the sensor was in close proximity to the data collection computer running the software.

In calculating average steps per day, average gait speed, average active minutes, and average distance per day, the researchers eliminated the day the sensor was assigned to each participant, the day the sensor was retrieved from the participant, and any days where average gait speed was 0 ft/sec (based on the assumption that the trackers were not worn on those days, or only worn for a very small portion of the day).

Driving Exposure

While participants completed their functional assessments, a member of the research team instrumented their personal vehicle. The collected data included number and duration of trips as well as vehicle speed during the one-month period. This allowed analysts to determine average and maximum trip lengths and trip speeds. Analysts coded weather/visibility conditions (wet/dry, day/dusk/night) and the presence or absence of passengers based on video data; the video also supported coding driver behaviors such as mirror and over-the-shoulder checks that could be affected by strength and flexibility.

Consistent with previous NHTSA research, the study team operationally defined a "trip" as any travel segment where a participant started the engine, moved his/her car from one location to another, then turned off the engine. This methodology permitted tabulation of the frequency of unique trips (e.g., travel from home to one destination). A series of "chained" trips (where a driver left home, made multiple stops, then returned home) would constitute multiple trips under this definition.

[2] Tractivity, developed by Kineteks Corporation in Vancouver, BC, Canada.

Figure 1 and Figure 2 present the configuration of the exposure data collection system installed in each study participant's car. Appendix D presents the installation manual developed for the installation technician. This system design was driven by the study's data needs, and it incorporated "lessons learned" from prior studies. The need for passive, positive driver ID on every trip dictated an image-based system. Still camera images would have met this need, but video technology was available at the same price and offered better resolution of driver behaviors such as head turns for shoulder checks. The study team employed a GPS data logger to obtain reliable location data updated every second.

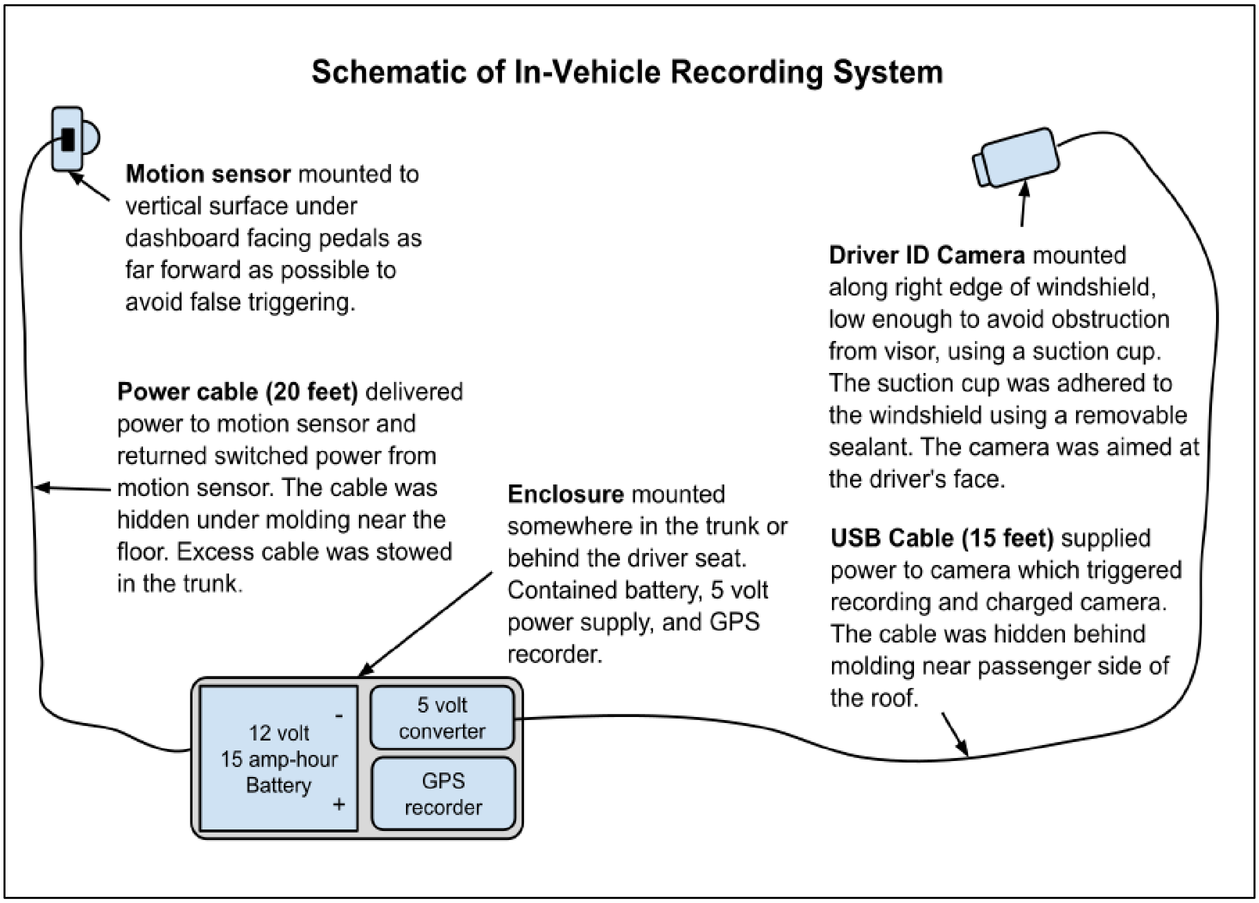

Figure 1. In-vehicle recording system use to capture driving exposure and driver behavior.

The video and GPS recorders were independent (non-integrated). The camera images included a GPS timestamp 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. 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 angle-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 which was capable of storing 30 hours of video, or one hour per day of driving time, for the entire month. GPS data were logged at 1 Hz on a 1 GB microSD card.

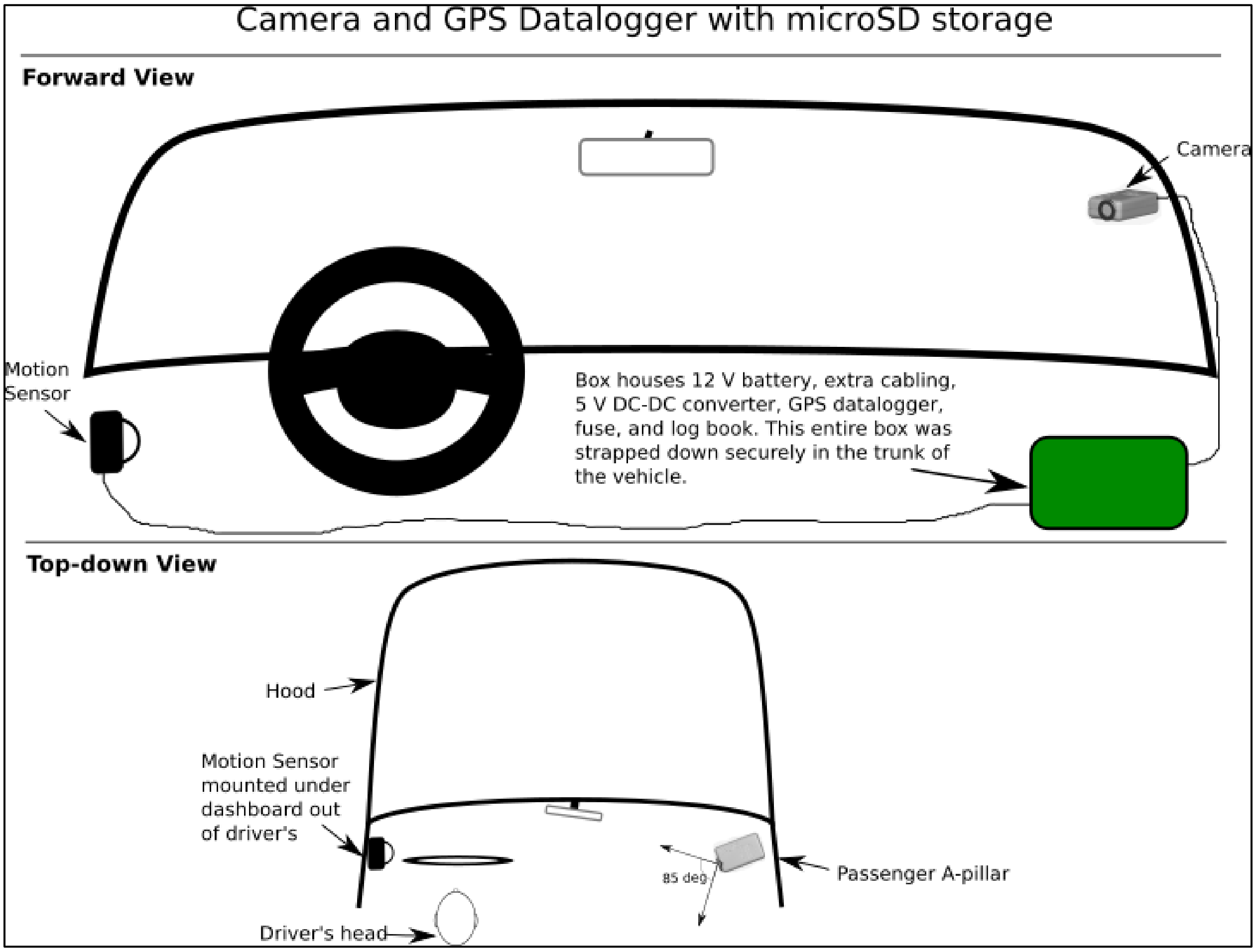

Figure 2. Forward and top-down views of camera and GPS datalogger installation.

Driving Performance Evaluation

A CDRS developed and conducted a standardized on-road test route. The route was 34.1 miles, took approximately 70 minutes to complete, and began and ended at the Galloway Ridge parking lot (see Appendix E). The test route 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 requested destination. At times, participants did not follow the instruction and proceeded in their accustomed manner.

The CDRS instructed participants to plan and make their own lane selection decisions for merges or turns. For example, the route included merging onto Interstate 40 West. Most participants were more accustomed to merging onto Interstate 40 East at this juncture as that was the route to a favorite 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. There were locations where participants were asked to make a challenging left turn; 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 needed to follow the planned route, which may include more difficult tasks. By design, the test route included situations in which older drivers are over-represented in crashes including:

- Left turns across traffic where cross-traffic does not stop (6);
- Unprotected left turns at intersections controlled by traffic lights (2);
- 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 (3);
- Merging onto a controlled access highway from a ramp/acceleration lane controlled by a yield sign (3);
- Changing lanes on a multi-lane roadway (3+);
- Negotiating two-way stop-controlled intersections;
- Parking and backing in congested parking lot environments including parking between two vehicles (3).

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, recognizing and managing hazards such as road construction and maintenance vehicles. The CDRS totaled the three subscores for an overall driving score, with higher scores denoting worse performance.

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. During the first week of test administration, several participants rolled through stop signs at the retirement community (i.e., approaching a near stop but not fully stopping). It was the opinion of the CDRS that these errors were causing the scores to be higher than the participant's actual driving performance would warrant. Following a discussion with the NHTSA COR and other study team members, it was agreed that the CDRS could provide a cue the first time this error was witnessed and not score any deductions for that single occurrence. The CDRS advised participants that any occurrences of rolling stops following the cue would be scored.

Results

Subject Sample

The study team recruited and consented 67 participants including 37 males and 30 females ranging in age from 70 to 90 (M = 78.6, SD = 5.1, Mdn = 79). Three of the 67 were unable to complete the on-road evaluation portion of the study. These included 2 males (ages 80 and 88) who completed the physical activity questionnaires, the driving exposure component, and wore the physical activity tracker for 30 days; both became ill prior to the evaluation. One female (age 85) completed all study phases but missed her on-road appointment three times and then declined to complete the study. The activity tracker failed to collect data for 2 males beyond the day it was issued, and for three others (2 females and 1 male) returned average daily step counts under 450, indicating either low battery or failure of the participants to wear the trackers all day every day. Differences in performance by sex, where significant, are provided in the text that follows.

Functional Assessments

Head/neck/torso flexibility. Table 1 presents the results of the head/neck flexibility test for 66 participants; the remaining participant twisted her lower body in the seat when completing this measure, so her data were excluded from analysis. A chi-square test found no significant sex difference in the proportion of participants passing this measure.

Table 1. *Head/Neck Flexibility Test Performance*

Sex	Pass (Row%)	Fail (Row%)	Total
Male	15 (40.5%)	22 (59.5%)	37 (100%)
Female	16 (55.2%)	13 (44.8%)	29 (100%)
Total	31 (47.0%)	35 (53.0%)	66 (100%)

Rapid pace walk. Eleven participants had walk times associated with mild impairment (6 females and 5 males) and 4 had scores indicating severe impairment (1 female and 3 males). The remaining 52 participants' walk times did not indicate impairment. Table 2 presents walk time summary statistics across the sample of 67 participants. A t-test indicated no significant difference in walk time for males versus females.

Table 2. *Rapid Pace Walk Performance*

Sex	Walk Time (sec)				
	Number	Range	Average	SD	Median
Male	37	4.05 – 11.16	6.17	1.84	6.02
Female	30	3.92 – 9.02	6.47	1.26	6.58
Total	67	3.92 – 11.16	6.31	1.60	6.09

Snellgrove Maze Test. Table 3 presents summary statistics for Snellgrove Maze Test performance, for each maze separately, as well as the combined scores, for 64 of the 67 participants. One participant was not able to complete Maze 1 within the time allotted before timeout (3 seconds), and therefore her score was excluded for Maze 1 and maze total scores. Two participants experienced a delay in touchscreen response during Maze 1 testing and 1 participant during Maze 2 testing, so these unreliable scores were excluded from the summary calculations. Using the cutpoints identified by Staplin et al. (2013), participants whose combined Maze 1 and Maze 2 scores were 36 seconds or higher but less than 42.2 seconds were considered to have a mild impairment in executive function, and those whose combined scores were 42.2 seconds or higher a serious impairment. Using these cutpoints, 4 participants had scores indicating mild impairment (1 female and 3 males) and 27 a serious impairment (12 females and 15 males). The remaining 33 participants' times did not indicate executive function impairment. T-tests indicated no significant sex difference in maze completion time, for either maze alone, or for the combined mazes.

Table 3. *Snellgrove Maze Test Completion Time*

Sex	Maze 1 Completion Time (sec)				
	Number	**Range**	**Average**	**SD**	**Median**
Male	36	4.13 – 145.32	32.66	34.67	19.23
Female	28	4.83 – 86.24	25.53	23.89	12.76
Total	64	4.13 – 145.32	29.54	30.41	16.88
Sex	**Maze 2 Completion Time (sec)**				
	Number	**Range**	**Average**	**SD**	**Median**
Male	37	7.26 – 56.5	16.66	8.55	15.03
Female	29	7.5 – 163.44	23.55	28.36	15.46
Total	66	7.26 – 163.44	19.68	19.97	15.22
Sex	**Maze 1 and Maze 2 Total Completion Time (sec)**				
	Number	**Range**	**Average**	**SD**	**Median**
Male	36	11.39 – 171.76	49.21	38.05	34.59
Female	28	12.57 – 172.25	49.01	36.26	34.34
Total	64	11.39 – 172.25	49.12	36.98	34.34

Trail-Making Test Parts A and B. Table 4 presents performance on these tests, by sex, for 66 participants (Part A) and 65 participants (Part B). Analyses excluded Part A completion time for one participant because of a delay in touch screen responsiveness. For Part B, one score was excluded due to screen unresponsiveness and another because of the participant's inability to complete the test before the time-out period (within 6 minutes). Fourteen participants had Part A scores associated with mild impairment (4 females and 10 males), and seven with serious impairment (3 females and 4 males). The remaining 45 participants' scores on Part A did not indicate impairment. Thirty-eight participants had Part B scores associated with mild impairment (15 females and 23 males) and 4 with serious impairment (2 females and 2 males). The remaining 23 participants' Part B scores did not indicate impairment. T-tests indicated no significant sex difference in either Trails A or Trails B completion time.

Table 4. *Trail-Making Completion Time*

Sex	Trail-Making Part A Completion Time (sec)				
	Number	**Range**	**Average**	**SD**	**Median**
Male	36	21.73 – 105.38	40.48	17.29	38.06
Female	30	23.55 – 164.02	40.49	25.15	34.47
Total	66	21.73 – 164.02	40.49	21.05	37.06
Sex	**Trail-Making Part B Completion Time (sec)**				
	Number	**Range**	**Average**	**SD**	**Median**
Male	36	42.63 – 234.41	99.86	41.69	93.86
Female	29	41.06 – 275.14	101.88	52.52	87.80
Total	65	41.06 – 275.14	100.76	46.46	90.24

Measures of Physical Activity

Phone-FITT questionnaire. Table 5 presents the number and percentage of participants, by sex, who indicated participating in each activity *in a typical week in the last month*. Females indicated the following "other" activities: leg lifts; handy person and community management activities (climbing ladders, repairs, setup); core exercises; hiking; screen printing (standing, pulling lifting); antique store management (moving/carrying, cleaning and staining); outdoor walking; aquatic strength training; and setup and take-down for events (chairs, tables). Males indicated the following "other" activities: kayaking, deep sea fishing, special events setup and clean-up; core exercises; wood working; hospital worker (walking to patient rooms); driving range; hiking; sit-ups; physical therapy; sailing; and boat maintenance.

Phone-FITT scores for the 67 participants ranged from 20.5 to 89 (M = 49.7, SD = 13.9, Mdn = 49.0). These scores fell between those reported by Gill et al. (2008) for their reliability and validity samples. Figure 3 shows the frequency distribution of Phone-FITT scores by sex as well as for the full sample. The average score for males was 47.8 (SD = 14.8, Mdn = 47.0) and for females was 52.1 (SD = 12.7, Mdn = 50.5). A t-test indicated no significant sex difference in Phone-FITT scores.

Table 5. *Responses to Phone-FITT Activities, by Sex*

Activity	Sex				Total (n=67)	
	Females (n=30)		Males (n=37)			
	Yes	No	Yes	No	Yes	No
A. Light housework such as tidying, dusting, laundry, or ironing	30 (100%)	0 (0%)	30 (81%)	7 (19%)	60 (90%)	7 (10%)
B. Making meals, setting and clearing the table, and washing dishes	29 (97%)	1 (3%)	34 (92%)	3 (8%)	63 (94%)	4 (6%)
C. Shopping (for groceries or clothes, for example)	30 (100%)	0 (0%)	35 (95%)	2 (5%)	65 (97%)	2 (3%)
D. Heavy housework such as vacuuming, scrubbing floors, mopping, washing windows, or carrying trash bags.	18 (60%)	12 (40%)	22 (59%)	15 (41%)	40 (60%)	27 (40%)
E. Home maintenance such as painting, cutting grass, or other yardwork.	6 (20%)	24 (80%)	9 (24%)	28 (76%)	15 (22%)	52 (78%)
F. Caring for another person (such as pushing a wheelchair or helping a person in or out of a chair or bed)	5 (17%)	25 (83%)	4 (11%)	33 (89%)	9 (13%)	58 (87%)
G. Lifting weights to strengthen your legs	11 (37%)	19 (63%)	20 (54%)	17 (46%)	31 (46%)	36 (54%)
H. Other exercises designed to strengthen your legs (such as standing up/sitting down several times in a chair or climbing stairs)	17 (57%)	13 (43%)	19 (51%)	18 (49%)	36 (54%)	31 (46%)
I. Lifting weights to strengthen your arms or other exercises to strengthen your arms (such as wall push-ups)	13 (43%)	17 (57%)	26 (70%)	11 (30%)	39 (58%)	28 (42%)
J. Walking for exercise	24 (80%)	6 (20%)	32 (86%)	5 (14%)	56 (84%)	11 (16%)
K. Dancing	3 (10%)	27 (90%)	0 (0%)	37 (100%)	3 (4%)	64 (96%)
L. Swimming	2 (7%)	28 (93%)	4 (11%)	33 (89%)	6 (9%)	61 (91%)
M. Bicycling (either outdoors or indoors on a stationary bike)	4 (13%)	26 (87%)	11 (30%)	26 (70%)	15 (22%)	52 (78%)
N. Other aerobic exercise (includes Zumba and Silver Sneakers, elliptical, rowing, stair stepper, etc.)	10 (33%)	20 (67%)	19 (51%)	18 (49%)	29 (43%)	38 (57%)
O. Stretching or balance exercises, including activities such as yoga and tai chi	20 (67%)	10 (33%)	23 (62%)	14 (38%)	43 (64%)	24 (36%)
P. Play golf ◻ Use cart (all 5 used cart) ◻ Do not use cart	2 (7%)	28 (93%)	3 (8%)	34 (92%)	5 (7%)	62 (93%)
Q. Play tennis ◻ Singles ◻ Doubles (both played doubles)	1 (3%)	29 (97%)	1 (3%)	36 (97%)	2 (3%)	65 (97%)
R. Gardening	12 (40%)	18 (60%)	14 (38%)	23 (62%)	26 (39%)	41 (61%)
S. Other	11 (37%)	19 (63%)	12 (32%)	25 (68%)	23 (34%)	44 (66%)

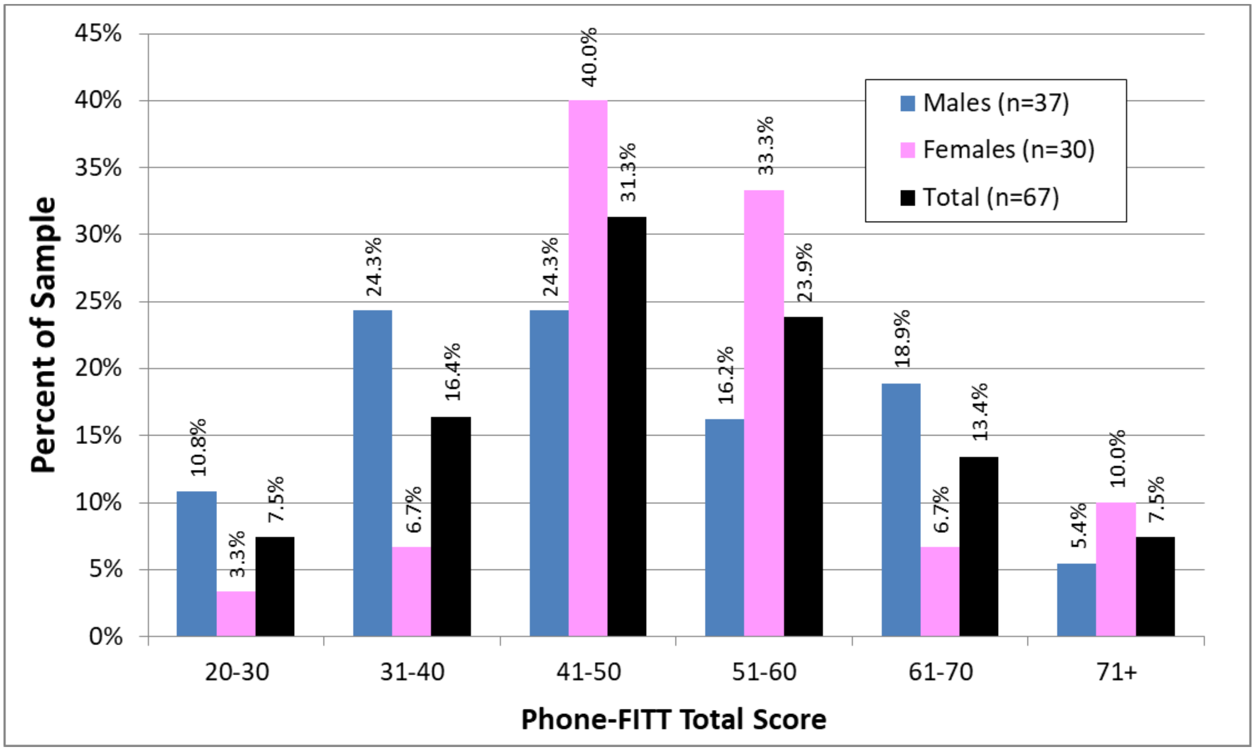

Figure 3. Frequency distribution of Phone-FITT total scores by sex and across the study sample.

VO_2 max fitness questionnaire and measures. VO_2 max scores for the 67 study participants ranged from 5.6 to 44.3 (M = 30.4, SD = 6.7, Mdn = 30.8). These scores are slightly lower than those reported by Nes et al. (2011) for their sample of participants over age 50. Figure 4 shows the frequency distribution of scores by sex and across the sample of 67 participants.

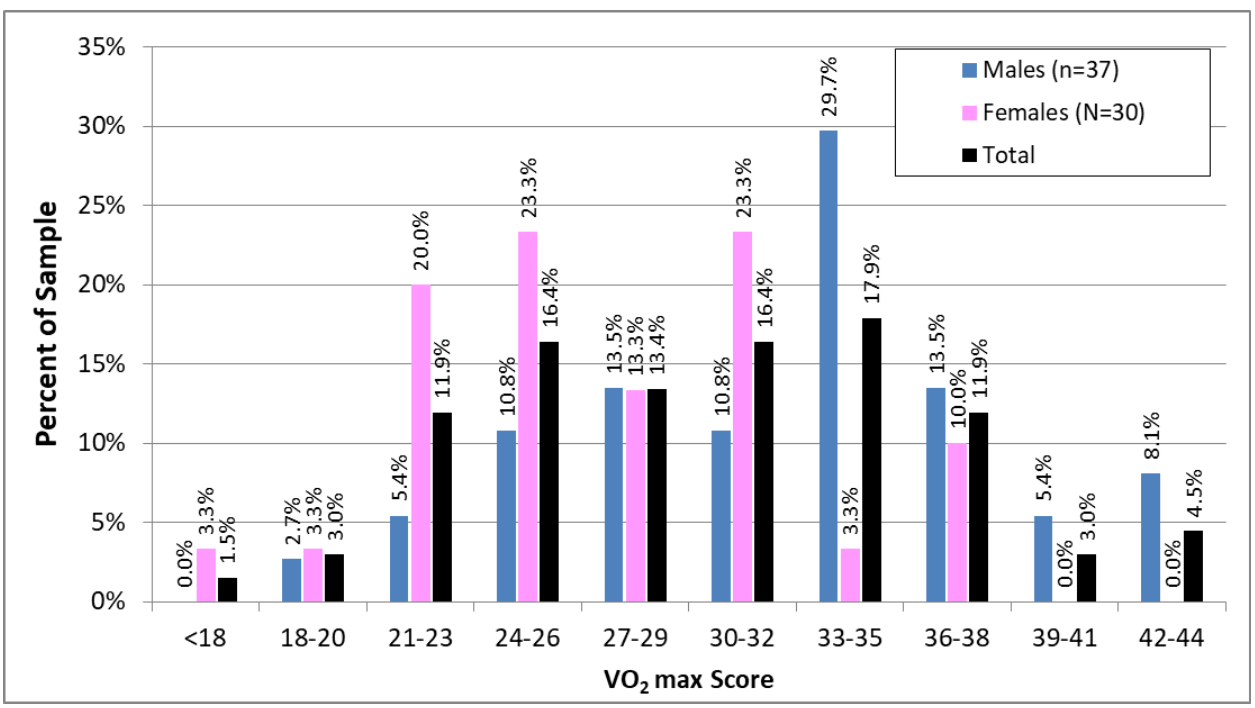

Figure 4. VO_2 max scores by sex and across the study sample.

Average VO_2 max for males was 32.9 (*SD*=6.0, *Mdn*=34.1) which was significantly higher than that for females, 27.3 (*SD*=6.4, *Mdn*=27.1) (t=3.66, df = 60, $p<0.0005$).

Table 6 shows fitness level by age and sex norms for people 60 and older (Heyward, 1998). As shown in Figure 5, 73.3% of the females and 56.8% of the males had scores associated with good or better cardiovascular fitness.

Table 6. *Fitness Level According to Age and Sex Norms, for Individuals Age 60 and Older*

VO_2 max Fitness Level	Males	Females
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

Source: The Physical Fitness Specialist Certification Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 1997, taken from Heyward, 1998.

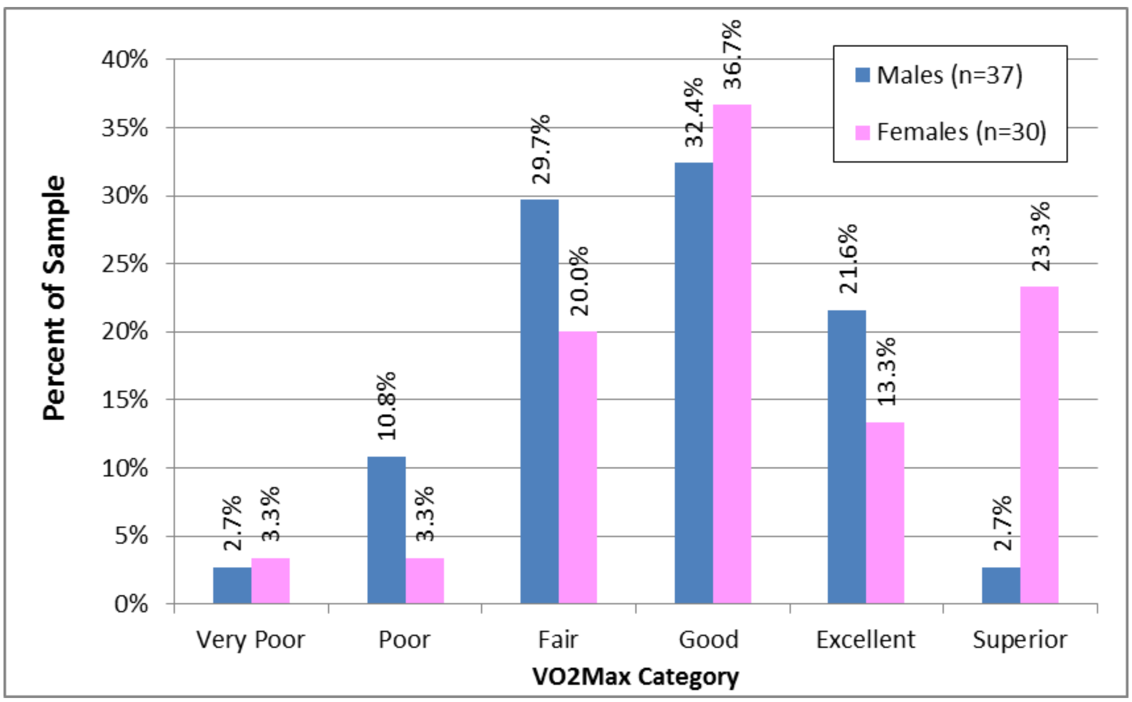

Figure 5. Categorization of VO_2 max scores (very poor to superior), by sex.

Responses to the frequency of exercise question were as follows:

- Almost never or less than once per week: n=6;
- Once a week: n=0;
- 2 to 3 times per week: n=30;
- Almost every day: n= 31.

Activity tracker. Tracker data were available for 65 participants. Table 7 provides summary statistics for data collected by the activity tracker, by sex. T-tests indicated no significant differences between males and females in average steps per day or active minutes per day; however, males covered significantly more distance per day (t=2.04, df=60, p=0.046) and had a faster pace (t=2.59, df=63, p=0.01).

Table 7. *Activity Tracker Summary Statistics, by Sex*

Sex	Statistic	Average Active Minutes Per Day	Average Step Count Per Day	Average Distance Per Day (Miles)	Average Gait Speed (Ft per Sec)
Males	n	35	35	35	35
	Range	11 - 244	421 - 14,890	0.14 - 7.85	0.59 - 3.57
	Average	81.61	4,781	2.13	1.75
	Standard Deviation	52.58	2,854	1.47	0.70
	Median	78	4,468	1.9	1.55
Females	n	30	30	30	30
	Range	7 - 229	221 - 10,437	0.06 - 4.3	0.43 - 2.81
	Average	74.09	4,073	1.50	1.33
	Standard Deviation	57.94	2,477	1.01	0.57
	Median	56	3,785	1.3	1.23
Total	n	65	65	65	65
	Range	7 - 244	221 - 14,890	0.06 - 7.85	0.43 - 3.57
	Average	78.14	4,454	1.84	1.55
	Standard Deviation	54.81	2,689	1.31	0.67
	Median	60	3,813	1.5	1.40

Tudor-Lock and Bassett (2004) provide the following guidance for categorizing activity level by number of steps per day:

- < 5,000: Sedentary;
- 5,000 – 7,499: Low active;
- 7,500 – 9, 999: Somewhat active;
- 10,000: Active;
- 12,500: Highly active.

Using this categorization, 40 of the 65 participants with activity tracker data are classified as sedentary (61.5% of the sample), 18 as low active (27.7%), 5 as somewhat active (7.7%), 1 as active, and 1 highly active. Figure 6 presents the proportion of male and female participants in each category, and shows little difference in the distribution, with the exception of a slightly larger proportion of females categorized as sedentary and a slightly higher proportion of males categorized as low active.

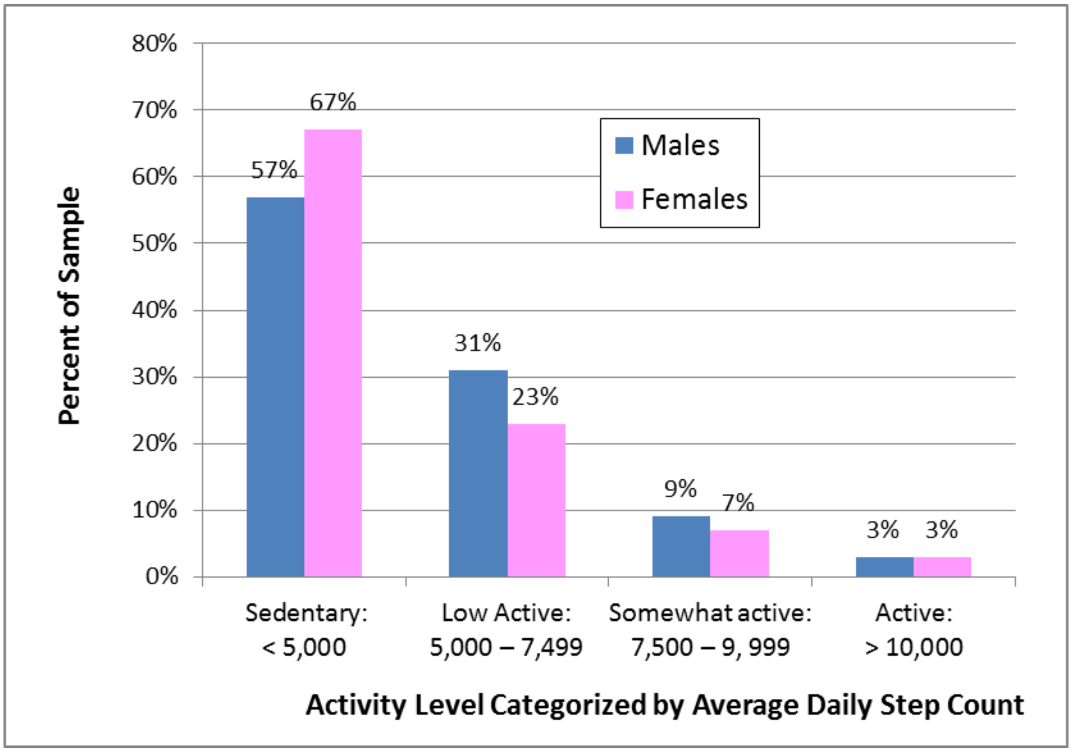

Figure 6. Activity level, by sex, based on average daily step count.

Using a pedometer to measure activity likely underrepresented physical activity for participants who swam (participants were advised to remove them if swimming); and for those who participated in activities requiring primarily upper body movement, such as lifting weights or rowing; and for activities designed to improve balance and strength, such as yoga and core exercises. This may explain the inconsistency in the activity level based on steps with 60% categorized as sedentary, versus the questionnaire responses regarding frequency of exercise, where only 9% indicated almost never exercising or exercising only once per week.

On-Road Evaluation

Appendix F 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 8 presents summary statistics, by sex, for each driving skills subset and total score. A t-test indicated no significant difference in overall road test scores by sex; however, large variances in scores (932 for females and 445 for males), may account for the lack of statistical significance between the mean scores. There also were no significant differences in performance by sex for the three skills subsets.

Table 8. *Road Test Scores by Subgroup and Sex*

Sex	Statistic	Road Test Points Off			
		Operational Skills	**Tactical Skills**	**Strategic Skills**	**Overall**
Males	n	35	35	35	35
	Range	0 - 18	0 - 100	0 - 10	0 - 105
	Average	1.3	20.5	2.6	24.5
	Standard Deviation	3.7	19.0	3.3	21.1
	Median	0	15	0	18
Females	n	29	29	29	29
	Range	0 - 10	0 - 126	0 - 20	0 - 126
	Average	1.2	31.0	2.9	35.1
	Standard Deviation	2.3	28.6	5.1	30.5
	Median	0.0	22.0	0.0	26.0
Total	n	64	64	64	64
	Range	0 - 18	0 - 126	0 - 20	0 - 126
	Average	1.3	25.3	2.7	29.3
	Standard Deviation	3.1	24.1	4.2	26.1
	Median	0	18	0	20

Scores were converted 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; and
- 100+: F, fail

Thirty-eight participants (59.4% of the sample) received an "A," 16 (25%) received a "B," and 5 (7.8%) received a "C." Five participants failed (3 "Ds" and 2 with scores 100+ or "Fs" who both ran a red light). Figure 7 presents road test performance by sex and test grade. Collapsing across both "passing" scores, a much larger proportion of males than females received passing grades (91% vs. 76%, respectively); however, a Fisher's Exact Test found this difference to be not significant.

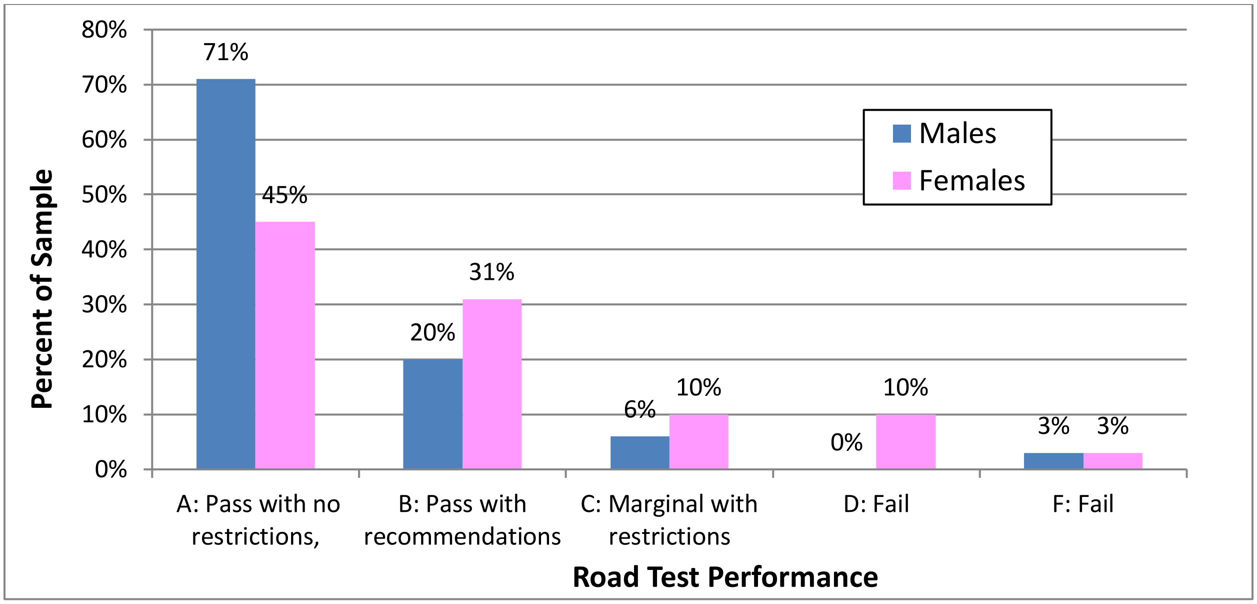

Figure 7. Road test performance by road test grade and sex.

Driving Exposure

The number of days that participants' vehicles were instrumented ranged from 25 to 62 (*M* = 38, *SD* = 8.4), with longer periods primarily due to delays in completing the on-road evaluations (at which time the in-vehicle equipment was removed from the participant's car). The number (and percentage) of participants by days their driving exposure was measured is shown in Table 9.

Table 9. *Number and Percent of Participants by Vehicle Instrumentation Days*

Number of Vehicle Instrumentation Days	Number (%) of Participants
25-29	9 (13.4%)
30-35	25 (37.3%)
36-40	11 (16.4%)
41-45	12 (18%)
46-50	3 (4.5%)
51-55	2 (3%)
56-60	4 (6%)
>60	1 (1.5%)

Video data were matched 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. These difficulties included:

- The camera clock ran too fast, and the clock errors accumulated throughout the trip sample for each driver. If the clock was set correctly prior to installation, it was typical for the clock to be too fast by about 3 minutes by the end of a drive.
- The GPS data loggers could take several minutes to obtain the first location fix depending on conditions. As such, there is a variable amount of missing data at the beginning of every GPS file.
- The GPS data logger's internal accelerometer motion sensor sometimes spontaneously activated. Because of this, multiple GPS files were created for some videos. [*Note: This feature of the GPS data loggers was disabled in the firmware to prevent this from occurring in the future*.]
- The GPS data logger could run on a lower voltage than the camera, and the camera took slightly longer to shut down than the GPS data logger; both of these characteristics of the in-vehicle instrumentation could result in more GPS files than video files for a given drive.

To compensate for the camera clock artifact, the researchers manually calculated a seconds-offset value for each driver's camera data by matching the first and last motion separately for video (first frame where background moves) and GPS (first record with non-zero speed).

Even after the camera offsets were applied, there were still time errors because the cameras *always* ran too fast. One effect of this, particularly for the shortest trips, was that the GPS log showed moment-to-moment speeds of 0 MPH and 0 distance when the video clearly showed movement. Accordingly, such GPS records were filtered out of data analysis, and the researchers applied a 0.1 mile default trip length to any trip video data showed to be valid but which had missing or truncated GPS coordinates in the trip log. For long trips, the effects of clock drift were less detrimental.

Because GPS and video data were collected using separate devices, the only link between the two separate sets of data was the timestamp. While the GPS timestamp was accurate, the timestamp on the video was not; all the camera timestamps needed to be corrected in the database. Another problem was that for a few drivers, the camera clock was set incorrectly (camera was inadvertently set to local time instead of UTC) or the camera reset itself to the default time after the internal camera battery died. In any case, even after the correction was applied, not all GPS data could be matched to a corresponding video. This resulted in a lower count of trips with videos linked to GPS (2,243 trips in the video file versus 1,939 trips in the GPS file). GPS data were matched for 86.4% of the video trips and 93.5% of the overall video driving time. 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 67 participants drove a total of 434 hours, logged 11,190 miles, and made 2,243 trips. Table 10 summarizes these characteristics.

Table 10. *Time and Distance Driven During Exposure Phase (n=67 drivers)*

Statistic (per Driver)	Range	Average	Standard Deviation
Number of Trips	6 - 117	33.5	19.8
Driving Hours	1.3 – 15.9	6.5	2.3
Distance (miles)	11.6 – 450.5	167.0	71.2

Trip distance and duration. Table 11 summarizes trip distance (miles driven per trip) based on the minimum, maximum, and average trip distance for each driver. The first three rows present the range, average, and standard deviation across the 67 drivers. These data show a large range in the longest trip made by each driver (1.6 miles versus 94 miles). The All Trips row represents the calculations across 1,939 trips. Table 12 shows trip duration in minutes, calculated as described above for 2,243 trips recorded in the video data, and again, shows a large range in the duration of the longest trip made between drivers (9 minutes versus 114 minutes [nearly 2 hours]). Average trip time for both males and females was 11.6 minutes, and average trip distance was similar (6.0 miles for males versus 5.4 miles for females).

Table 11. *Trip Distance, by Driver (n=67 drivers, 1,939 matched GPS-video trips)*

Trip Distance (Miles)	Range (Miles)	Average (Miles)	Standard Deviation (Miles)
Minimum trip distance per driver	0.1 – 1.9	0.2	0.3
Maximum trip distance per driver	1.6 – 93.7	25.5	15.7
Average trip distance per driver	0.6 – 14.0	6.5	6.7
All Trips	0.1 – 93.7	5.8	7.1

Table 12. *Trip Duration, by Driver (n=67 drivers, 2,243 video trips)*

Trip Duration (Minutes)	Range (Minutes)	Average (Minutes)	Standard Deviation (Minutes)
Minimum trip time per driver	< 1.0 – 5.5	1.2	0.9
Maximum trip time per driver	8.8 – 113.5	43.5	17.1
Average trip time per driver	3.2 – 26.1	13.2	4.3
All trips	< 1.0 – 113.5	11.6	11.3

Maximum trip speed. The maximum speed reached for each of the 67 participants ranged from 38.5 mph to 88.8 mph. Only 1 participant had a maximum speed below 55 mph, and 9 participants had a maximum speed below 65 mph.

Trips in adverse weather and at night. If any part of a trip included fog or rain, or if the pavement was wet, the video coder coded the trip as an adverse weather trip. The use of windshield wipers was a key indicator of adverse weather conditions. The vast majority of trips were conducted under dry weather and pavement conditions. The overall percentage of trips made during wet or foggy conditions was 6.2% and ranged from 0.0% to 26.7% across the 67 drivers. The video coder also coded trips as nighttime trips, if any part of the trip occurred during darkness. Only 1 participant made trips at nighttime (2 of 21 trips, or 10%).

Trips with passengers. If a passenger was present at any time during a trip, the video coder recorded the trip as passenger present. Thirty-one percent of the total trips taken had at least one passenger. The proportion of trips taken with passengers across the 67 drivers ranged from 0% to 100%, and averaged 34.3%. Passengers were present in 36.5% of trips made by male participants and 23.7% of trips made by female participants.

Driver looking behavior. The video coder recorded instances of hard left and right head turns for participants who performed direct looks over their left and right shoulders. A hard right head turn (right shoulder blind spot check) was coded when a participant's head movement over their right shoulder enabled the coder to see the driver's entire left ear. A hard left head turn (left shoulder blind spot check) was coded when a participant's head movement over the left shoulder precluded visibility of his or her entire nose.

When a participant made a head movement that fell between straight ahead and hard left, the video coder recoded a soft left head turn (left glance). These looks included head turns to view window buttons, seat belt, and left (driver's) side rearview mirror; looks to others outside of the vehicle; looks made at ticket booths; and looks toward mailboxes and road signs on the left side of the road. When a participant made a head movement that fell between straight ahead and hard right, the video coder recoded a right soft head turn (right glance). Soft right head turns included looks toward the radio, vehicle temperature controls, the video camera, and the inside rearview mirror; looks toward front-seat passengers; and looks toward the right outside rearview mirror, road signs, and mailboxes on the right side of the road.

For each driver, the analyst summed head turns by head turn type and direction, and then divided by the number of minutes the participant drove during the exposure study, to normalize the data. Table 13 summarizes the range, average, and standard deviation of head turn frequencies per minute for the 67 participants for left glances, left shoulder checks, right glances, and right shoulder checks. It also presents left and right glances, combined, per minute; left and right shoulder checks, combined, per minute; as well as all head turns (glances and shoulder checks in both directions) per minute.

Table 13. *Summary of Head Turns per Minute by Driver (n=67 drivers, 2,243 trips)*

Head Turn Type	Head Turns per Minute		
	Range	Average	Standard Deviation)
Left Glance	1.0 – 5.9	2.7	1.0
Left Shoulder Check	0.0 – 0.5	0.1	0.1
Right Glance	0.9 – 6.9	3.6	1.4
Right Shoulder Check	0.0 – 0.5	0.1	0.1
Left + Right Glances	1.9 – 11.8	6.4	2.1
Left + Right Shoulder Checks	0.0 – 0.8	0.2	0.2
All Head Turns, Both Directions	2.0 – 12.3	6.6	2.2

Deriving a Meaningful Measure of Activity Level

Correlations between the two activity questionnaires and between each activity questionnaire and the four measures recorded by the activity tracker (steps per day, active minutes per day, average gait speed, and distance per day) were weak to moderate. The largest correlation, between the VO_2 max questionnaire score and average daily gait speed, was only of moderate strength (r = 0.338). The correlation between the VO_2 max questionnaire score and the Phone-FITT questionnaire was slightly lower at r = 0.320. The VO_2 max measure generally had stronger correlations with the activity tracker measures than did the Phone-FITT questionnaire. provides the correlation coefficient for each comparison.

Table 14. *Correlations Between Measures of Activity*

Measures	Correlation Coefficient
Phone-FITT Score and Active Minutes per Day	0.194
Phone-FITT Score and Steps per Day	0.156
Phone-FITT Score and Gait Speed	0.094
Phone-FITT Score and Daily Distance	0.131
VO_2 max Score and Phone-FITT Score	0.320
VO_2 max Score and Active Minutes per Day	0.180
VO_2 max Score and Steps per Day	0.238
VO_2 max Score and Gait Speed	0.338
VO_2 max Score and Daily Distance	0.277

Correlations between the three measures of activity and overall driving score ranged from -0.061 (overall driving score and active minutes per day) to 0.114 (overall driving score and VO_2 max score).

The two activity questionnaires provided complementary information about physical activity. The VO_2 max questionnaire measured cardiovascular fitness, while Phone-FITT assessed physical activity *over a typical week during the past month*. One might assume that a person who is more physically active would have a higher level of cardiovascular fitness, but findings showed only a moderate association. There may have been a seasonal confound to Phone-FITT responses, as participants were enrolled in the study and completed Phone-FITT between January and June; those who enrolled in the winter may have reported less outdoor physical activity than they would have had they completed the questionnaire in the warmer spring and summer months. While the Phone-FITT questionnaire was completely self-reported, the VO_2 max questionnaire had a self-report component (the three activity questions) in addition to objective measures (resting heart rate and waist circumference). The self-report component could have reduced the accuracy of the questionnaire scores relative to the activity tracker measures. However, one of the objective measures on the VO_2 max questionnaire, the resting heart rate, could have been influenced by medications reducing its accuracy in predicting cardiovascular fitness level (e.g., beta blockers would lower heart rate, while thyroid medications could increase it).

Activity trackers provided objective measures of active minutes, steps, distance, and average gait speed per day. However, because the tracker could not be worn in water, it did not record activities such as swimming and water aerobics. Also, because the tracker was worn on the ankle, participation in several other physical activities could result in the tracker underestimating physical activity (e.g., lifting weights, and stretching and balance exercises, such as yoga, Pilates, sit-ups/crunches, and Tai Chi), as these activities generate few to no steps.

The Phone-FITT questionnaire gathered information describing participation in a multitude of physical activities, including the number of days per week and the duration (using four categories). Participants' Phone-FITT responses captured activities that the activity tracker did not. Researchers calculated an equivalent step count for these activities to add to the average daily tracker step count to derive a Unified Physical Activity Index (UPAI), a scale assumed to have at least interval properties, to support data analyses.

The researchers combined elements of the questionnaires and activity tracker data to derive a single, continuous scale ranging from 1 (lowest level of physical activity) to 100 (highest level of activity). They targeted four activities from the Phone-FITT questionnaire for equivalent step count calculations: lifting weights to strengthen the legs, lifting weights to strengthen the arms, swimming, and stretching/balance exercises (designated as G, I, L, and O on the Phone-FITT questionnaire – see Appendix C). The activity "other exercises for leg strengthening" (activity H) was not included, because these could include activities such as climbing stairs, which would generate steps, and standing up and sitting down in a chair several times, which would not, noting that no specific description of the activity was captured. The questionnaire included spaces to add up to three additional activities not listed elsewhere (activities labeled S, T, and U). The researchers reviewed each filled-in activity and gauged the tracker's ability to accurately record steps associated with the indicated activities. The equivalent step count was derived for each activity based on the calories burned for the duration of that activity compared to the calories that the participant would have burned by walking at a pace of 3 mph[3] for the same duration. This was determined as follows, with example data representing a 77-year-old female who was 4'11" tall and weighed 106 pounds, who lifted weights for 16 to 30 minutes once per week.

1. Enter age, sex, height, weight (from the VO_2 max questionnaire), and activity duration from Phone-FITT questionnaire activity duration category (midpoint of range) for each activity into the online calorie calculator, including the activity of walking for the same duration at a pace of 3 mph.[4]

   Input:

   - Age = 77
   - Sex = Female
   - Height = 4'11"
   - Weight=106

---

[3] 3 mph was selected based on research showing average walking speed for older pedestrians crossing at signal controlled crosswalks was 4.11 - 4.33 feet per second (2.8 to 2.95 mph). TranSafety, Inc., 1997, and Carey,2005.
[4] Calories burned calculator: www.healthstatus.com/calculate/cbc

- Lifting Weights Duration (midpoint of 16 to 30 minutes)= 23 minutes
- Walking 3 mph Speed Duration = 23 minutes

Output:

- Calories for lifting weights for 23 minutes = 63
- Calories for walking 23 minutes at 3 mph speed = 80

2. Obtain the number of steps walked per mile (Bumgardner, n.a.).

Input:

- Height = 4’11”

Output:

- Steps walked per mile = 2,557

3. Multiply obtained step count by 3, because walking speed selected covers a distance of 3 miles in one hour.

- Steps walked per hour = 3 x 2,557 = 7,671

4. Adjust the step count per hour to reflect the step count for the duration of the Phone-FITT activity.

- Steps for 23 minutes = (Lifting weights duration/walking duration) x steps per hour
- Steps for 23 minutes = (23/60) x 7,671
- Steps for 23 minutes =2,940.55

5. Apply the calorie ratio to the step count to obtain the equivalent step count.

- Equivalent step count = (calories burned lifting weights for 23 minutes/calories burned walking for 23 minutes) x steps walked in 23 minutes
- Equivalent step count = (63/80) x 2,940.55
- Equivalent step count =2,315.68

6. Multiply the equivalent step count by the number of days per week the participant reported engaging in the activity.

- Weekly equivalent step count = step count x days of activity
- Weekly equivalent step count = 2,315.68 x 1
- Weekly equivalent step count = 2,315.68

7. Divide the weekly equivalent step count by 7 to obtain the equivalent step count per day.

- Daily equivalent step count = weekly equivalent step count/7
- Daily equivalent step count = 2,315.68/7
- Daily equivalent step count = 330.81

The equivalent step counts for underestimated tracker activities were added to the average step count per day measured by the tracker, as an enhanced daily step count. The enhanced daily step count for the 67 participants ranged from 1,322 to 25,308.[5] To obtain the Unified Physical Activity Index, the researchers divided the enhanced step count by 25,308, and then multiplied by 100. This resulted in a metric of physical activity with endpoints ranging from 0 to 100, based on the enhanced step count. The resulting UPAI scores ranged from 5 to 100.

The activity trackers assigned to two participants did not record activity beyond the initial day they were provided; trackers returned average daily step counts under 450 for three other participants. For these five participants, the step equivalents were calculated for all activities reported on the Phone-FITT questionnaire.

Table 15 presents summary statistics for the enhanced step counts across the sample and for males and females separately, while Table 16 presents the UPAI scores.

Table 15. *Enhanced Daily Step Counts, by Sex*

Sex	Enhanced Daily Step Counts				
	Number	Range	Average	SD	Median
Male	37	1,844 – 25,308	7,062	4,540	6,375
Female	30	1,322 – 16,976	6,716	3,663	6,519
Total	67	1,322 – 25,308	6,908	4,144	6,393

Table 16. *Unified Physical Activity Index Scores, by Sex*

Sex	Unified Physical Activity Index Scores				
	Number	Range	Average	SD	Median
Male	37	7 - 100	28	18	25
Female	30	5 - 67	27	14	26
Total	67	5 - 100	27	16	25

Correlations Between the Unified Physical Activity Index and Driving Performance

The researchers performed correlations between the road test total score and the UPAI, as well as correlations between each road test subscore and UPAI. The correlational coefficients for the 12 comparisons are shown in Table 17. Figure 8 shows the scatter plot for UPAI score and total road test score (r = -0.061). All correlations were very weak. While very weak, the directionality for all correlations between road test performance and UPAI except for strategic skills and UPAI, were negative, indicating that higher physical activity levels (higher UPAI

[5] While an average step count per day of 25.308 sounds high, this individual reported walking for exercise 7 days a week for 31 to 60 minutes each day, swimming 7 days per week for 31 to 60 minutes each day, water aerobics 3 days per week for 31 to 60 minutes each day, stretching/balance exercises 7 days per week for 16 to 30 minutes per day, and gardening 2 days per week for 31 to 60 minutes per day, in addition to regular household activities such as light housework, meal preparation, shopping, and heavy housework. The VO_2 max score placed this participant in the "Good" category for cardiovascular fitness. This participant's tracker failed to work properly (averaged 421 steps per day), so all activities listed on Phone-FITT were used for equivalent step calculations.

scores) were associated with better road test performance (lower road test scores). The positive correlation between the strategic subset of road test skills and UPAI indicates that higher levels of physical activity (higher UPAI scores) were associated with poorer strategic skill performance (more points scored off).

Table 17. *Correlation Between UPAI and Road Test Performance, for All Participants, and by Sex*

Road Test Component	Correlation with UPAI		
	Male	**Female**	**All**
Total Points Off	r = -0.048	r = -0.053	r = -0.061
Operational Points Off	r = -0.037	r = -0.167	r = -0.074
Tactical Points Off	r = - 0.059	r = - 0.072	r = -0.075
Strategic Points Off	r = 0.071	r = 0.163	r = .109

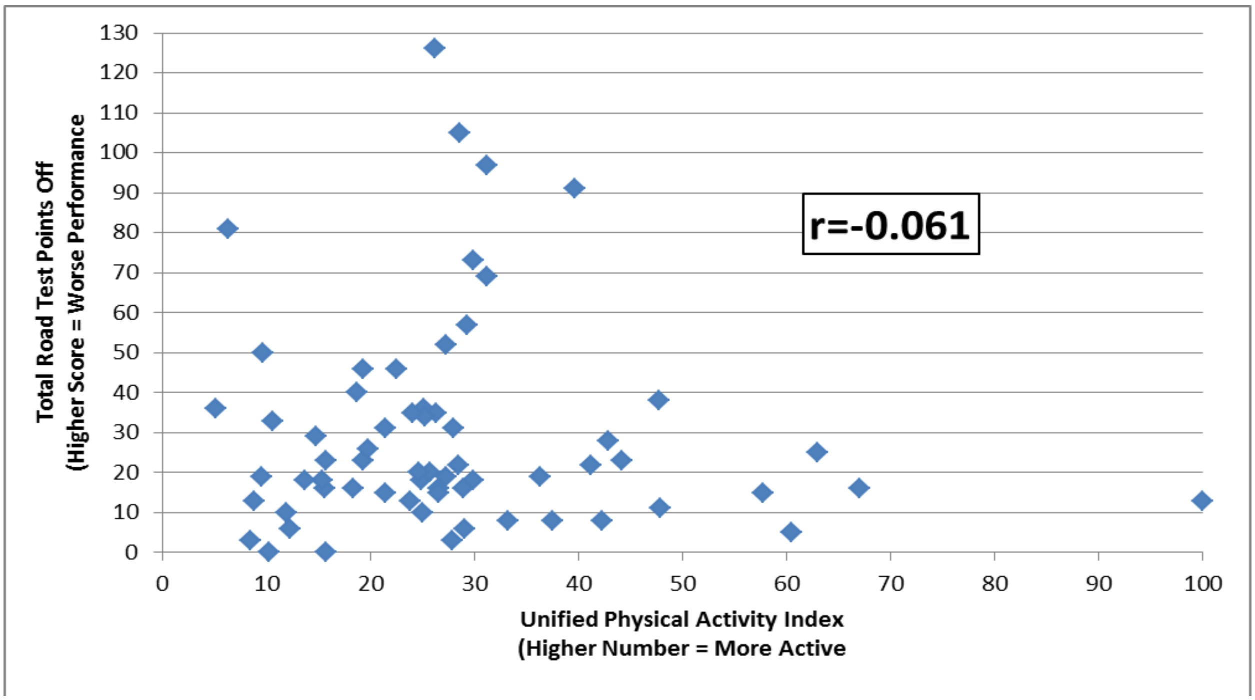

Figure 8. Scatter plot showing relationship between road test score and UPAI.

The preceding scatter-plot draws attention to the study participant with a UPAI score of 100. This score, while valid (see explanation in the preceding footnote of how this score was calculated), is such an outlier that it may be questioned whether stronger correlations would result with the removal of this data point. In fact, this manipulation results in even weaker correlations than those reported in Table 10.

Correlations Between Functional Measures and Driving Performance

Correlations between the overall driving score and each measure of functional ability were weak to very weak, with Trail Making Part B the strongest at $r = 0.197$, higher than the correlations between road test score and either of the physical activity questionnaires or the UPAI (see Table 18). For all but the Snellgrove Maze Test, the correlations were positive, indicating that increasing time to complete the functional measures (poorer performance) was associated with increasing counts of points scored off (also poorer performance). For the Snellgrove Maze Test, longer completion time (poorer performance) was associated with fewer points scored off (better strategic skill performance); however, this association was the weakest of the four.

Table 18. *Correlations Between Functional Measures and Road Test Performance*

Functional Measure	Correlation with Road Test Score (Total Points Off)
Trails A	0.142
Trails B	0.197
Maze 1 and 2	-0.034
Walk Time	0.092

Correlations Between the Unified Physical Activity Index and Driving Exposure

The analyst normalized trip counts, total driving time, and total driving distance for each participant by dividing by the number of days his or her vehicle was instrumented. The analyst also normalized looking behavior (glances and shoulder checks) for each driver by dividing by the participant's total driving minutes. Left and right glances per minute were combined to produce the *glances per minute* variable, left and right shoulder checks were combined to produce the *shoulder checks per minute* variable, and the glances and shoulder checks per minute were combined to produce an *all glances and shoulder checks per minute* variable.

Table 19 presents correlations between UPAI and the exposure variables selected for analysis. The strength of the relationships between UPAI and to the examined exposure variables was weak to none, with the strongest relationship being the frequency of shoulder checks per minute ($r = -0.120$). The direction of the relationship was unexpected; the higher the physical activity score, the fewer the number of shoulder checks per minute.

Again, removal of the extreme UPAI score from the analyses resulted in even weaker correlations, for every exposure measure.

Table 19. *Correlations Between UPAI and Driving Exposure Measures (n=67)*

Driving Exposure Measure	Correlation with UPAI
Trips per Vehicle Instrumentation Day	-0.070
Driving Minutes per Vehicle Instrumentation Day	-0.073
Longest Trip Time (Minutes)	0.046
Average Trip Time (Minutes)	-0.033
Driving Miles per Vehicle Instrumentation Day	-0.048
Longest Trip Length (Miles)	0.055
Average Trip Length (Miles)	0.030
All Glances per Minute	0.069
All Shoulder Checks per Minute	-0.120
All Glances and Shoulder Checks per Minute	0.057

Correlations Between Functional Measures and Driving Exposure

Correlations between the physical functional measures and driving exposure (Table 20) were generally weak to none. The highest was between head/neck flexibility and number of shoulder checks per minute (r = -0.228). Since head/neck flexibility was scored as a 0, indicating pass (able to turn the head to look behind), or a 1, indicating fail (not able to turn the head to look behind), the relationship indicated fewer shoulder checks with poorer head/neck flexibility. There was also a weak relationship between better cardiovascular fitness (higher VO_2 max) and more miles driven per vehicle instrumentation day (r = 0.19) as well as longer distance trips (r = 0.19).

Table 20. *Correlations Between Physical Function and Driving Exposure (n=66)*

Driving Exposure Measure	Measures of Physical Function			
	Phone-Fitt Total Score (Higher Score = More Active)	**VO_2 max Score** (Higher Score = More Fit)	**Walk Time** (Higher score = poorer performance)	**Head Neck** (Higher score = poorer performance)
Trips per Vehicle Instrumentation Day	0.000	0.116	-0.056	0.004
Driving Minutes per Vehicle Instrumentation Day	-0.001	0.139	-0.036	0.098
Longest Trip Time (Minutes)	-0.167	0.132	-0.021	0.089
Average Trip Time (Minutes)	-0.046	-0.016	-0.006	0.132
Driving Miles per Vehicle Instrumentation Day	0.047	0.188	-0.067	0.092
Longest Trip Length (Miles)	-0.111	0.192	-0.108	0.091
Average Trip Length (Miles)	0.025	0.116	-0.114	0.004
All Glances per Minute	0.075	-0.105	-0.105	-0.009
All Shoulder Checks per Minute	0.066	0.006	0.112	-0.228
All Glances and Shoulder Checks per Minute	0.079	-0.102	-0.093	-0.030

Similarly, the relationships between cognitive function and driving exposure were generally very weak to none (see Table 21). The highest correlation was between Trails B time and number of minutes driven per day of vehicle instrumentation (r = -0.225). A longer time to complete Trails B (poorer performance) was associated with fewer minutes driving per day.

Table 21. *Correlations Between Cognitive Function and Driving Exposure*

Driving Exposure Measure	**Measures of Cognitive Function** (higher scores = poorer performance)				
	Trails A Time	**Trails B Time**	**Maze 1 Time**	**Maze 2 Time**	**Maze 1 + Maze 2 Time**
Trips per Vehicle Instrumentation Day	-0.117	-0.179	-0.034	-0.037	-0.049
Driving Minutes per Vehicle Instrumentation Day	-0.129	-0.225	-0.078	-0.054	-0.094
Longest Trip Time (Minutes)	0.089	0.087	-0.123	0.025	-0.088
Average Trip Time (Minutes)	0.027	0.037	0.004	-0.072	-0.036
Driving Miles per Vehicle Instrumentation Day	-0.115	-0.195	-0.121	-0.083	-0.146
Longest Trip Length (Miles)	-0.035	0.010	-0.103	-0.105	-0.143
Average Trip Length (Miles)	-0.015	-0.035	0.034	-0.121	-0.039
All Glances per Minute	-0.032	-0.029	-0.095	-0.160	-0.167
All Shoulder Checks per Minute	-0.125	-0.134	0.016	-0.013	0.006
All Glances and Shoulder Checks per Minute	-0.042	-0.040	-0.092	-0.157	-0.163

Logistic Regression to Determine Relationships Between Physical Activity Measures, Functional Measures, and Driving Performance

The researchers employed a second statistical approach to evaluate the relationships between driving performance and the functional and physical activity measures. They calculated the average values for each measure, based on three road test performance categories: A (pass with no restrictions), B (pass with recommendations), and marginal/fail. The marginal/fail category included scores of C (marginal with restrictions), D (fail), and F (fail). The average values for each of the three road test performance outcome categories for each functional or activity measure are shown in Table 22.

As shown in Table 22 only Maze 2 Completion Time, Trail-Making Part A Completion Time, and Trail-Making Part B Completion Time showed some association with road test performance score category; by visual inspection, the scores on these measures, and only these measures, were similar for those passing the road test with scores of A or B, *and* were substantially better than for those who marginally passed or failed the road test.

Table 22. *Average Functional and Physical Activity Scores by Road Test Performance Category*

Functional or Physical Activity Measure	**Road Test Performance Outcome**		
	A	**B**	**Marginal/Fail**
Maze 1 Completion Time (sec)	33.50	21.05	28.23
Maze 2 Completion Time (sec)	**16.79**	**16.26**	**33.34**
Maze 1 + Maze 2 Completion Time (sec)	50.29	37.01	63.57
Trails A Completion Time (sec)	**35.40**	**39.94**	**53.74**
Trails B Completion Time (sec)	**89.35**	**99.76**	**131.15**
VO_2 max Score	30.2	31.1	30.2
Phone-Fitt Score	51.4	46.6	48.8
UPAI Score	29.3	25.9	25.9

In the next step of the analysis, the researchers combined road test scores of A and B into one "pass" category and developed a logistic regression model to determine if the relationship between road test performance score category and these performance measures was statistically significant. The logistic regression model predicted the natural log of the odds of getting a "pass" as a function of the independent variables (functional measures), i.e., if p is the probability of getting a pass, then natural log of the odds will be $\ln\left(\frac{p}{1-p}\right)$, where "ln' denotes natural logarithm. When all three functional measures were introduced simultaneously, none of them was statistically significant, likely because these three measures were correlated with each other. Table 23, Table 24, and Table 25 show the results of the logistic regression when the three functional measures were introduced one at a time.

Table 23. *Logistic Regression Model for Maze 2 Completion Time**

Variable	Coefficient	S.E.	Wald	df	Sig.
ln_maze2	-1.300	.653	3.966	1	.046
Constant	14.410	6.452	4.988	1	.026

*Maze2 time is in milliseconds.

Based on Table 23, the regression equation is as follows:

$$\ln\left(\frac{p}{1-p}\right) = 14.410 - 1.3 \times \ln(maze2time)$$

This equation can also be rewritten as:

$$\left(\frac{p}{1-p}\right) = \exp[14.410 - 1.3 \times \ln(maze2time)]$$

For example, if the maze time completion is 20,000 milliseconds, the odds of getting a "pass" will be exp[14.410 – 1.3*ln(20,000)] = 4.6. As indicated in Table 23, the natural log of the Maze 2 completion time reached statistical significance at the 0.05 level ($p = 0.046$).

Table 24. *Logistic Regression Model for Trail-Making Part A Completion Time**

Variable	Coefficient	S.E.	Wald	Df	Sig.
ln_Trails A	-1.777	.957	3.449	1	.063
Constant	20.465	10.174	4.047	1	.044

*Trails A time is in milliseconds.

The natural log of the Trail-Making Part A completion time failed to reach statistical significance at the 0.05 level but reached significance at the 0.10 level (p = 0.063).

Table 25. *Logistic Regression Model for Trail-Making Part B Completion Time**

Variable	Coefficient	S.E.	Wald	df	Sig.
ln_Trails B	-2.110	.946	4.974	1	.026
Constant	25.971	10.979	5.595	1	.018

* Trails B time is in milliseconds.

Based on Table 25, the regression equation is as follows:

$$\ln\left(\frac{p}{1-p}\right) = 25.971 - 2.110 \times \ln(Trails\ B)$$

or,

$$\left(\frac{p}{1-p}\right) = \exp[25.971 - 2.110 \times \ln(Trails\ B)]$$

The natural log of the Trail-Making Part B completion time reached statistical significance at the 0.05 level (p = 0.026).

Table 23, Table 24, and Table 25 indicate that higher values of Maze 2 completion time and Trail-Making Parts A and B completion times (i.e., poorer performance) are associated with a lower odds of passing the road test.

Multiple Regression to Determine Relationships Between Physical Activity Measures, Functional Measures, and Driving Exposure

The study team performed multiple regressions to explore the relationships between the physical function/activity measures and the measures of driving exposure, and between the cognitive function measures and driving exposure.

Relationship between physical function/activity and driving exposure. Five measures were entered into the regression analyses as predictor (independent) variables:

- Phone-Fitt Total Score;
- Unified Physical Activity Index;
- VO_2 max Score;
- Walk Time (msec); and
- Head/Neck Flexibility.

The analyst ran a separate regression analysis using each driving exposure variable as the dependent variable. These analyses included 66 participants (as one participant did not perform the head/neck measure correctly). The 10 exposure measures used as dependent variables were:

- Trips per Vehicle Instrumentation Day;
- Driving Minutes per Vehicle Instrumentation Day;
- Longest Trip Time (minutes);
- Average Trip Time (minutes);
- Driving Miles per Vehicle Instrumentation Day;
- Longest Trip Length (miles);
- Average Trip Length (miles);
- All Glances per Minute;
- All Shoulder Checks per Minute; and
- All Glances and Shoulder Checks per Minute.

F-tests indicated that none of the models were statistically significant overall (see Appendix G). The model using All Shoulder Checks per Minute as the dependent variable, showed that head/neck flexibility was a statistically significant predictor at the 0.10 level (p=0.054). Eliminating all other variables except head/neck flexibility from the model, and re-running the regression yielded a statistically significant model at the 0.10 level (F=0.066) with an R Square value of 0.05, indicating that head/neck flexibility explained a mere 5% of the variance in left and right shoulder checks per minute.

Relationship between cognitive function and driving exposure. Three measures were entered into the regression analyses as predictor variables of the ten exposure measures:

- Trails A Time (msec);
- Trails B Time (msec); and
- Maze 2 Time (msec).

Maze 1 Time and Total Maze Time were excluded, because they were highly correlated (r=0.83), and Maze Total Time was highly correlated with Maze 2 Time (r=0.56) resulting in near multi-collinearity. Regression analyses were run separately using each of the 10 exposure outcome variables and the three cognitive function variables for 61 participants with full data sets. F-tests indicated that none of the models were statistically significant (see Appendix H). While the model using all three variables to predict driving minutes per vehicle instrumentation day was not significant (F=-.14), Trails B was significant at the 0.05 level (p=0.047). Re-running the regression analysis with Trails B as the only predictor variable resulted in a significant regression coefficient (p=0.02) and a correlation of r=0.28, that explained 8% of the variance in driving minutes per vehicle instrumentation day (see Figure 9).

SUMMARY OUTPUT: Driving Minutes Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.280					
R Square	0.078					
Adjusted R Square	0.063					
Standard Error	4.841					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	121.56	121.56	5.19	0.03	
Residual	61	1429.60	23.44			
Total	62	1551.16				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13.96	1.48	9.42	1.641E-13	11.00	16.93
Trails B (msec)	-3.01295E-05	1.32E-05	-2.28	0.03	-5.65836E-05	-3.67544E-06

Figure 9. Regression analysis for Trails B and driving minutes per vehicle instrumentation day.

Conclusions and Discussion

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. Both the prevalence of age-related functional decline, and evidence linking such declines with the risk of crash involvement, reinforce the notion that safe mobility may be buttressed by maintaining fitness with advancing age. This research examined the relationship between a comprehensive set of measures of physical activity level, as well as selected measures of cognitive status, and the results of a CDRS-administered driving assessment and an instrumented-vehicle log of naturalistic driving behavior. Researchers hypothesized that indices showing higher activity levels and higher cognitive status would relate significantly to better driving performance and greater exposure.

The rationale for a focus on activity level in this study was twofold. First, greater head/neck flexibility may be presumed to facilitate increased movement to scan the environment for potential hazards and conflicts, and greater leg strength should improve pedal control by mitigating errors related to fatigue. Second, the cardiovascular benefits of higher physical activity may positively influence cognition as required to more rapidly perform these scanning and control behaviors, appropriate to the moment-to-moment demands of driving. This research was designed to test the direct relationship between activity level and driving performance, and between activity level and exposure; and also to examine the indirect effects of differences in activity level, i.e., as a mediating variable, where the cognitive benefits believed to accrue from higher physical activity are associated with better performance and/or increased exposure.

Quantifying activity level in this research proved challenging. The two activity questionnaires provided complementary information about physical activity, but they measured two different, albeit related things. The pedometer provided objective measures of activity, but only for lower body movement; and because it could not be worn in water, activities such as swimming and water aerobics were not recorded. Further, correlations between these different sources of information about participants' activity level were only weak to moderate. As detailed in the description of study methods, these challenges led researchers to construct a UPAI in an effort to obtain the most comprehensive indicator of physical activity level among participants. However, analyses did not confirm hypotheses concerning the relationship between this indicator and either driving performance, or driving exposure. Correlations were near zero for all measures.

While a restriction of range in the outcome variables (performance and exposure) is frequently problematic in such analyses, this was not evident in the road test scores or in the trip characteristics measured for this sample of independent living older adults. Neither could researchers attribute the absence of differences related to activity level to error introduced when formulating the UPAI, as the measures of physical activity in isolation fared no better. Even the measures of physical function—specifically, head/neck flexibility—could, at best, account for 5% of the variance, and only in a single driving behavior. This was matched almost exactly by the strength of relationship between a higher (worse) score on the Trails B measure of cognitive status, i.e., visual search with divided attention, and fewer driving minutes per day.

When researchers examined the physical activity and cognitive status measures together, a somewhat different picture emerged. First, they selected variables to include in regression analyses based on the criterion of an explicit pattern of results on the road test: scores on a given measure must be similar for participants who passed the on-road assessment with no restrictions or with only recommendations (scores of "A' or "B') and, at the same time, markedly better than for participants with marginal or failing road test outcomes. Three cognitive measures (Maze 2, Trails A, and Trails B), but none of the physical activity measures, met this criterion.

A subsequent logistic regression to test the strength of association of the selected cognitive measures with pass/fail outcomes on the road test indicated that higher values of Maze 2 completion time and Trail-making Parts A and B completion times (poorer performance, in each case) all were associated with lower odds of passing the road test. The results were significant for Trails B (p=0.026) and Maze 2 (p=0.046), and approached significance for Trails A (p=0.063). Multiple regression was also applied to examine the association between these same cognitive measures and 10 different exposure measures; Trails B was the only variable to reach significance (p=0.02), explaining 8% of the variance in driving minutes per day.

The present findings do not support the hypothesis that a higher level of physical fitness, as operationalized among the study sample via a snapshot of the included measures of physical activity, is associated with better on-road performance (a surrogate for safety). Apparently, neither does it result in greater exposure (a surrogate for mobility within the community). Nor is it the case that a behavior widely regarded as essential for safe driving—how actively a driver scans the environment, operationalized by the frequency of glances to the sides—is significantly predicted by the driver's head/neck flexibility.

One conclusion to be drawn from these results is that the physical actions older drivers take to safely operate a motor vehicle primarily reflect habits acquired from years of experience; they are *not* directly influenced by their prevailing physical activity (i.e., "fitness") level, at least not within the range of individual differences observed in this study sample. Instead, the indirect effects of moderate physical activity in improving cardiovascular fitness may be the most appropriate focus for future studies of the link between exercise and driving. As cited earlier, recent research confirms a relationship between cardiovascular 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). Given this perspective, it is not surprising that deficits in these aspects of cognitive function would translate into poorer on-road assessment scores and reduced exposure, as evidenced in this study.

Several limitations in the present research must be acknowledged. As already noted, the interval over which both physical activity (steps) and driving exposure were monitored was relatively restricted, roughly a month on average. Potentially confounding seasonal effects were perhaps more important, as these monitoring intervals spanned dates from mid-winter (January-February) through late spring (April-May) across the study sample. Less obvious is a potential bias relating to the sociodemographic characteristics of the study sample; these participants were all recruited from a residential community that markets itself to middle-class and more affluent retirees. All participants were vehicle owners and active drivers, per inclusion criteria, and in many cases brought a degree of sophistication to this research based on their participation in prior (though unrelated) studies. Finally, the research team received anecdotal reports of isolated individuals who were "briefed" about the assessment protocol and/or the test route for the driving evaluation from a fellow participant, and may have practiced to try to improve their score.

Future investigations in this area may be advised to monitor physical activity and indices of cardiovascular health over an extended period, where researchers hypothesize that significant changes (gains) in such indices over the observation period will manifest in significant improvements in driving performance. Also, with respect to the selection of additional dependent variables in future research, it may be less fruitful to examine idiosyncratic driver behaviors such as head or eye movements. Increased fitness may give drivers greater *capacity* for a whole range of behaviors, but cannot necessarily be expected to override habits acquired over many decades of experience.

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Appendix A: Participant Recruitment Material

Informational Sheet:
Physical Fitness and Driving Performance
A Research Study Funded by the
National Highway Traffic Safety Administration (NHTSA)

Research Objectives: The study is designed to address the following research questions:
(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?

Performing Organizations: The UNC Highway Safety Research Center in partnership with TransAnalytics, LLC and Driver Rehabilitation Services

Importance of the Research:
Regular physical activity is associated with numerous health benefits, including improvements in many cognitive and physical abilities demonstrated to be important to driving. This research will directly test the hypothesis that increased physical activity is associated with 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 Research Activities:
This project will be carried out in two Phases to address the two research questions above. In Phase I we hope to recruit 90 adults ages 70 and older representing a **cross-section of physical activity levels**. Participants will meet individually with a member of the research team to complete a brief questionnaire documenting their usual physical activities and will be given a few computer-based visual and cognitive assessments. Also at this time participants

will receive a lightweight, unobtrusive activity tracker to wear for 3-4 weeks, and some equipment will be installed in their vehicle to automatically record how often and how much they drive.

After wearing the physical activity tracker and having their driving trips recorded for the 3-4 week period, they will be scheduled to meet with a certified driver rehabilitation specialist to have their driving skills professionally evaluated. At this time the physical activity tracker and the equipment installed in the participant's vehicle will also be retrieved. The driving exposure, physical activity, and driving evaluation data will be analyzed by researchers at the UNC Highway Safety Research Center to determine the relationship between older adults' usual level of physical activity and driving abilities and exposure (Research Question 1 above).

In Phase 2 of the project, we will seek to recruit 90 additional **sedentary (or low activity)** adults ages 70 and older and enrolling 60 of them into one of two 6-month physical activity interventions (a standard "Senior Fitness" type class or Zumba Gold). Participants' physical activity levels and driving exposure will again be monitored. In addition, driving skills will be evaluated both prior to and at the conclusion of the 6-month exercise intervention. Analyses will be carried out to determine whether participation in regular physical activities leads to improvements in driving performance or changes in driving exposure (Research Question 2 above).

Project Timeline:
Phase 1 - Recruitment starting January 2016 and extending for 5 months.
Phase 2 - Recruitment starting fall of 2016 and extending for 9-12 months.
Entire project scheduled for completion late 2017

Photo of Older Driver

Contact for Further Information:
Kristel Robison, UNC Highway Safety Research Center
Email: krobison@email.unc.edu Phone: 919-962-6404

Newsletter Article:

Physical Fitness and Driving

A Research Study Funded by
The National Highway Traffic Safety Administration

Are you age 70 or older? Do you drive? Have you ever wondered whether there are things you could be doing to help you keep driving safely, longer?

We all know that there are many benefits to staying physically active as we age. But did you know that one of these benefits might be maintaining your driving skills?

The UNC Highway Safety Research Center is conducting a research study to evaluate the relationship between older adults' physical activity levels and driving performance. A follow-on study will examine whether less active older adults who increase their level of physical activity also become better drivers.

The study will be based in Fearrington Village, and is being carried out in partnership with Galloway Ridge and the Duke Center for Living. All participants will receive individualized feedback on their driving strengths and weaknesses from an occupational therapist who is a certified driver rehabilitation specialist. Participants will also receive a $100 gift card. The results of the research will help inform national programs and policies directed at helping older adults maximize their safe driving lifespans.

An information session is being held (day, date) at (time) in (location). UNC project staff will be on hand to give a brief presentation on aging and driving and provide more details about the Physical Fitness and Driving Study. Please plan to join us!

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: October 15, 2015
IRB Study # 13-3557
Title of Study: Physical Fitness and Driving Performance (Phase 1)
Principal Investigator: William Hall
Principal Investigator Department: Highway Safety Research
Principal Investigator Phone number: [redacted]
Principal Investigator Email Address: hall@hsrc.unc.edu
Funding Source and/or Sponsor: National Highway Traffic Safety Administration

A federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. The OMB Control Number for this information collection is 2127-0711. Public reporting for this collection of information is estimated to be approximately 30 minutes per interview, including the time for reviewing instructions, completing and reviewing the collection of information. All responses to this collection of information are voluntary. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Information Collection Clearance Officer, National Highway Traffic Safety Administration, W51-316, 1200 New Jersey Ave, S.E., Washington, DC, 20590

<u>What are some general things you should know about research studies?</u>
You are being asked to take part in a research study. To join the study is voluntary.
You may refuse to join, 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. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researchers or with any staff members at the Duke Center for Living at Fearrington and/or Galloway Ridge.

Details about this 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 being physically active affects older adults' driving abilities and also whether it affects how often and how much they drive. 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 regular physical activity or exercise also extend to improving your driving abilities and practices.

You are being asked to be in the study because you are an adult, age 70 or older, and because you have a currently valid North Carolina driver's license and access to a car that you can drive.

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 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 older adults will take part in this study.

How long will your part in this study last?
Your total time commitment if you choose to participate in this research study will be two hours: one hour today, and another hour approximately one month from today. In between these two one-hour sessions you will be asked to go about your normal daily activities.

What will happen if you take part in the study?
If you agree to take part in this study, there are a few things that 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 be worn around your ankle, that we will want you to wear for the next three weeks (except when swimming, bathing or showering). We will also be installing some equipment in your car that will use GPS (global positioning system) technologies to automatically record information about your driving, such as how many trips you make each week, the number of miles you drive, the speeds you travel, etc. The equipment will also 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 possible child abuse, we will need to report this to the proper authorities.

After three weeks have passed, we will contact you 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 about 45 minutes, and will start and end at the Duke Center for Living at Fearrington. After completing the evaluation, the evaluator will remove all equipment from your vehicle, and will also retrieve the physical activity monitor that we will be giving you today.

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 the physical activity questionnaire, and you always have the right to end your participation in the study at any time.

What are the possible benefits from being in this study?

Research is designed to benefit society by gaining new knowledge. The benefits to you from being in this study will include individualized feedback on your driving strengths and weaknesses from a certified driver rehabilitation specialist (a service typically valued at $350).

What are the possible risks or discomforts involved from being in this study?

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.

How will your personal information 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 follow-ups in scheduling your driving evaluation and retrieving the physical activity monitoring device and driving exposure equipment installed in your vehicle. 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. While each individual participant's data acquired in this research project will be made available to our study sponsor (the National Highway Traffic Safety Administration), no information that could be used to identify you personally will be shared outside of the UNC research team.

Research data may be used by the agency in furtherance of highway safety purposes. In no case, however, will the data be linked to you personally by name or video.

Participants will not be identified by name 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 contained in the records. 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, personal information about you and other participants that are part of this research study could be reviewed by representatives of the University, the research sponsor (NHTSA), or any other government agency 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 will be involved in a motor vehicle crash, and be injured, while having your driving evaluated. 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, Duke Center for Living, nor Galloway Ridge has set aside funds to pay you for any such reactions or 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 be given a $100 gift card for taking part in this study. This gift card will be given to you immediately upon completion of the on-road driving evaluation. There will be no pro-rated compensation to participants who do not complete all requirements for the study.

Will it cost you anything to be in this study?
Your only cost to participating in this study will be any costs associated with your travel to the Duke Center for Living at Fearrington (or Galloway Ridge) for the two required meetings with members of the research staff. For most of you living in or near Fearrington Village, these costs should be minimal.

Who is sponsoring this study?
This research is funded by the National Highway Traffic Safety Administration. This means that the research team is being paid by NHTSA for doing the study. The researchers do not, however, have a direct financial interest with the sponsor or in the final results of the study.

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.

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 to IRB_subjects@unc.edu.

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) Include Zumba and Silver Sneakers, but also elliptical, rowing, stairstepper, etc.	☐ 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: User Manual for In-Vehicle Recording System

User Manual for In-Vehicle Recording System

For the Driver Physical Fitness Project

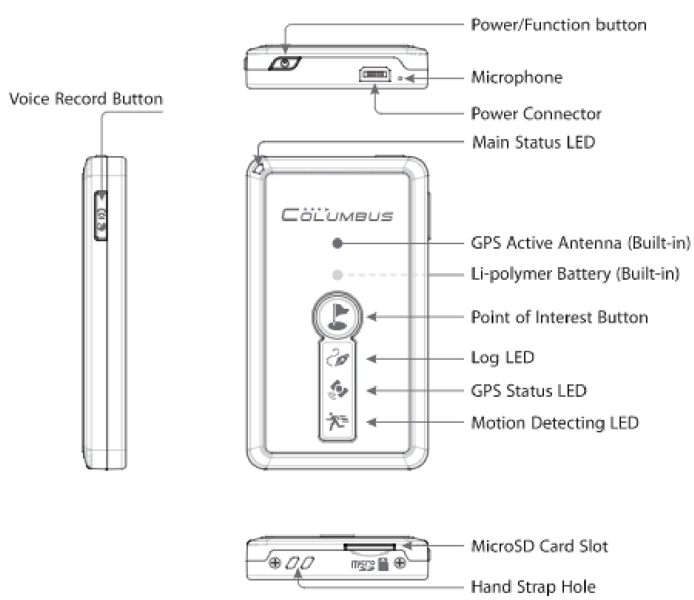
The recording system consists of the following main components:

- **12-volt 15-amp-hour Battery**: The battery powers the entire system for 1 month or up to about 60 hours of driving, whichever comes first. A 1-amp fuse is connected to the positive terminal of the battery to protect the electronics. No power is drawn from the vehicle.

- **Motion sensor**: Using a far infrared sensor and a lens with an angular coverage of 60 degrees, this sensor is mounted vertically on the left side of the vehicle facing where the pedals are located under the dashboard. The delay is set to 13 minutes so if there is no movement from the driver for 13 minutes, the motion sensor with turn off the entire system.

- **Video recorder (pictured to the right)**: Video is saved to a microSD card whenever power is applied to the charging port. The camera is mounted near the right edge of the windshield, low enough to avoid occlusion from the visor, using a suction cup. The suction cup is adhered to the windshield using silicone glue. The lens of the camera is directed towards the driver's face. Because of the 85 degree horizontal angle of view, it is not necessary to verify optimal camera aim by looking at the recorded video; aiming can be done visually by pointing the lens at the driver's head. **STATIC ELECTRICITY DISCHARGE HAZARD: DO NOT TOUCH THE SILVER HEATSINK ON THE CAMERA.**

- **GPS recorder (schematic to the right):** GPS data are saved to a microSD card as long as power is being supplied to the power port. **You must use the Columbus V-990 cable in order for autorecord to work!** The GPS recorder is attached to the inside of the battery box using a piece of velcro. Please see **Exhibit 6. Columbus V-990 Features & Manual** for more details about using the GPS recorder. **DO NOT PRESS THE POWER/FUNCTION BUTTON WHILE THE DEVICE IS ON AS THIS WILL ENABLE MOTION DETECTION. IF THE MOTION DETECTION LED IS ON,**



DISABLE MOTION DETECTION BY SHORT PRESSING THE POWER BUTTON UNTIL YOU HEAR A BEEP AND THE MOTION DETECTION LED IS OFF.

- **5-volt converter**: Power to the camera is provided via a DC-DC converter which converts the 12 volts from the battery to 5 volts. The converter has a USB connector which the USB cable plugs into.

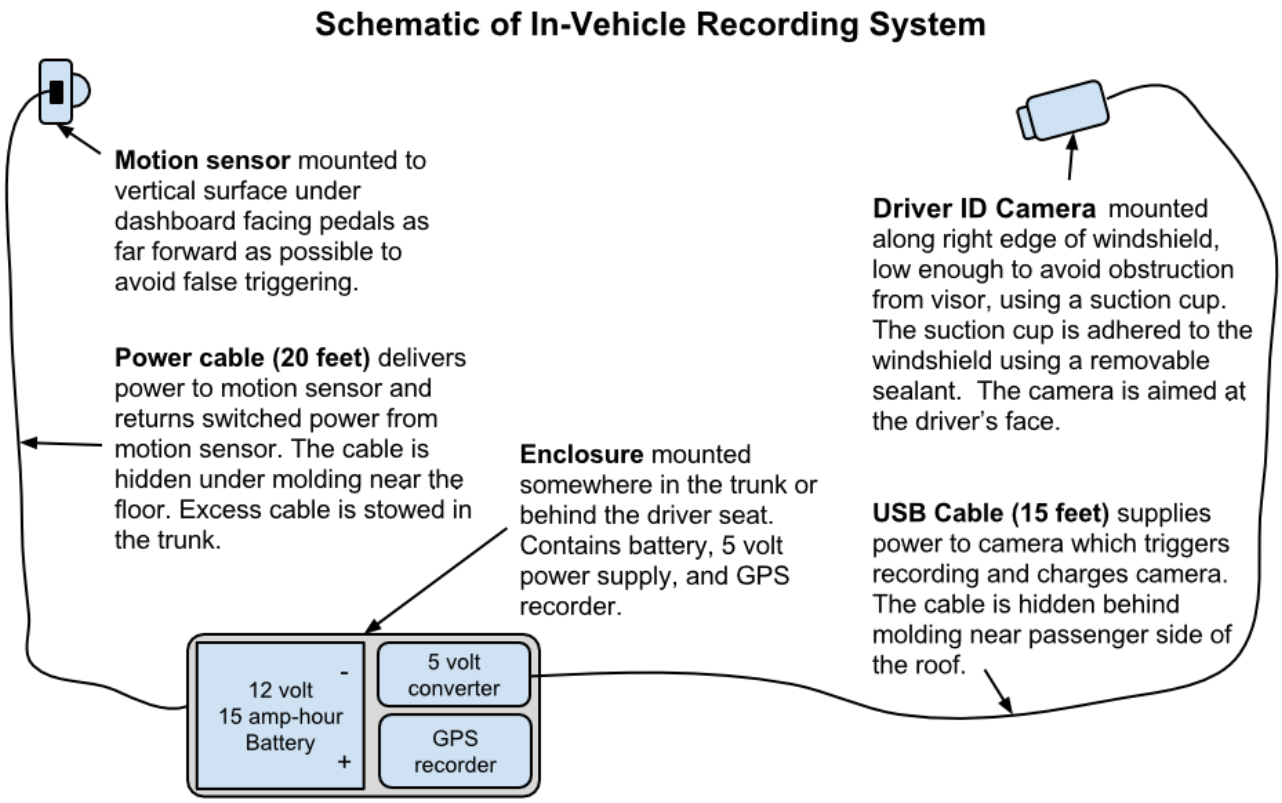
- **Video recorder USB cable (15 feet)**: Delivers power to the camera which triggers recording and charges the camera battery.

- **GPS recorder USB cable (6 feet)**: Delivers power to the GPS recorder which triggers recording and charges the GPS recorder battery. This cable is labeled. **You must use the Columbus V-990 cable in order for the autorecord to work!**

- **Power cable (20 feet)**: This cable connects to the battery (solid red lead is positive, striped red lead is negative) and delivers power to the motion sensor. The switched power from the motion sensor (solid blue lead is positive, striped blue lead is negative) then connects to the power inputs for the 5 volt converter.

- **Enclosure**: The battery, GPS recorder, 5-volt DC converter, and extra cable are enclosed in a plastic box that is attached to the car somewhere in the trunk of the vehicle or behind the driver in vans and trucks.

The drawing below is a top-down schematic of the in-vehicle recording system. For each component, a brief description is provided along with an overview of how & where the component is to be installed in the vehicle.



Installer Toolkit

In addition to the equipment that gets installed in the car, the following items are needed to install and maintain the system (Note: you should always use the items provided to minimize potential problems with the equipment):

- **Charger**: Only use the **BatteryMINDer Plus with SmarTECHnology (Model 1510)** charger to charge the batteries and charge one battery at a time. ***Connect charger directly to battery terminals, not to the fuse.*** In charging mode (14.4 volts) it takes about 10 hours to charge a fully discharged battery and after that the charger automatically switches to maintenance mode which makes it impossible to overcharge the battery. To make sure that you get a full charge on the batteries, it is better to put the batteries on the charger for at least 24 hours. When charging, the bottom green LED will flash on and off. When charging is complete, the charger goes into maintenance mode (13.4 volts) which is indicated by constant green LED.
- **Log book**: Each system has its own log book in the battery box. You will write any comments you have about the system in this book including the installation date/time and deinstallation date/time, battery voltage upon return, camera microSD card number, GPS microSD card number, and a ***rough*** idea of the number of trips recorded for each driver based on the number of video files on the camera microSD card and number of GPS files on the GPS microSD card.
- **Voltmeter (and 2 spare AA batteries)**: You will need to measure battery voltage when the battery is returned after the recording period. If the voltage is below 10 volts, this needs to be recorded in the log book for the battery and the battery capacity needs to be tested before it can be used again. Please notify TransAnalytics staff when a battery comes back with less than 10 volts.
- **Phillips or slotted tip screwdriver**: This is needed to tighten the camera mount.
- **Cutting pliers**: Used primarily to cut the excess off of nylon ties.
- **Allen key (3/16 inch)**: Required to adjust the bolt holding the camera to the suction cup mount.
- **Gaffer's tape**: This is removable tape that won't leave a residue and will handle high temperatures. It is used to attach the cable to the vehicle, if necessary, and to keep the cable away from latches that could pinch the cable.
- **Electrical tape**: This may be needed for electrical work or to mask off part of the motion sensor lens that is exposed to outside illumination. Masking the motion sensor may be necessary in trucks where there is very little depth between the firewall and the front of door.
- **Paper towel**: Used to clean silicone glue off of the windshield, and general purpose cleaning.
- **Plastic scraper**: Used to scrape sealant off of the windshield without scratching it.

- **Open end wrench or nut driver (⅜ inch)**: Used to hold the nut when making adjustments to the camera mounting bracket
- **Silicone glue (GE Premium Silicone Glue)**: This is used to adhere the suction cup to the windshield.
- **Cotton swabs:** Used to apply the silicone glue to the suction cup
- **Silicone remover (McKanica Silicone Caulk Remover):** Used during uninstallation to remove the silicone glue.
- **Metal razor scraper:** Used during uninstallation to remove silicone glue that cannot be removed using the silicone remover. **CAUTION: This scraper could damage the windshield if used incorrectly.**
- **MicroSD reader**: Raw GPS data is saved to a 1 GB microSD card and the camera data is saved to a 64 GB microSD card. When the driver returns for uninstallation, this data needs to be copied to an external USB hard drive. In order to do this, the computer being used needs to have a slot (preferably USB 3.0) to read the cards. Since these slots are rarely present, even on laptops, this card reader that plugs into a USB slot is provided.
- **Computer**: Any computer with USB ports should be able to perform the copying function. The transfer will be somewhat faster with USB 3.0 ports.
- **Crimper:** Used to attach the connectors to the ends of the power cable wires and the USB DC-DC converter inside the battery box.
- **Spare fuses and fuse cables:** Used to replace blown fuses (attached to battery).
- **Sharpie pens (red and black):** Use the pens to write the driver ID number on the microSD cards and installation information on the 3x5 cards.
- **Index cards**: Used to record information about the installation.
- **Bags**: Used for storing the filled microSD cards.
- **Windex wipes**: Used to clean off the windshield around where the suction cup will be mounted.
- **Camera reset tool**: Used to press the reset button on the camera. The reset is above the USB port, close to the center of the camera. If lost, just use the end of a small paper clip. (Note: the hole closer to the edge of the camera is the rear LED).
- **Nylon ties**: For securing the battery box at the end of installation. These can also be used to mount the motion sensor if necessary.
- **Trim removal (5-piece set)**: Used to hide cables under interior floor trim. They can also be used to remove the trim pieces, but **trim removal is not recommended** because the clips that hold the trim in place can easily be broken.
- **Telescoping mirror**: Used to inspect the LED on the camera after it is mounted.

- **First-aid kit**

Pre-Installation

At least 24 hours prior to installation, it is important to go over this checklist. Prepare **two complete systems per installation**, so components may be replaced in case of failure or damage. ***Failure to complete the following steps completely can result in lost or corrupted data.***

1. **Main battery fully charged (x2)**: If the measured battery voltage is over 13 volts (range 13.1 to 13.4 volts), the battery has a full charge.
2. **Charge camera battery (x2):** Ensure that the camera battery is fully charged using a USB charger. Simply plug the USB charging cable into the camera, turn it off by pressing the power button, then wait until the faint green LED shuts off. If the battery is fully discharged, it will take about 2.5 hours to charge.
3. **Charge GPS battery (x2)**: Plug the GPS datalogger into the USB charger until the LED turns green. If the battery is fully discharged, it will take about 3.5 hours to charge.
4. **Set camera clock (x2)**: Because the clock in the camera is not accurate, it needs to resynced ***before every installation***. The instructions for setting the camera are displayed in **Exhibit 3**. After you have set the camera clock, use these steps to check that the camera is set correctly: (1) Press the power button and wait for the yellow light to remain on (no flashing). (2) Press the top (shutter) button until the LED light starts blinking. (3) Press the top (shutter) button again to stop recording. (4) Press the power button to turn off the camera. (5) Remove the microSD card and insert it into the SD card reader. (6) Using a computer, open up the folder on the microSD card where the video files are saved. (7) Ensure that the Date Modified column is viewable in the Details folder view option. (8) Confirm that the time and date stamp for the file just recorded is present and accurate. (9) If the file is not present, remove the microSD card and repeat steps 1-8. If the file time and date stamp is incorrect, refer to **Exhibit 3. Setting Computer Time**. (10) Save the test files in a folder for the system number; these files may be needed for later troubleshooting. (11) Return microSD card to camera.
5. **Vehicle lookup**: Find out as much as possible about the vehicle so you can identify the mounting options that are most likely to work. For example, vans and trucks tend to have a steeper windshield slope so you may have to use a longer bolt that attaches the camera to the suction cup mount (supplied). Also, older vehicles, especially cargo vans and trucks, might not have carpet in the rear of the vehicle behind the driver seat but they might have loops that attach to the frame of the vehicle. You can find pictures using Google Images. For all other interior and exterior pictures, use www.cars.com.
6. **Reconfirm or reschedule appointment**: If bad weather is expected, you should reschedule (unless of course you can work underneath a shelter of some sort). Otherwise, call the driver to remind them about their appointment and ask them if they need directions or if they have any questions.
7. Make sure you have a printout of the **INSTALLATION CHECKLIST** with you.

8. **Set aside a 1 GB (for GPS) and 64 GB (for camera) card**: You don't need to assign a driver ID yet, but set aside the storage cards. Every 1 GB microSD to be used to record GPS data must have a file called "CONFIG.txt" located in the root of the card. The contents of the file:

   1,000,001,
   notes:
   1 Professional mode
   000 Over-speed tag
   001 Spy mode timer

   This file can be created manually using Notepad or downloaded from
   https://drivinghealth.com/fizfit/

9. **Toolkit check**: Make sure all the tools are in the toolkit and that they are functioning properly. For example, the voltmeter batteries might need to be replaced (2 AA batteries should be in the toolkit).

10. **Package everything up:** Take care not to let the camera lens touch anything inside the battery box.

Installation

The time to complete installation depends on the vehicle and the placement of the motion sensor. Normally, it should only take about 30 minutes to complete an installation. To allow for potential problems with mounting of the motion sensor, you may want to allocate at least 1 hour to complete installation. The procedure is as follows:

1. Find the optimal attachment location for the battery box somewhere behind the driver and preferably out of sight of the driver and passengers (e.g., the trunk). Set the battery box next to this location. ***Do not attach the battery box to the car at this time.***

2. Find a location underneath the steering wheel for the motion sensor that is (a) shielded, as much as possible, from light outside the vehicle and (b) facing the direction of the control pedals. This usually means that the motion sensor gets clipped to a vertical panel on the left side as close to the firewall (which is the floor beneath the control pedals) as possible. As a rule of thumb, if you can see the white hemispherical sensor lens from outside the vehicle, it is too exposed. Also be sure the motion sensor is rigidly mounted (e.g., ***don't attach to wires or cables***) and cannot be easily kicked by the driver.

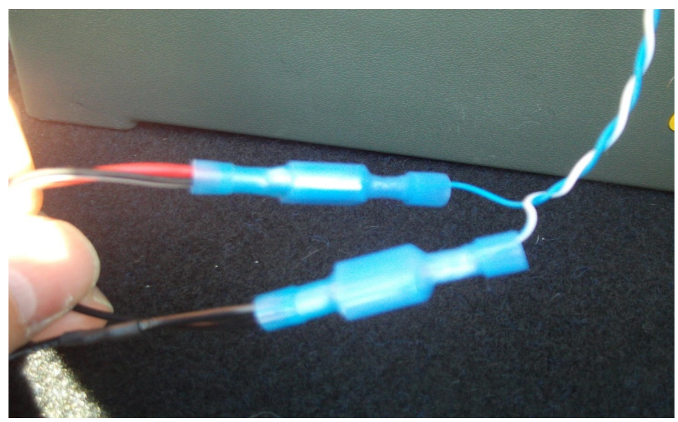
3. Route the power cable to where the battery box will be attached. Hide the cable under the molding near the floor of the car. Make sure the cable won't get pinched by the molding or latches near the power cable (use gaffer's tape if necessary to keep the cable away from latches).

4. Put the power cable under the seat belt assembly so as not to interfere with the use of the seat belt. Continue to hide the power cable under molding if possible. Finally, thread the cable around seats (or through if the rear seat doesn't fold) to the rear of the vehicle.

5. Ensure that the battery is attached to the Velcro at the bottom of the battery box, oriented so that the battery terminals are closest to the hinge of the box.

6. Attach the fuse cable to the positive battery terminal and then attach the **solid red wire** on the power cable to the open end of the fuse. Leave the **striped red wire** on the power cable disconnected for now. [Note: If any of the connectors seem loose, tighten them by squeezing the flat sides of the connector with pliers.]

7. Connect the **solid blue power** cable wire (female connector) to the **red** (positive) wire attached to the 5 volt converter in the battery box. Connect the **striped blue** power cable wire to the **black** (negative) wire attached to the 5 volt converter.



8. Plug the Columbus V-990 USB cable (labeled "Columbus V-990") into the GPS recorder and then plug the other end into a power port. Secure the GPS recorder to the side of the battery box using the velcro on one side of the GPS recorder. Make sure that the connector does not hang over the edge of the battery (see image to the right for proper location). **THE CABLE FOR THE GPS RECORDER IS NOT A STANDARD CABLE AND THE GPS RECORDER WILL NOT WORK IF THE CAMERA CABLE IS PLUGGED INTO IT. ALSO MAKE SURE NOTHING TOUCHES ANY OF THE BUTTONS ON THE GPS RECORDER.**

9. Plug the camera USB cable into the open USB power port inside the battery box.

10. Route the camera USB cable along the right side of the vehicle, through seams in the rear seat (if any), and along the roof towards the windshield. In some cars, it may be necessary to route the cable along the floor (and under all seat belt assemblies). ***Do not hide the cable yet.***

11. Pull down the passenger-side visor and locate the highest spot near the far right edge of the windshield that won't be blocked by the visor. Mark this spot with a piece of tape.

12. Make sure the suction cup is clean. **STATIC ELECTRICITY DISCHARGE HAZARD: DO NOT TOUCH THE SILVER HEAT SINK ON THE CAMERA**.

13. Use a cotton swab to put a very thin, even film of the silicone glue (the same width as the head of the cotton swab) along the outer edge of the suction cup. The silicone glue takes a few minutes to start curing so you can smooth out the silicone if needed. If you try to smooth it out and the film becomes uneven, start over by applying the silicone remover, waiting a few minutes, and then wiping everything off.

14. Remove the tape marking the location for the cup and then push the suction cup onto that spot on the windshield. Make sure that there is a good seal around the edge of the suction cup by inspecting it from outside the vehicle. You should see a solid black ring around the edge of the suction cup.

15. Adjust the camera lens so that it points to where the driver's head would be located and then tighten all the bolts to lock the camera in position.

16. Plug the USB cable into the USB port on the camera.

17. Starting near the camera, start hiding the cable behind molding along the roof of the vehicle leaving only about 2 inches of excess cable near the camera. Be careful not to tug on the cable as it will misalign the camera. If necessary, use gaffer's tape to keep the cable from hanging down.

18. Close all doors, except for the door/trunk that gives you access to the battery box.

19. Plug the striped red wire from the power cable into the battery's black (negative) terminal.

20. Verify that the GPS recorder LED (it is the light in the middle that looks like a satellite) and the camera LED are both flashing about once a second. If necessary, use the telescoping mirror to confirm the camera LED is on.

21. Wait about 13 minutes for the system to shut off automatically.

22. After the system shuts off, walk around the vehicle. If the system turns on, then you need to adjust the location of the motion sensor or mask off the lens using black electrical tape, wait another 13 minutes, and retest. Repeat this step until walking around the vehicle no longer results in the system turning on. Although this adds to the installation time, it shouldn't be necessary if the initial mounting location is not exposed to direct illumination from outside the vehicle.

23. With the system off, open the driver's door and sit in the driver's seat with feet on the pedals. Now, get out of the vehicle and look to see if the system is on. If so, then the motion sensor placement is working. **Make sure that the sensor is not able to move on its own (e.g., if you attached it to a cable or wire it won't work correctly) and that it can't get bumped by the driver's feet.**

24. Write down the installation time and date in the log book and the driver's ID. You can add any comments to the log book that you believe might help troubleshoot problems encountered after data collection is completed.

25. Put the excess USB and power cable into the battery box, if possible. Be careful not to inadvertently cause the connectors to become loose inside the battery box. Also make sure that nothing is pressing up against any buttons on the GPS recorder. If you cannot get all the excess cable inside the battery box, make sure the excess is hidden under a seat (and make sure it can't get tangled in the seat adjustment mechanism) or attached to the outside of the battery box using the nylon strap (preferably behind the box). **Make sure the cables exiting the battery box rest in the slots near the hinge.**

26. Attach the battery box to the vehicle (see the next page for configurations). Close the battery box latch and lock it with a nylon tie.

Methods for Attaching the Battery Box

There are multiple alternative methods for attaching to the vehicle.

1. The battery box is attached to a metal loop which is bolted to the vehicle frame.

2. The battery box is secured using a device called Stayhold which has velcro on the bottom and a strap that wraps around the battery box.

2. The battery box is secured with a nylon strap to the back of a seat, with the strap tucked inside the lid.

4. The battery box is secured with a nylon strap to latch anchors (present in most vehicles manufactured after 2002) which can be found in the seat crease at the bottom of the backrest of the rear seat. See **Exhibit 4. Mounting Battery Box to Latch Anchor** for the full instructions.

Uninstallation

This procedure should take less than 15 minutes. In some cases, it may take 30 to 40 minutes to complete the uninstall. For example, it will take longer to uninstall in cars without folding rear seats (most Cadillacs and Buicks). To uninstall:

1. Immediately after the driver arrives for their uninstall appointment, detach the battery box from the vehicle, cut off the nylon tie and open the lid.
2. Write down the date, time and driver ID of the uninstallation in the log book.
3. Verify that the system is on and that both GPS and camera are recording (1 flash per second for LEDs on each device). If either the GPS recorder or the camera are not recording, you need to make a note of this in the log book for later troubleshooting. ***You do not need to wait until the system shuts off to proceed.***
4. Disconnect the solid red connector on the power cable from the fuse in the battery box then disconnect the other three connectors.
5. Remove the power cable from battery box.
6. Disconnect the USB cable from the camera.
7. Place paper towels underneath where the suction cup is mounted.
8. Release the suction cup from the windshield by pinching around the edges of the seal with your fingernails or the plastic scraper. If that doesn't work, you may have to use the metal razor scraper but **only use this as a last resort** because it can damage the suction cup and the windshield.
9. Apply the silicone remover gel to the silicone on the windshield and the suction cup and wait about 5 minutes.
10. Use the plastic scraper to scrape the silicone and silicone remover gel off of the windshield. Be careful not to let anything drop onto the dashboard or floor of the vehicle. Using a paper towel, remove remaining silicone glue and silicone remover gel from the suction cup and windshield
11. Clean off windshield with a Windex wipe
12. Remove the camera USB cable from the car by taking it out from under the molding.
13. Detach the motion sensor from the vehicle.
14. Take the power cable out from under the molding.
15. Detach the battery box from the vehicle.
16. Wrap the power cable around the orange cord wrap.
17. Clean off the rest of the sealant on the windshield using a paper towel and/or a plastic scraper.

Post-Uninstallation

These steps should be performed as soon as possible after the driver has been released from the study. This should only take about 15 minutes.

1. Create copy verification files using the procedure outlined in **Exhibit 5. microSD Card Maintenance** in the section titled “Create Copy Verification Files.”
2. Copy data to the external hard drive. ***The raw data should never be deleted from the cards.***
3. Run the file called TestFiles.exe on the copy to verify that there are no errors.
4. Write down the number of trips recorded. For video, this is simply the highest number in the sequence saved to the camera card. If the last file of video is “REC_0057.MOV” then 57 trips were recorded. For GPS files, select all .csv files, right-click, select properties, then look for number of files. This is the number of GPS trips recorded. Please note that these 2 numbers may not be the same.
5. Inspect uninstalled system components for damage by turning on the system and collecting test data with test cards.
6. Measure battery voltage to make sure it isn't lower than 10 volts. Notify TransAnalytics immediately if any components need to be replaced or repaired, or if the battery voltage dropped below 10 volts. This will allow us to resolve problems well in advance of the next installation.
7. Ship the GPS and camera cards to TransAnalytics.

User Manual for In-Vehicle Recording System
Exhibit 1. Mobius Actioncam Settings

To check the settings you need to download and unzip the software from this link.

www.mytempfiles.info/mobius/mSetup.zip

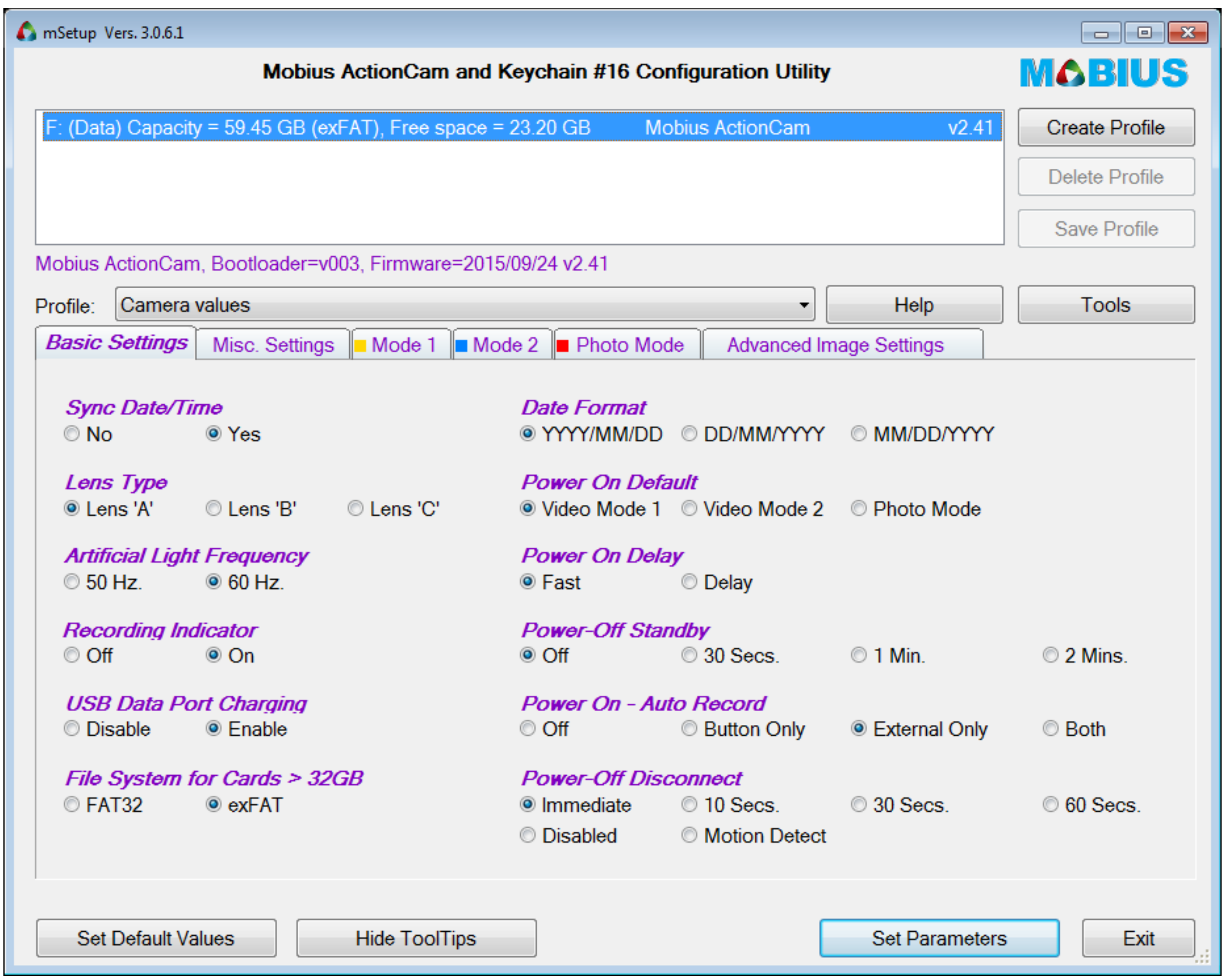
Here is a link to the official manual for the Mobius Actioncam.

www.mytempfiles.info/mobius/MobiusManual.pdf

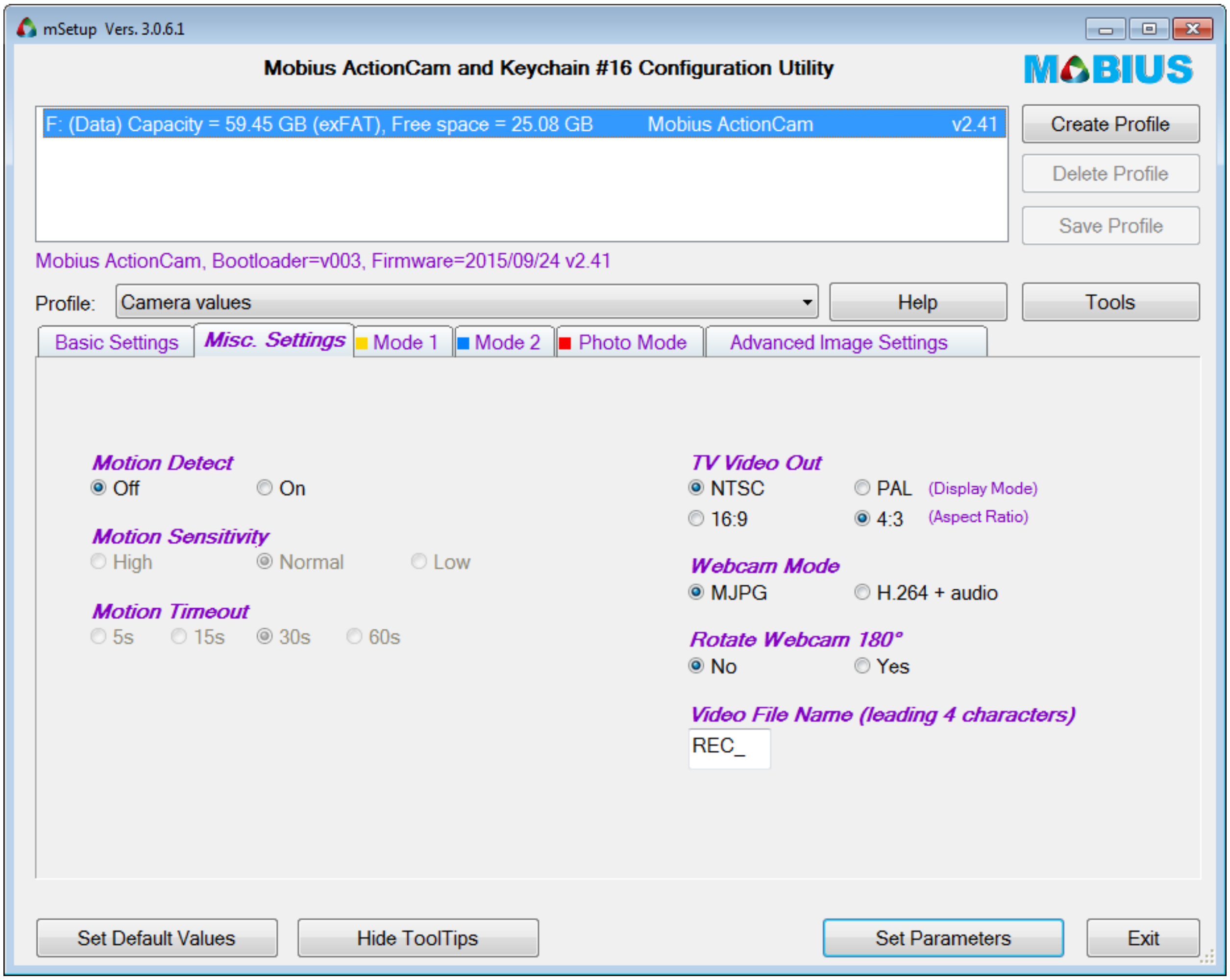
For other information, use this link.

www.mytempfiles.info/mobius/index.html

Basic Settings Page

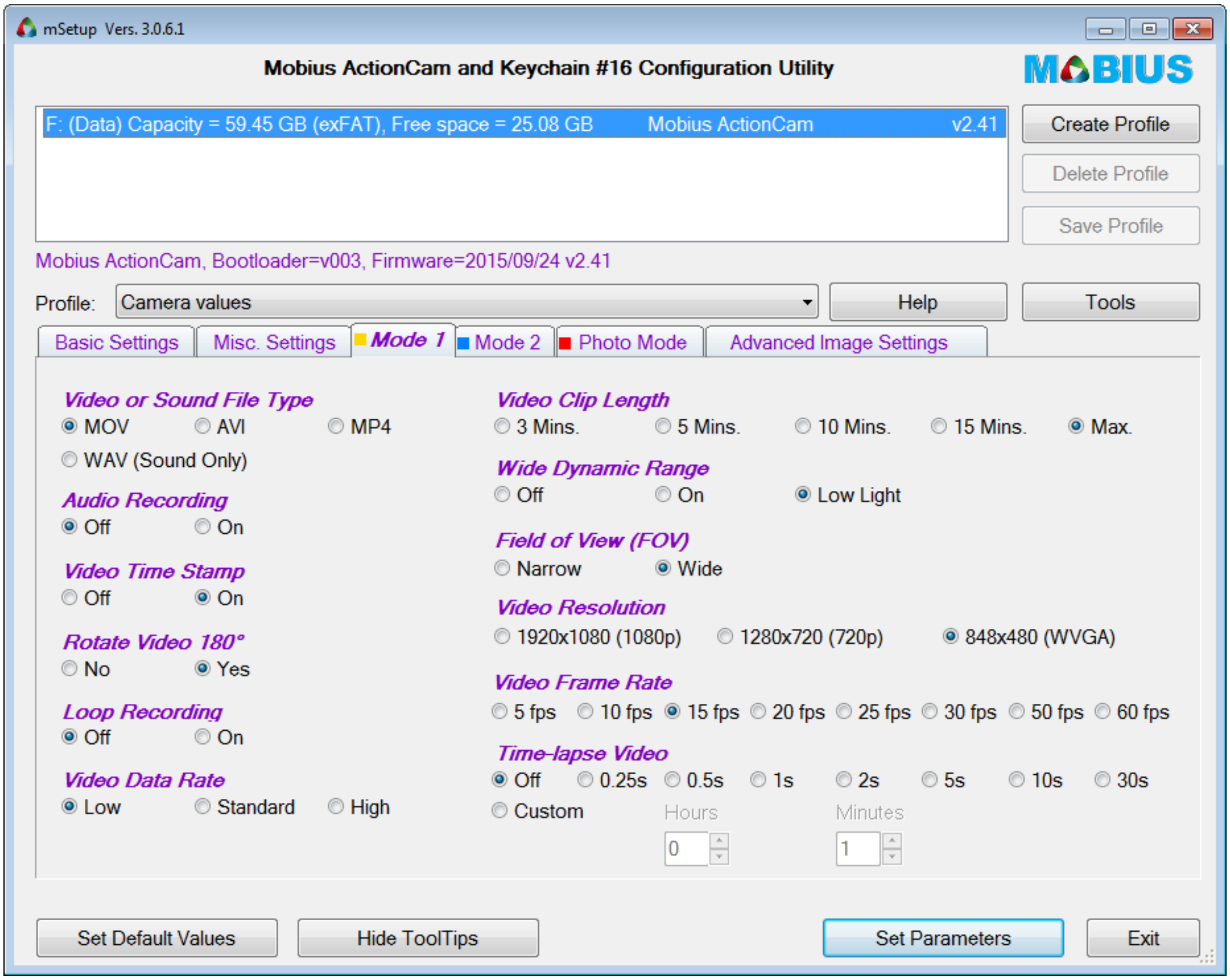


Miscellaneous Settings Page


mSetup Vers. 3.0.6.1
Mobius ActionCam and Keychain #16 Configuration Utility
MOBIUS
F: (Data) Capacity = 59.45 GB (exFAT), Free space = 25.08 GB Mobius ActionCam v2.41
Create Profile
Delete Profile
Save Profile
Mobius ActionCam, Bootloader=v003, Firmware=2015/09/24 v2.41
Profile: Camera values
Help
Tools
Basic Settings
Misc. Settings
Mode 1
Mode 2
Photo Mode
Advanced Image Settings
Motion Detect
Off On
Motion Sensitivity
High Normal Low
Motion Timeout
5s 15s 30s 60s
TV Video Out
NTSC PAL (Display Mode)
16:9 4:3 (Aspect Ratio)
Webcam Mode
MJPG H.264 + audio
Rotate Webcam 180°
No Yes
Video File Name (leading 4 characters)
REC_
Set Default Values
Hide ToolTips
Set Parameters
Exit

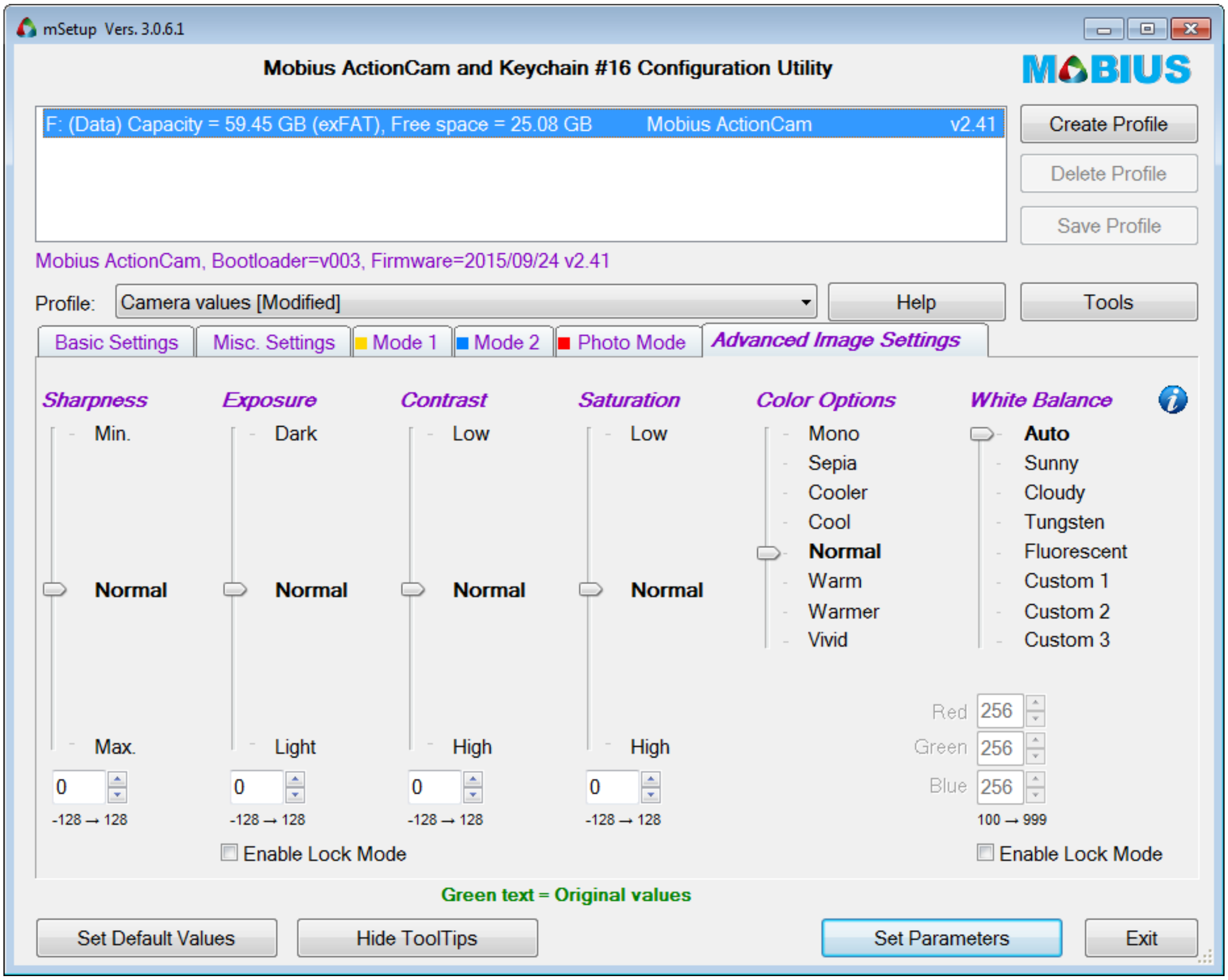
Mode 1 Page

Please note that the Mode 2 page has the same settings as the Mode 1 page.



Advanced Image Settings Are All Set to Defaults.

The settings on this page are all defaults.



User Manual for In-Vehicle Recording System
Exhibit 2. Reacquiring the Almanac

The GPS recorder has a battery that saves something called an almanac. The almanac tells the GPS recorder what satellites to use in obtaining a GPS fix which dramatically reduces the time it takes to obtain a location fix.

Whenever the GPS recorders are shipped for use in a different location, you need to acquire a new almanac. To do this, you need to power up the GPS recorders until a GPS fix has been acquired. The GPS can be powered by any USB power port.

Let the GPS run until you hear 3 beeps (2 short and 1 long) and the GPS LED is flashing which indicates that a GPS fix has been obtained. Let it run for a few minutes after this then look at the data on the microSD card to see if it got a fix. The way to tell if it got a fix is to look for data like this (first line contains variable names).

```
INDEX,TAG,DATE,TIME,LATITUDE N/S,LONGITUDE E/W,HEIGHT,SPEED,HEADING,FIX MODE,VALID,PDOP,HDOP,VDOP,VOX
1    ,T,151106,124841,40.441223N,075.338826W,100  ,0   ,0  ,3D,SPS ,2.2  ,2.0  ,1.0  ,
2    ,T,151106,124844,40.441176N,075.338825W,99   ,0   ,0  ,3D,SPS ,2.0  ,1.8  ,0.9  ,
3    ,T,151106,124845,40.441173N,075.338823W,99   ,0   ,0  ,3D,SPS ,1.9  ,1.6  ,0.9  ,
4    ,T,151106,124846,40.441168N,075.338819W,99   ,0   ,0  ,3D,SPS ,1.9  ,1.6  ,0.9  ,
5    ,T,151106,124849,40.441151N,075.338808W,101  ,0   ,0  ,3D,SPS ,1.8  ,1.6  ,0.8  ,
```

[Note: If you don't see the PDOP, HDOP, and VDOP variables it means you didn't configure the CONFIG.txt file correctly. Please check that the file exists and that it is correct.]

The 40.441151N,075.338808W in the last line is a good GPS fix for our offices in Quakertown, PA. To verify that you have acquired a good GPS fix for your location, you need to edit the GPS coordinates to look like this.

40.441151,-075.338808

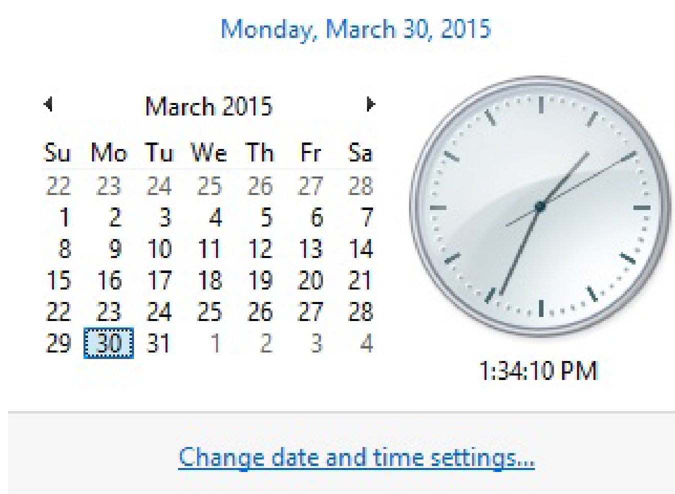
Note that latitude (the left number) is positive because we are above the equator and longitude is negative because we are west of the prime meridian. Paste the coordinates into Google Maps search box to find the location. After verifying that it is a good fix (i.e. that the GPS coordinates accurately give your location), delete the data from the card and recharge the battery. If there is no fix within the entire data file, then run it for another 2 minutes and check the data. Repeat this process until it starts getting a fix.

User Manual for In-Vehicle Recording System
Exhibit 3. Setting Computer Time

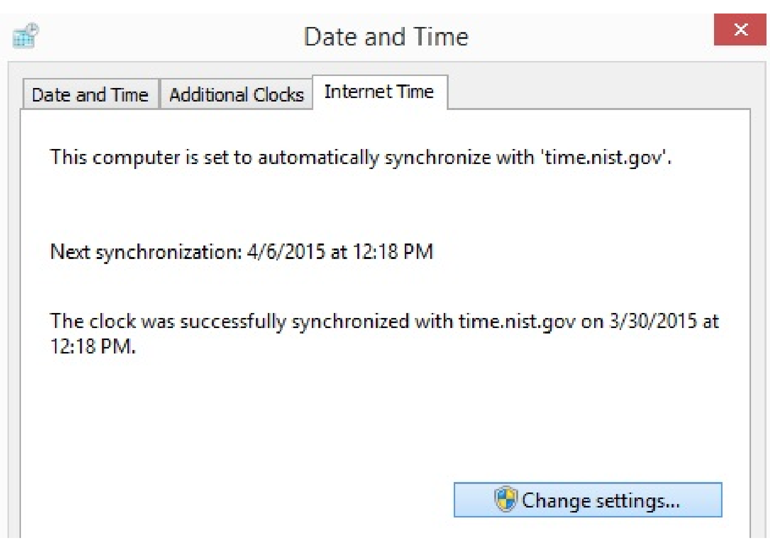
The camera synchronizes to the time on the computer used to view the settings with mSetup.exe. For the camera time and date to be correct, you must follow these instructions.

1. Ensure that your computer has an Internet connection.
2. Connect the camera to the computer using the USB plug.
3. Click on the date and time on the taskbar.

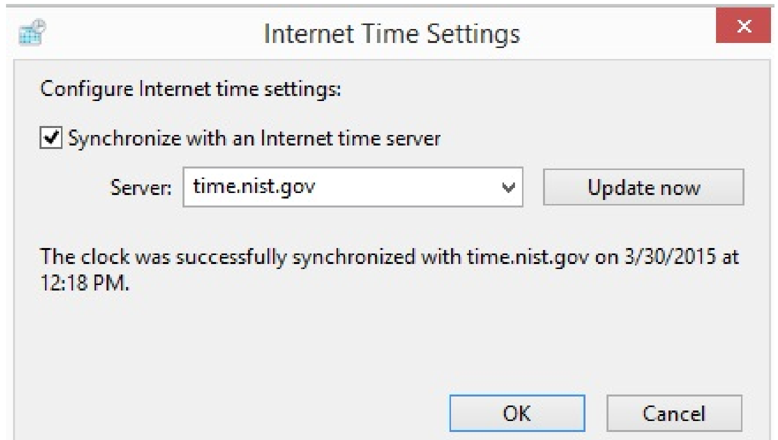
4. Select the option to "Change date and time settings…"



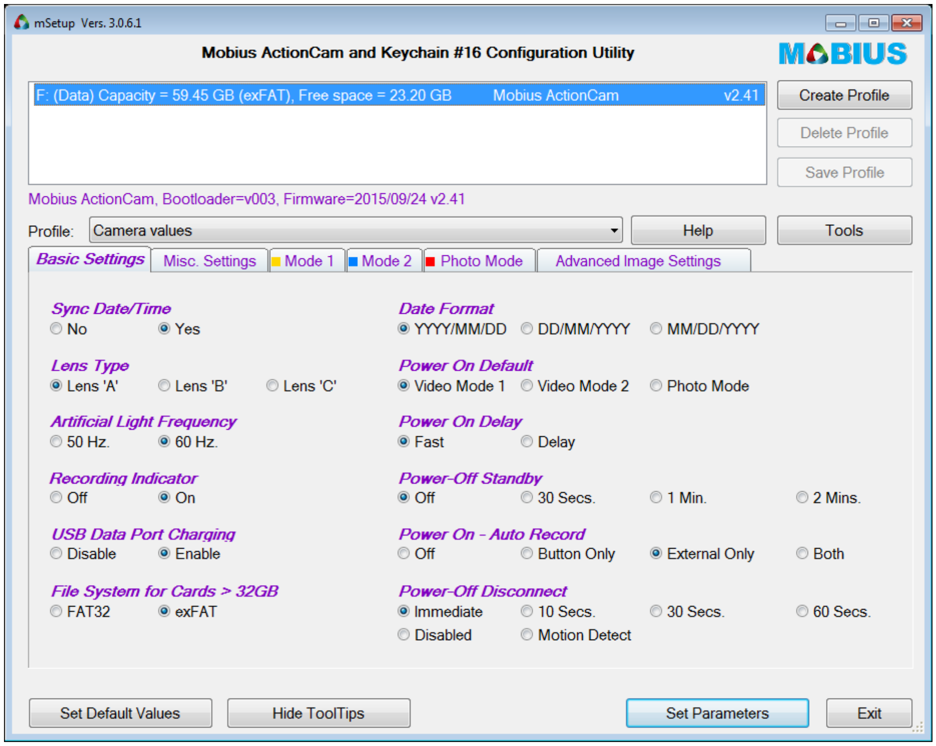
5. Go to the tab called "Internet Time" and select the option to "Change settings…"



6. Check box “Synchronize with an Internet time server” and select “time.nist.gov” from the “Server” dropdown list. Click “OK.”
7. Click “OK” to exit the “Date and Time” window.



8. We are going to use “(UTC) Coordinated Time Zone” for this project so that (1) time stamps for video and GPS data match and (2) we don't have errors when going on (in March) and off (in November) daylight saving time (DST) while the equipment is in the field. [Note: The actual day for the start and end of DST varies every year.] In step 5, notice the screen with three tabs. Open the “Date and Time” tab, click the “Change time zone...” button, select “(UTC) Coordinated Time Zone” from the pulldown menu, and then press OK to exit the screens.
9. Download camera software from www.mytempfiles.info/mobius/mSetup.zip. Install file , run it, connect the camera to a USB port on the computer, select the driver letter for the camera, and go to Basic Settings page.
10. Confirm that the camera’s Basic Settings match the settings shown below. If the settings do not match, then set them to the correct values.



11. To save the settings and synchronize the date/time on the computer to the camera, press the "Set Parameters" button before exiting.
12. Repeat Pre-Installation item 3 to confirm camera's timestamp is correct.
13. If the time is correct, set the time zone back to the correct value.

User Manual for In-Vehicle Recording System
Exhibit 4. Mounting Battery Box to Latch Anchor

1. Verify that the driver does not need to use their latch. If they do not, you can proceed.

2. Identify latch anchor (present in most cars manufactured after 2002). It should be present in the rear seats of the car, in the crease at the bottom of the backrest.

3. Starting in the trunk behind the seat, thread the nylon strap through the latch.

4. Thread the other end of the nylon strap through the second latch.

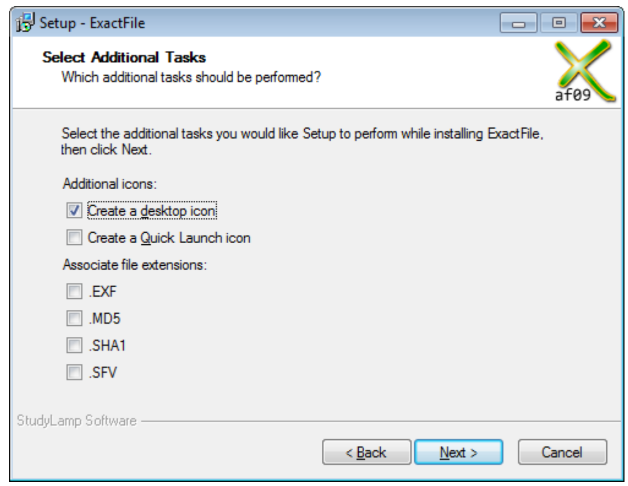
5. Pull both ends of the nylon strap into the trunk.

6. Put one end of the nylon strap through the handle on top of the battery box. Pull the other end of the nylon strap underneath the battery box. Connect the ends of the buckle together, tighten the grip, and tie the excess strap ends together.

Create Copy Verification Files

Before you copy data from the microSD cards, you need to create copy verification files that will tell you if the files were all correctly copied to the external hard drive. You need to do this separately for the GPS and video data. First, you will need to install the software ExactFile from this link.

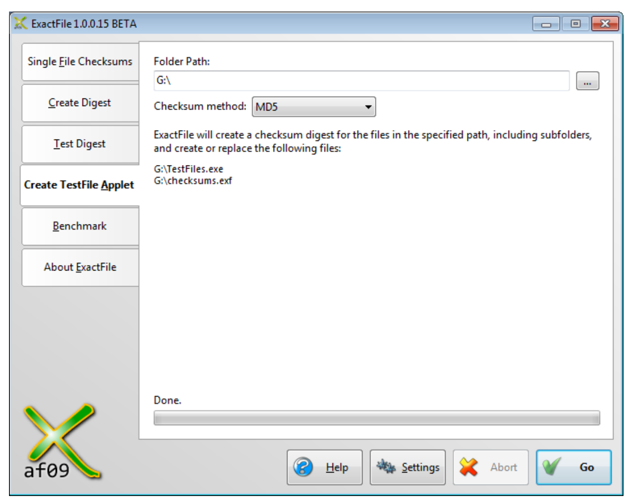
www.exactfile.com/files/ExactFile-Setup.exe



Run the downloaded installer. Make sure the option to create a Desktop icon is checked. Turn off all other options (e.g., no quick launch and uncheck all file associations) as shown in the image to the right.

Before you run ExactFile, find the drive letter for the data you are about to copy (***don't copy it yet***) and create a folder on the external hard drive where you are ***copying to***. Then you need to:

1. Launch ExactFile using the Desktop icon.
2. Select the "Create TestFile Applet" tab (as shown in the screenshot to the right).
3. Set the "Folder Path:" field to the drive letter containing the to-be-copied original data.
4. Make sure the "Checksum method" is set to MD5.
5. Press the "Go" button.
6. When it is done, it should have created two files: TestFiles.exe and checksums.exf.
7. Run the TestFiles.exe on the micrdSD card and when it is done it should say "Testing completed. EVERY FILE IS OK."



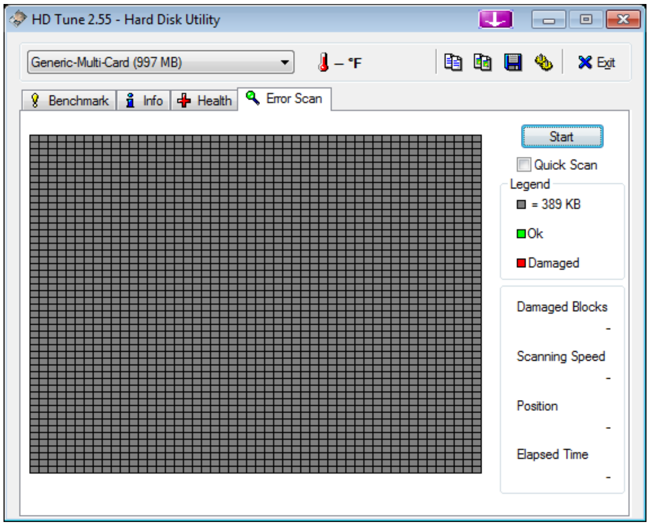
8. Now copy the files to the folder on the external hard drive. Select all files using Ctrl-A and then copy all selected files using Ctrl-C. Go to the folder on the external hard drive and paste files using Ctrl-V.
9. After the copying is completed, run the TestFiles.exe file again ***from the copy you just made on the external hard drive***. When it is done, it should say "Testing completed. EVERY FILE IS OK." If

it doesn't say this, something went wrong and you'll have to try recopying or just recopy the files that were missing and/or corrupted. It is important to run the TestFiles.exe from the card (to make sure original data is ok) and from the external hard drive (to verify that the copy is ok).

Formatting microSD Cards

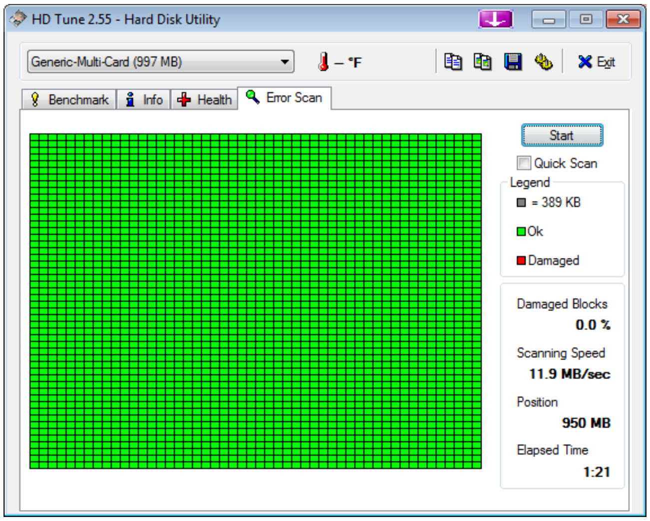
1. Download and install SD Formatter from here. www.sdcard.org/downloads/formatter_4/eula_windows/SDFormatterv4.zip
2. Insert microSD card into USB card reader and then run SD Formatter. **IMPORTANT:** Make sure the correct pathway is selected in the "Drive" dropdown menu. Verify that you have selected the correct drive letter by looking at the amount of storage on the drive. If it is different, you have selected the wrong drive.
3. Click the Option button on the main menu
4. From the FORMAT TYPE dropdown menu, select "FULL (OverWrite)"
5. FORMAT SIZE ADJUSTMENT should be "OFF"
6. Select "OK"
7. Select "Format"
8. Once the card is formatted, safely remove/eject the SD card
9. Remove the SD card from the card reader.

Checking MicroSD Cards for Errors



1. Download and install HDTune from here: www.hdtune.com/files/hdtune_255.exe
2. Insert the microSD into the card reader and then plug the card reader into a USB port.
3. Launch HD Tune.
4. Select the microSD card from the pulldown menu on top-left.
5. Select the Error Scan tab (rightmost tab).
6. Click the Start button.

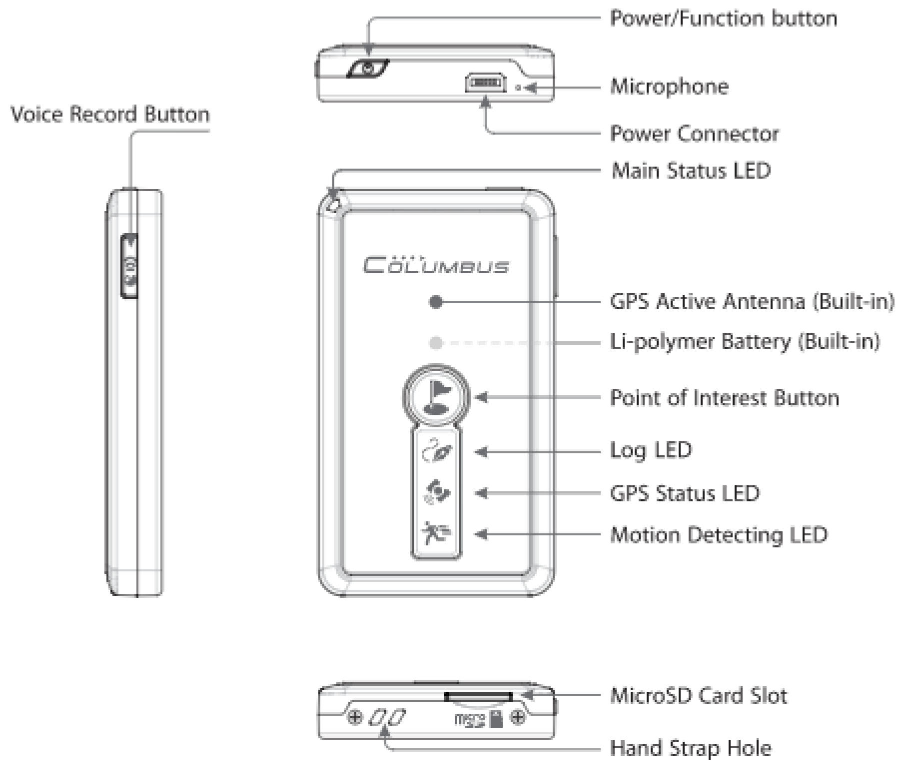
7. When the scan finishes, it should report 0% Damaged Blocks. If any blocks are damaged, you can try reformatting the card to see if that solves the problem. **You cannot use any cards with damaged blocks.**



User Manual for In-Vehicle Recording System
Exhibit 6. Columbus V-990 Features & Manual

There are a few important aspects of the GPS recorder features that need to be understood:

1. Autorecord Cable: The autorecord record feature does not work unless the Columbus V-990 cable is plugged into the power connector port. The cable is labeled to prevent accidental cable swapping.



2. Motion Detection Off: Motion detection mode needs to be off. Verify that the Motion Detecting LED light on the bottom (see runner icon in schematic) is off. If not, a short press on the power/function button when it is on will disable it.

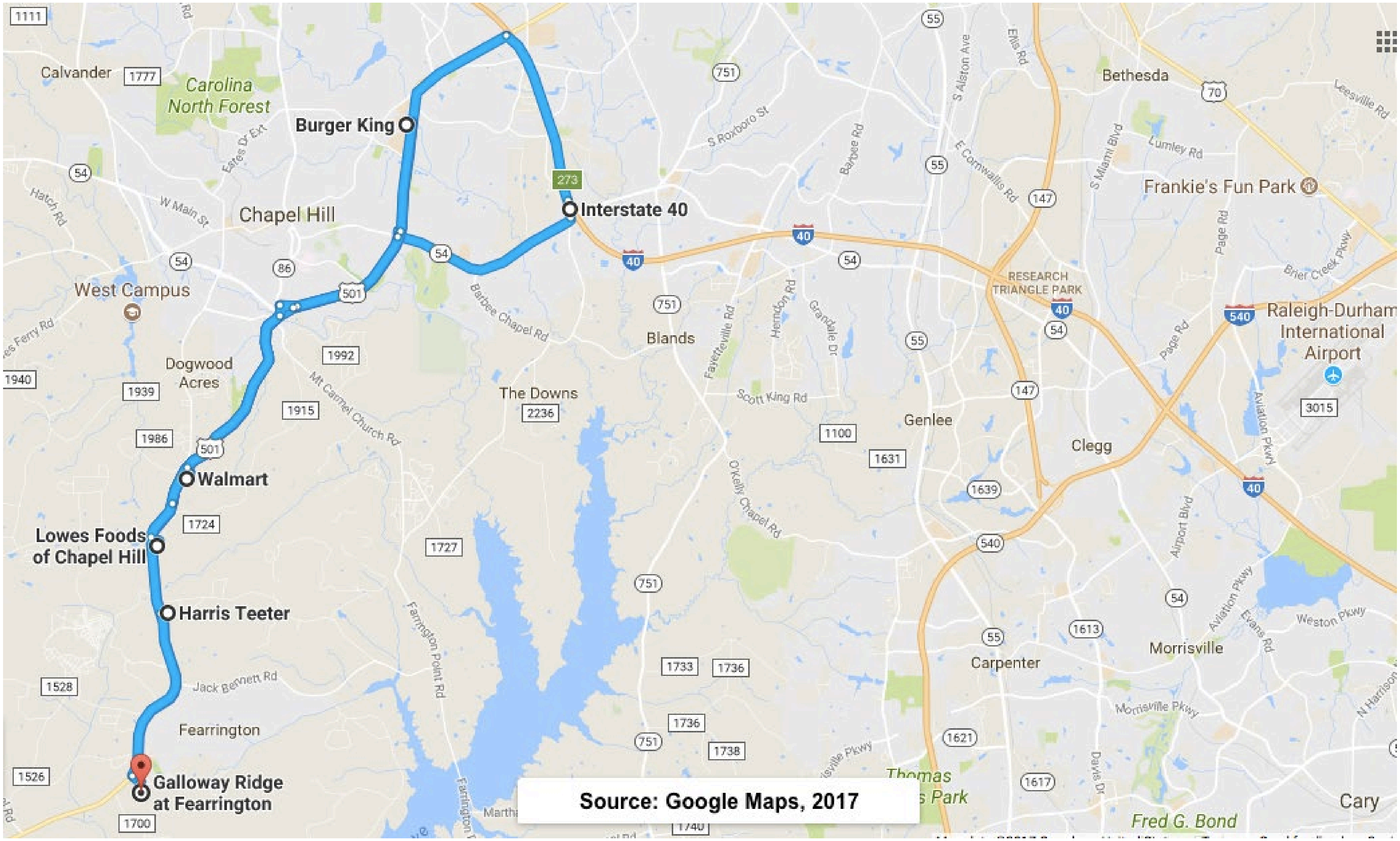
3. Beeps: The recorder makes a lot of beeps. These beeps might be noticed by the driver but with the GPS recorder in the battery box the beeps are much less audible.

4. Buttons: You don't need to use the Voice Record, Power/Function, or Point of Interest buttons. You should always power up the device using power applied to the charging port via the Columbus V-990 cable.

   For more detail, the User Manual can be downloaded at this link.

   http://cbgps.com/download/Columbus_V-990_User_Manual_V1.0_ENG.pdf

Appendix E. Test Route Used by CDRS for On-Road Assessment



Source: Google Maps, 2017

Appendix F: On-Road Score Sheet and Summary Scores

Operational Skills	Number of Participants With Errors (n=64)	Total Error Score*
Independent access to vehicle (1)	0	0
Negotiation of driver door (1)	0	0
Seat adjustment (3)	0	0
Wheel adjustment (3)	0	0
Mirror adjustment (3)	1	3
Fastens seat belt (3)	1	3
Ignition Control (3)	0	0
Gear selection appropriate (3)	3	9
Brake pedal use (3)	3	15
Accelerator pedal use (3)	6	27
Steering (5)	2	10
Signal ability (5)	2	15
Adjusts Heating and Air/Radio if needed(5)	0	0
Turn Signal/Lights/Wiper/Cruise controls used if necessary (5)	0	0
Parking brake used if necessary (5)	0	0
Operational Points off	**14****	**82**

Comments:

Tactical Skills	Number of Participants With Errors (n=64)	Total Error Score*
Visual Skills:		
Fails to scan environment/tunnel vision (10)	1	10
Awareness of signage (5)	3	15
Fails to check speedometer(5)	0	0
Vehicle Position:		
Lane maintenance/centered position (5)	9	45
Drives in proper lane (5)	2	10
Follow distance/Lateral Cushion (5)	7	55
Stopping position (5)	11	80
Response to other traffic (5)	1	5
Intersections/Turns *(Right)*		
Check Traffic (5)	1	5
Fails to signal(5)	2	10
Proper Lane (5)	8	55
Speed (3)	1	3
Safe gap selection/yield (10)	0	0
Fails to make complete stop, obvious roll (10)	7	70
Fails to make complete stop (3) (Very near stop but vehicle does not settle back)	24	96
Runs red light (100)	1	100

	Number of Participants With Errors (n=64)	Total Error Score*
Intersections/Turns *(Left)*		
Check Traffic (5)	1	5
Fails to signal (5)	8	45
Proper Lane (5)	18	125
Speed (3)	1	3
Safe gap selection/yield (10)	4	40
Fails to make complete stop, obvious roll (10)	6	60
Fails to make complete stop (3) (Very near stop but vehicle does not settle back)	23	105
Runs red light (100)	1	100
Lane changes:		
Fails to signal (5)	9	75
Fails to use mirrors to check traffic (5)	2	10
Fails to perform necessary blind spot checks (5)	8	50
Position (3)	8	27
Speed (3)	3	9
Lane (5)	2	15
Safe gap selection/yield (10)	3	30
Merges on/off limited access hwy		
Judgment of space (5)	7	35
Signaling(5)	4	25
Speed regulation (5)	4	25
Visual scanning/Blind spot (5)	2	10
Vehicle Handling:		
Judge and regulate speed (5)	25	215
Smooth steering (5)	0	0
Smooth accelerator(5)	0	0
Smooth braking(5)	0	0
Appropriate use of signals (5)	1	10
Response to traffic signal (5)	0	0
Parking : Approach (3)	1	3
Position (3)	3	9
Speed (3)	0	0
Backing: Check Traffic (5)	0	0
Position (3)	1	3
Speed (3)	0	0
Safe/yield (10)	0	0
3-pt turn around (5)	3	15
U-Turn	3	15
Traffic Circle (5)	0	0
Tactical Points Off	***62***	***1617***

Comments:

Strategic Skills	Number of Participants With Errors (n=64)	Total Error Score*
Correct and safe decisions		
Residential (5)	0	0
City (5)	0	0
Limited access hwy (5)	0	0
Route planning(5)	5	25
Route logically sequenced (5)	0	0
Remembers and executes the route in the preplanned order(5)	11	55
Maintains/regulates conversation appropriately (5)	3	15
Problems following rules of the road (5)	2	10
Fails to make decisions in advance of Maneuvers (5)	1	5
Separates hazards (5)	3	15
Fails to observe cues from other road users (5)	0	0
Fails to anticipate(5)	2	10
Attention deficit – "looked but didn't see" (5)	1	5
Decreased Processing speed(5)	2	10
Impaired following directions (5)	5	25
Strategic Points Off	**25****	**175**

Comments:

SCORING: TOTAL POINTS OFF= (A – 0-24; pass with no restrictions), (B – 25-49; pass with recommendations), (C – 50-75; marginal with restrictions; marginal with training), (D – 76-99; Fail), (F – 100 up; Fail)

A vertical mark beside an item indicates points off (tally). The point value of each item is in parenthesis. Each item may have several vertical marks beside it representing the errors that were committed more than one time. Multiply the number of vertical marks times the point value in parenthesis to get the Points Off for that item (total).

100 or more Total Points Off is a failure.
TOTAL ROAD POINTS ……………..____________ Score:

Feedback provided to Participant:

* 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 Brake Pedal Use: 3 participants made brake pedal errors, but 1 of them made the error 3 times, so that person's brake pedal score was 9, while the other 2 participants only did it once, so each of their error scores was 3. Error score = 9 + 3 + 3 = 15.

** 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.

Appendix G: Analysis Results for Non-Significant Regression Models –Physical Function/Activity and Driving Exposure

SUMMARY OUTPUT: Trips Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.172					
R Square	0.030					
Adjusted R Square	-0.051					
Standard Error	0.618					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	0.698	0.140	0.366	0.870	
Residual	60	22.883	0.381			
Total	65	23.580				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.826	0.631	1.308	0.196	-0.437	2.088
Phone Fitt Total Score (Higher Score = More Active)	6.08895E-05	0.007	0.009	0.993	-0.013	0.013
Unified Physical Activity Index (Higher Score = More Active)	-0.005	0.006	-0.889	0.377	-0.016	0.006
Vo2Max Score (Higher Score = More Fit)	0.013	0.013	1.008	0.317	-0.012	0.038
WalkTime (msec) (Higher Score = Less Fit)	-2.32289E-05	5.25E-05	-0.443	0.660	0.000	8.17E-05
HeadNeck (0=Pass, 1-Fail)	0.025	0.156	0.158	0.875	-0.287	0.336

SUMMARY OUTPUT: Driving Minutes Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.222					
R Square	0.049					
Adjusted R Square	-0.030					
Standard Error	4.996					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	77.946	15.589	0.624	0.682	
Residual	60	1497.770	24.963			
Total	65	1575.716				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	7.872	5.107	1.541	0.128	-2.344	18.087
Phone Fitt Total Score (Higher Score = More Active)	0.002	0.053	0.038	0.970	-0.104	0.108
Unified Physical Activity Index (Higher Score = More Active)	-0.040	0.045	-0.899	0.372	-0.129	0.049
Vo2Max Score (Higher Score = More Fit)	0.137	0.101	1.351	0.182	-0.066	0.340
WalkTime (msec) (Higher Score = Less Fit)	-0.0001	0.0004	-0.289	0.774	-0.001	0.001
HeadNeck (0=Pass, 1-Fail)	1.179	1.259	0.936	0.353	-1.340	3.697

SUMMARY OUTPUT: Longest Trip Time (Mins)						
Regression Statistics						
Multiple R	0.303					
R Square	0.092					
Adjusted R Square	0.016					
Standard Error	17.028					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	1756.547	351.309	1.212	0.315	
Residual	60	17397.283	289.955			
Total	65	19153.830				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	42.369	17.406	2.434	0.018	7.553	77.185
Phone Fitt Total Score (Higher Score = More Active)	-0.361	0.180	-2.006	0.049	-0.721	-0.001
Unified Physical Activity Index (Higher Score = More Active)	0.139	0.152	0.915	0.364	-0.165	0.443
Vo2Max Score (Higher Score = More Fit)	0.509	0.345	1.473	0.146	-0.182	1.200
WalkTime (msec)	-0.00029	0.0014	-0.1976	0.8441	-0.0032	0.0026
HeadNeck (0=Pass, 1-Fail)	3.602	4.290	0.840	0.404	-4.980	12.184

SUMMARY OUTPUT: Longest Trip Time (Mins)						
Regression Statistics						
Multiple R	0.167					
R Square	0.028					
Adjusted R Square	0.013					
Standard Error	17.056					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	536.822	536.822	1.845	0.179	
Residual	64	18617.008	290.891			
Total	65	19153.830				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	53.940	7.816	6.901	2.77421E-09	38.325	69.555
Phone Fitt Total Score (Higher Score = More Active)	-0.205	0.151	-1.358	0.179	-0.507	0.097

SUMMARY OUTPUT: Average Trip Length (Mins)						
Regression Statistics						
Multiple R	0.141					
R Square	0.020					
Adjusted R Square	-0.062					
Standard Error	4.516					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	24.800	4.960	0.243	0.942	
Residual	60	1223.459	20.391			
Total	65	1248.258				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13.690	4.616	2.966	0.004	4.457	22.923
Phone Fitt Total Score (Higher Score = More Active)	-0.012	0.048	-0.247	0.806	-0.107	0.084
Unified Physical Activity Index (Higher Score = More Active)	-0.004	0.040	-0.104	0.917	-0.085	0.076
Vo2Max Score (Higher Score = More Fit)	0.009	0.092	0.097	0.923	-0.174	0.192
WalkTime (msec) (Higher Score = Less Fit)	-0.0001	0.0004	-0.262	0.794	-0.0009	0.0007
HeadNeck (0=Pass, 1-Fail)	1.157	1.138	1.017	0.313	-1.119	3.433

SUMMARY OUTPUT: Driving Miles Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.258					
R Square	0.067					
Adjusted R Square	-0.011					
Standard Error	2.519					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	27.150	5.430	0.856	0.516	
Residual	60	380.735	6.346			
Total	65	407.885				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.548	2.575	0.989	0.326	-2.603	7.698
Phone Fitt Total Score (Higher Score = More Active)	0.007	0.027	0.278	0.782	-0.046	0.061
Unified Physical Activity Index (Higher Score = More	-0.021	0.022	-0.952	0.345	-0.066	0.024
Vo2Max Score (Higher Score = More Fit)	0.084	0.051	1.637	0.107	-0.019	0.186
WalkTime (msec) (Higher Score = Less Fit)	-7.97891E-05	0.0002	-0.373	0.711	-0.001	0.0003
HeadNeck (0=Pass, 1-Fail)	0.631	0.635	0.994	0.324	-0.639	1.901

SUMMARY OUTPUT: Longest Trip Length (Miles)						
Regression Statistics						
Multiple R	0.319					
R Square	0.102					
Adjusted R Square	0.027					
Standard Error	15.558					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	1641.674	328.335	1.356	0.254	
Residual	60	14523.298	242.055			
Total	65	16164.971				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	25.017	15.903	1.573	0.121	-6.794	56.828
Phone Fitt Total Score (Higher Score = More Active)	-0.283	0.164	-1.720	0.091	-0.611	0.046
Unified Physical Activity Index (Higher Score = More Fit)	0.081	0.139	0.581	0.563	-0.197	0.359
Vo2Max Score (Higher Score = More Fit)	0.562	0.316	1.780	0.080	-0.070	1.193
WalkTime (msec) (Higher Score = Less Fit)	-0.001	0.001	-0.791	0.432	-0.004	0.002
HeadNeck (0=Pass, 1-Fail)	3.916	3.920	0.999	0.322	-3.926	11.757

SUMMARY OUTPUT: Average Trip Length (Miles)						
Regression Statistics						
Multiple R	0.151					
R Square	0.023					
Adjusted R Square	-0.059					
Standard Error	2.818					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	11.128	2.226	0.280	0.922	
Residual	60	476.458	7.941			
Total	65	487.586				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.642	2.880	2.306	0.025	0.880	12.403
Phone Fitt Total Score (Higher Score = More Active)	-0.006	0.030	-0.208	0.836	-0.066	0.053
Unified Physical Activity Index (Higher Score = More A	-0.003	0.025	-0.117	0.907	-0.053	0.047
Vo2Max Score (Higher Score = More Fit)	0.043	0.057	0.758	0.451	-0.071	0.158
WalkTime (msec) (Higher Score = Less Fit)	-0.0002	0.0002	-0.729	0.469	-0.001	0.0003
HeadNeck (0=Pass, 1-Fail)	0.160	0.710	0.225	0.822	-1.260	1.580

SUMMARY OUTPUT: All Glances Per Minute						
Regression Statistics						
Multiple R	0.200					
R Square	0.040					
Adjusted R Square	-0.040					
Standard Error	2.161					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	11.635	2.327	0.498	0.776	
Residual	60	280.246	4.671			
Total	65	291.881				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	8.422	2.209	3.812	0.000	4.003	12.840
Phone Fitt Total Score (Higher Score = More Active)	0.011	0.023	0.474	0.637	-0.035	0.056
Unified Physical Activity Index (Higher Score = More Fit)	0.006	0.019	0.318	0.752	-0.032	0.045
Vo2Max Score (Higher Score = More Fit)	-0.056	0.044	-1.287	0.203	-0.144	0.031
WalkTime (msec) (Higher Score = Less Fit)	0.000	0.000	-0.839	0.405	-0.001	0.0002
HeadNeck (0=Pass, 1-Fail)	-0.046	0.545	-0.085	0.933	-1.135	1.043

SUMMARY OUTPUT: All Shoulder Checks Per Minute						
Regression Statistics						
Multiple R	0.324					
R Square	0.105					
Adjusted R Square	0.031					
Standard Error	0.193					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	0.263	0.053	1.410	0.234	
Residual	60	2.237	0.037			
Total	65	2.499				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.116	0.197	0.586	0.560	-0.279	0.510
Phone Fitt Total Score (Higher Score = More Active)	0.002	0.002	1.164	0.249	-0.002	0.006
Unified Physical Activity Index (Higher Score = More Active)	-0.002	0.002	-1.303	0.197	-0.006	0.001
Vo2Max Score (Higher Score = More Fit)	0.0001	0.004	0.034	0.973	-0.008	0.008
WalkTime (msec) (Higher Score = Less Fit)	1.66107E-05	1.64E-05	1.012775	0.315234	-1.61965E-05	4.94E-05
HeadNeck (0=Pass, 1-Fail)	-0.096	0.049	-1.969	0.054	-0.193	0.002

SUMMARY OUTPUT: All Glances And Shoulder Checks Per Minute						
Regression Statistics						
Multiple R	0.192					
R Square	0.037					
Adjusted R Square	-0.043					
Standard Error	2.211					
Observations	66					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	11.204	2.241	0.458	0.806	
Residual	60	293.300	4.888			
Total	65	304.504				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	8.537	2.260	3.778	0.000	4.017	13.058
Phone Fitt Total Score (Higher Score = More Active)	0.013	0.023	0.565	0.574	-0.034	0.060
Unified Physical Activity Index (Higher Score = More Act	0.004	0.020	0.197	0.845	-0.036	0.043
Vo2Max Score (Higher Score = More Fit)	-0.056	0.045	-1.255	0.214	-0.146	0.033
WalkTime (msec) (Higher Score = Less Fit)	-0.0001	0.0002	-0.732	0.467	-0.0005	0.0002
HeadNeck (0=Pass, 1-Fail)	-0.142	0.557	-0.255	0.800	-1.256	0.972

Appendix H: Analysis Results for Non-Significant Regression Models –Cognitive Function and Driving Exposure

SUMMARY OUTPUT: Trips Per Vehicle Instrumentation Day							
Regression Statistics							
Multiple R	0.198						
R Square	0.039						
Adjusted R Square	-0.010						
Standard Error	0.619						
Observations	63						
ANOVA							
	df	*SS*	*MS*	*F*	*Significance F*		
Regression	3	0.922	0.307	0.803	0.497		
Residual	59	22.577	0.383				
Total	62	23.499					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	
Intercept	1.224	0.204	6.004	1.27E-07	0.816	1.631	
Trails A (msec) (Higher Score = Less Fit)	-3.177E-06	6.73E-06	-0.472	0.638	-1.66387E-05	1.03E-05	
Trails B (msec) (Higher Score = Less Fit)	-2.2148E-06	2.27E-06	-0.976	0.333	-6.75568E-06	2.33E-06	
MAZE 2 (msec) (Higher Score = Less Fit)	3.547E-06	5.55E-06	0.639	0.526	-7.56681E-06	1.47E-05	

SUMMARY OUTPUT: Driving Minutes Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.294					
R Square	0.087					
Adjusted R Square	0.040					
Standard Error	4.900					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	134.507	44.836	1.867	0.145	
Residual	59	1416.655	24.011			
Total	62	1551.162				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13.923	1.614	8.625	4.844E-12	10.693	17.154
Trails A (msec) (Higher Score = Less Fit)	6.14063E-06	5.33E-05	0.115	0.909	-0.0001	0.0001
Trails B (msec) (Higher Score = Less Fit)	-3.64515E-05	1.8E-05	-2.028	0.047	-7.24212E-05	-4.81895E-07
MAZE 2 (msec) (Higher Score = Less Fit)	2.21055E-05	4.4E-05	0.502	0.617	-6.5931E-05	0.0001

SUMMARY OUTPUT: Longest Trip Time (Mins)						
Regression Statistics						
Multiple R	0.170					
R Square	0.029					
Adjusted R Square	-0.020					
Standard Error	16.504					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	479.046	159.682	0.586	0.626	
Residual	59	16070.057	272.374			
Total	62	16549.103				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	41.368	5.437	7.608	0.000	30.488	52.247
Trails A (msec) (Higher Score = Less Fit)	0.0002	0.0002	1.291	0.202	-0.0001	0.001
Trails B (msec) (Higher Score = Less Fit)	-5.6202E-05	6.05E-05	-0.928	0.357	-0.0002	6.49E-05
MAZE 2 (msec) (Higher Score = Less Fit)	-9.0294E-05	0.0001	-0.609	0.545	-0.0004	0.0002

SUMMARY OUTPUT: Average Trip Length (Mins)						
Regression Statistics						
Multiple R	0.206					
R Square	0.042					
Adjusted R Square	-0.006					
Standard Error	4.453					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	51.735	17.245	0.870	0.462	
Residual	59	1170.064	19.832			
Total	62	1221.799				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13.344	1.467	9.095	7.93E-13	10.408	16.280
Trails A (msec) (Higher Score = Less Fit)	6.98564E-05	4.84E-05	1.442	0.154	-2.70547E-05	0.000
Trails B (msec) (Higher Score = Less Fit)	-1.78588E-05	1.63E-05	-1.093	0.279	-5.05484E-05	1.48E-05
MAZE 2 (msec) (Higher Score = Less Fit)	-4.68436E-05	4E-05	-1.172	0.246	-0.000126852	3.32E-05

SUMMARY OUTPUT: Driving Miles Per Vehicle Instrumentation Day						
Regression Statistics						
Multiple R	0.262					
R Square	0.069					
Adjusted R Square	0.021					
Standard Error	2.522					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	27.734	9.245	1.453	0.237	
Residual	59	375.373	6.362			
Total	62	403.108				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.059	0.831	7.291	8.7E-10	4.396	7.721
Trails A (msec) (Higher Score = Less Fit)	8.50083E-06	2.74E-05	0.310	0.758	-4.63901E-05	6.34E-05
Trails B (msec) (Higher Score = Less Fit)	-1.69546E-05	9.25E-06	-1.832	0.072	-3.54702E-05	1.56E-06
MAZE 2 (msec) (Higher Score = Less Fit)	2.70749E-06	2.26E-05	0.120	0.905	-4.26096E-05	4.8E-05

SUMMARY OUTPUT: Longest Trip Length (Miles)						
Regression Statistics						
Multiple R	0.146					
R Square	0.021					
Adjusted R Square	-0.028					
Standard Error	15.931					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	325.565	108.522	0.428	0.734	
Residual	59	14974.021	253.797			
Total	62	15299.586				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	26.023	5.248	4.958	6.34E-06	15.521	36.525
Trails A (msec) (Higher Score = Less Fit)	0.0001	0.0002	0.739	0.463	-0.0002	0.0005
Trails B (msec) (Higher Score = Less Fit)	-2.8562E-05	5.84E-05	-0.489	0.627	-0.0001	8.84E-05
MAZE 2 (msec) (Higher Score = Less Fit)	0.000	0.000143	-1.004	0.320	-0.0004	0.000

SUMMARY OUTPUT: Average Trip Length (Miles)						
Regression Statistics						
Multiple R	0.248					
R Square	0.061					
Adjusted R Square	0.014					
Standard Error	2.765					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	29.555	9.852	1.289	0.287	
Residual	59	451.069	7.645			
Total	62	480.624				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.903	0.911	7.578	2.84E-10	5.080	8.726
Trails A (msec) (Higher Score = Less Fit)	4.64569E-05	3.01E-05	1.544922	0.128	-1.37145E-05	0.0001
Trails B (msec) (Higher Score = Less Fit)	-1.43278E-05	1.01E-05	-1.41254	0.163	-3.46245E-05	5.97E-06
MAZE 2 (msec) (Higher Score = Less Fit)	-3.43023E-05	2.48E-05	-1.38171	0.172	-8.39789E-05	1.54E-05

SUMMARY OUTPUT: All Glances Per Minute						
Regression Statistics						
Multiple R	0.211					
R Square	0.045					
Adjusted R Square	-0.004					
Standard Error	2.162					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	12.856	4.285	0.917	0.438	
Residual	59	275.719	4.673			
Total	62	288.576				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.361	0.712	8.931	1.49E-12	4.936	7.786
Trails A (msec) (Higher Score = Less Fit)	2.4346E-05	2.35E-05	1.036	0.305	-2.26976E-05	7.14E-05
Trails B (msec) (Higher Score = Less Fit)	-2.354E-06	7.93E-06	-0.297	0.768	-1.8223E-05	1.35E-05
MAZE 2 (msec) (Higher Score = Less Fit)	-3.154E-05	1.94E-05	-1.625	0.110	-7.03758E-05	7.3E-06

SUMMARY OUTPUT: All Shoulder Checks Per Minute						
Regression Statistics						
Multiple R	0.226					
R Square	0.051					
Adjusted R Square	0.003					
Standard Error	0.199					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	0.126	0.042	1.061	0.373	
Residual	59	2.337	0.040			
Total	62	2.463				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.266	0.066	4.050	0.0002	0.134	0.397
Trails A (msec) (Higher Score = Less Fit)	-3.8E-06	2.16E-06	-1.768	0.082	-8.15708E-06	5.05E-07
Trails B (msec) (Higher Score = Less Fit)	8.38E-07	7.3E-07	1.148	0.255	-6.22508E-07	2.3E-06
MAZE 2 (msec) (Higher Score = Less Fit)	1.78E-06	1.79E-06	0.997	0.323	-1.79465E-06	5.36E-06

SUMMARY OUTPUT: All Glances And Shoulder Checks Per Minute						
Regression Statistics						
Multiple R	0.195					
R Square	0.038					
Adjusted R Square	-0.011					
Standard Error	2.215					
Observations	63					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	11.464	3.821	0.779	0.510	
Residual	59	289.390	4.905			
Total	62	300.854				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.626	0.730	9.082	8.35E-13	5.166	8.086
Trails A (msec) (Higher Score = Less Fit)	2.05203E-05	2.41E-05	0.852	0.398	-2.76756E-05	6.87E-05
Trails B (msec) (Higher Score = Less Fit)	-1.5159E-06	8.12E-06	-0.187	0.853	-1.77731E-05	1.47E-05
MAZE 2 (msec) (Higher Score = Less Fit)	-2.9756E-05	1.99E-05	-1.496	0.140	-6.95459E-05	1E-05

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