Supporting Statements: Part B
[title of collection]
OMB Control Number: 2127-XXXX
(NHTSA-2024-0056)

Abstract:

The National Highway Traffic Safety Administration (NHTSA) is seeking approval for this new information collection request (ICR) to collect detailed information on current body size and shape, posture, and motion of vehicle occupants. This research will support NHTSA in the development of tools used for occupant protection during crashes, particularly in the context of crashworthiness among occupants over a wide range of body shapes and sizes. This research will add to collective knowledge and is not intended to inform regulations or policy.

The designs of anthropomorphic test devices (ATDs, commonly known as crash test dummies) are based on measurements of volunteers sitting in vehicle and laboratory seats. The current generation of ATDs is based on data gathered at University of Michigan Transportation Research Institute (UMTRI) in the 1980s. Since that time, the U.S. population has change substantially, most notably due to the large increase in body mass.[1] Measurement technologies have also improved dramatically with the development of fast three-dimensional surface measurement systems. Seating configurations have also expanded from the traditional seat posture collected in the 1980s with increased recline angles in modern vehicles. This combination of a population size shift and more variable seat configurations presents a clear need for updated seated anthropometry to be collected with new advanced anthropometry measurement capabilities.

The data collections, approved by the Institutional Review Board at the University of Michigan, will be performed once to obtain the target number of valid test participants. Study participants will be male and female licensed adult drivers from the general public, and participation will be voluntary with monetary compensation provided. Participants are recruited using University of Michigan's Health Research portal, https://umhealthresearch.org/. The voluntary study would involve recruiting licensed drivers for two studies (in-lab and in-vehicle). For the in-lab study, the following information collections include (1) an online screening questionnaire; (2) an eligibility phone call to confirm eligibility, interest, and schedule a time in the lab; (3) informed consent for the in-lab study and anthropometric measurement. A subset of the in-lab participants will be asked to participate in the in-vehicle study and the following information collections include (1) a pre-drive questionnaire for the in-vehicle study; (2) informed consent for the in-vehicle study and anthropometric measurements; and (3) a post-drive questionnaire for the in-vehicle study.

In this study, 3D surface scan data quantifying body size and shape in a range of postures will be obtained. Posture, position, and belt fit in driver and passenger seating mockups that are adjusted

[1] Flegal, Katherine M., et al. "Trends in obesity among adults in the United States, 2005 to 2014." Jama 315.21 (2016): 2284-2291

to a wide range of vehicle configurations and using multiple seats will be measured. The participants will be selected to span a wide range of stature and weight, spanning the 5th percentile female (height 149.8 cm and body weight 49.8 kg) to 95th percentile male (height 187.4 cm and body weight 130.3 kg) values.[2] Individuals with high body mass will be preferentially selected to address the current lack of data from that cohort. An in-vehicle study will be conducted using participants recruited from among those participating in the laboratory study. The goal of the in-vehicle study is to validate the driver postures measured in the laboratory and to obtain high-resolution 3D data on postures and movements during driving. A particular focus is on the lower extremities, where crash injury data have indicated a large difference in risk between male and female drivers.[3] Body scans, measurements, and any video will be de-identified prior to submission to NHTSA. Statistical models will also be developed from de-identified data and made available to the public through a software tool.

This research study will gather a new database of information on adult body size, shape, posture, and motion to support advancement in these safety applications. This study will add to the body of knowledge on motor vehicle anthropometry and will support occupant crash safety and protection through the development of human body models (HBMs) and anthropomorphic test devices (ATDs). A technical report on the project and outcomes will be prepared and published.

It is estimated a total 1,033 burden hours for the new collection. The only cost burdens respondents may incur are those related to travel to and from the study location for those that participate. The estimated total travel cost burden to all respondents will be no more than $10,720.

B. JUSTIFICATION

B.1 Describe the potential respondent universe and any sampling or other respondent selection to be used.

The respondent universe will be licensed drivers, ages 18 and older. The sample frame will be the licensed drivers, ages 18 and older in the Ann Arbor, MI region, and willing to travel to UMTRI. It is anticipated the sample frame will adequately represent the respondent universe with respect to anthropometry. From the Ann Arbor sampling frame, a convenience sample will be collected using University of Michigan's Health Research portal, https://umhealthresearch.org/. The study information as IRB approved will be provided to the research portal containing tens of thousands of registered participants who have opted to be contacted about safety research studies. Due to the broad inclusion criteria for this study, the

[2] Fryar, Cheryl D. et al. (2021). Anthropometric reference data for children and adults : United States, 2015-2018. 3(46).

[3] Forman, J., Poplin, G. S., Shaw, C. G., McMurry, T. L., Schmidt, K., Ash, J., & Sunnevang, C. (2019). Automobile injury trends in the contemporary fleet: Belted occupants in frontal collisions. *Traffic Inj Prev*, *20*(6), 607-612. https://doi.org/10.1080/15389588.2019.1630825

study information will likely be included in the portal's broadcast emails to registered participants. Prospective participants will respond to the U-M Health Research posting by completing a screening questionnaire on a Google Form. Participants who screen eligible will be contacted by phone to confirm the survey responses and, if eligible, to schedule an appointment (see scripts). Eligible participants are those whose answers to the Google Form questions are consistent with the inclusion and exclusion criteria. Self-reported stature and body weight are collected within the initial Google Form and the study team will use this to ensure target stature and body weight bins are adequately sampled. We estimate that 2000 screening questionnaires will be filled out to obtain the needed number of subjects. The form has 23 questions, including name, address, and time slots available. We estimate that up to 600 individuals will need to be contacted to obtain the needed number of 300 subjects for the lab study. This considers that some people's schedules may not match up with lab openings, or they may not show up for their scheduled appointment.

Eligibility requirements include the ability to read and speak English, to drive for two hours continuously, hold a current and unrestricted U.S. driver's license, have at least one year as a licensed driver, drive a car daily for an average of at least 15 minutes, and be comfortable driving on the highway and local roads. Exclusion criteria include individuals with musculoskeletal ailments impeding the ability to walk or sit comfortably or musculoskeletal deformities such as scoliosis or amputations.

B.2 Describe the procedures for the collection of information.

Individuals who have expressed interest in study participation through the University of Michigan's Health Research portal and meet the eligibility criteria based on their Google Form (FORM 1824) will be contacted by phone (FORM 1825). The investigators identify individuals who may be eligible based on their responses on the screening questionnaire, confirm eligibility and continued interest, and set up a time for in-lab consent and data collection. No new information is obtained during this call. At the study visit, the 300 participants will be escorted to a private room upon arrival at UMTRI for the consent process (FORM 1826). Each version of the consent is set up electronically. Participants will undergo the consent process with a member of the research team using a desktop computer or tablet. After electronically signing the consent document, the participant will be able to download or be emailed a copy of the signed form. After consent, participants will undergo a series of anthropometric measurements to include (1) standard manual anthropometric measurements; (2) seated measurements in a hardseat with a portable coordinate measuring machine (FARO Arm); (3) additional landmark measurements in seating mockups using the FARO Arm; (4) a 3D surface scan in the seating mockup using a 3D scanner; and (5) whole body scanning in the VITUS XXL whole body laser scanner.

A subset of the in-lab respondents will be selected for the in-vehicle study. These 100 participants will be asked to complete an electronic questionnaire to capture additional

information about footwear (FORM 1827). The 100 participants from the in-lab study will participate in the in-vehicle study. Upon arrival for the in-vehicle study, participants will undergo the consent process with a member of the research team (FORM 1828). After consent, participants will be trained on the vehicle-specific safety and ADAS features (we plan to select vehicles with adaptive cruise control; other ADAS systems may also be present). The training will include video and presentations of the vehicle technologies obtained from the manufacturer, relevant excerpts from the owner's manual, and materials developed by the research team that demonstrate the performance of the vehicle functions. Once seated in the vehicle, participants will be prompted to select a comfortable seat position and posture. A prescribed adjustment procedure with prompting for each component will be used to ensure that the subject adjusts everything and doesn't just accept what they were provided. Posture, belt fit, and position of selected vehicle components will be recorded using a FARO Arm coordinate measurement system and the vehicle DAS. Naturalistic driving data collection will occur whenever the participant needs to drive somewhere over the course of a 7 to 10-day period where data is collected whenever the participant drives, but the on-site study time is only 2 hours. If future budget appropriations limit data collection efforts, data will only be collected over a 2-hour planned route. The total burden hours will be a total of two hours regardless of budget appropriations. Participants will be asked to drive as they normally would in their everyday driving. Video will be recorded of the driver and foot well to capture motion throughout each drive. After the data collection period, participants will return the vehicle to UMTRI, and their posture and belt fit will be recorded again will be recorded again using a FARO Arm before they exit the vehicle. They will then complete a post-drive questionnaire to obtain feedback about their experience in the study as well as vehicle comfort (FORM 1848). The in-lab time for vehicle data collection will take 2 hours between the pre- and post-drive collections.

The final sample will consist of 300 participants for the in-lab study and 100 participants for the in-vehicle study. The respondents will be males and females, ages 18 and older. Efforts will be made to enroll male and female participants across a range of ages, stature by sex, and body mass index (BMI). Although there are no fixed requirements, target enrollment will be 50% male and 50% female where 50% of individuals have a BMI under 30 kg/m^2, 33% have a BMI between 30 kg/m^2 and 40 kg/m^2, and 17% have a BMI greater than 40 $kg/m.^2$ An age between 30 and 60 years will be targeted for roughly 70% of the total participants.

B.3 Describe methods to maximize response rates.

Participation in the study is voluntary. Response rate will be maximized through the broad range of inclusion criteria and utilization of the large network established through the University of Michigan's Health Research portal. NHTSA plans to provide monetary payment at a rate of $40 per hour for both in-lab and in-vehicle study participation. Each part of the study (in-lab and in-vehicle) requires two hours of time, so an anticipated $80 will be provided to participants for each study. Such compensation is consistent with normal experimental practice to compensate

participants for their time and encourage participation in research studies. We determined that $40 per hour is appropriate to capture opportunity costs and travel. Recruitment of non-college aged individuals should be competitive with hourly rates found in a college town without payment being coercive while also high enough to draw in professionals that make more than the average wage. The amount of compensation offered covers typical costs incurred such as travel. Our facility does not charge for parking and the nearest bus is free fare. The screening questionnaire through University of Michigan's Health Research portal will remain open for the duration of the study to allow continuous enrollment until 300 participants are reached.

B.4 Describe any tests of procedures or methods to be undertaken.

This project will include two data collection studies: 1) In-Lab Study and 2) In-Vehicle Study.

In-Lab Study

Overview

Participants will complete a written informed consent in an UMTRI laboratory. Participants will change into tight-fitting clothing provided by the investigators. Body shape will be recorded in multiple postures using two optical surface measurement systems. Posture will be recorded using a manual coordinate measurement machine and a 3D optical sensing system as the participant sits in a range of vehicle seating conditions.

Manual Measurements

Manual measurements of body dimensions will be obtained using standard anthropometric techniques.

Body Composition

Body mass and composition (fat and lean mass percentages) will be measured in the laboratory using a Tanita SC-331S bioelectric impedance analysis scale. Weight and percent body fat will be the average of two measurements assessed (to the nearest 0.1 kg and 0.1%, respectively) with the Tanita scale. Two measures of each will be taken, and if not within 0.2 kg and 0.2%, a third measure will be taken.

Whole-Body Surface Measurement

Surface body shape data will be gathered using a VITUS XXL surface measurement system (Vitronic/Human Solutions: https://www.vitronic.com/en-us/3d-bodyscan/scanner-for-performance-diagnostics). The system is an upgraded version of a VITUS system that the study team has used on more than a dozen previously approved studies with adults and children (e.g., HUM00158177). Over a measurement interval of about 12 seconds, eye-safe, invisible lasers sweep a horizontal line on the participant from top to bottom. Cameras on four columns around

the participant capture the contour of the line and convert it to about 500k 3D points. Software stitches the point data into a smooth “avatar” representing the body surface.

Data will be gathered in a range of standing and seated postures. Prior to data collection, landmarks on the participant’s body, such as at the elbows and knees, may be marked using non-toxic skin paint to facilitate identification of these locations on the scan data. The total duration of high-resolution surface measurement will be about 30 minutes.

Surface point cloud data will be gathered using a lower-resolution system developed at the University of Michigan based on depth cameras. This system has two consumer-grade “depth cameras” that use infrared light to measure the distance from the camera to the participant and convert the information to 3D points. Measurements using the low-resolution system will be made with the participant in their street clothing as well as in the clothing used for the high-resolution measurements. These sensors have been used by the study team in several prior IRB-approved studies (e.g., HUM00158177). The total duration of low-resolution surface measurement will be about three minutes.

Head and Hand Surface Measurement

Head and hand surface data will be gathered in a 3dMD surface measurement system (https://3dmd.com/3dmdhead/) that uses high-resolution photographs from specially designed cameras to compute the surface shape. For these measurements, the participant will sit in an adjustable chair with their heads or hands located at the center of the measurement volume. Participants will wear a wig cap that gathers and compresses their hair to enable accurate measurement of the face, ears, and neck. Additional data on scalp contour may be obtained using an optical probe with a blunt tip that enables the surface points to be computed. Head/face data will be gathered with a range of facial expressions to capture the associated variation in face shape. The total duration of head measurement will be approximately 15 minutes.

Hand shape data will be gathered in the same 3dMD surface measurement system. Participants’ hands will be measured in a range of poses, including a flat hand, fist, and various grasps. For some poses the participant will grasp or place their hands against an object, such as a cylinder or ball. The total duration of hand measurement will be approximately 10 minutes.

Grip Strength

Grip strength in both hands will be measured using a hand dynamometer. The aperture will be adjusted to provide an equivalent hand posture for all participants. Three trials will be performed using each hand, alternating between left and right. Each trial will be a one second ramp up followed by a three-second hold. The investigator will coach the participant to produce maximum effort.

Mockups and Seats

Participants will be measured as they sit in a mockup of a vehicle interior and in multiple seats. The mockups will represent the essential interior components of the vehicle interior, including the instrument panel, pedals, steering wheel, floor, seat, and belt. The new mockup will use recent-model components, including the instrument panel, steering wheel, and steering column. We may add a center console and minimal door armrest to enable measurement of inboard-leaning postures. The mockup will be designed to be highly adjustable, such that the relationships between the steering wheel, pedals, and seats will represent a wide range of different vehicle driver package configurations. A range of belt anchorage locations will also be included.

The passenger mockup will be constructed that will enable the belt anchorages to be moved and provide adjustability for seat height (SAE H30). These parameters, along with seat back angle, will be used to set test conditions. We will use the same seats for the passenger mockup, since left and right front seats are typically very similar. The mockups will be designed so that the seats can be rapidly switched out.

In some mockup conditions, the participant's posture will be measured using a FARO Arm coordinate digitizer. The investigator will identify surface landmarks of interest, such as the top of the sternum, place the FARO Arm probe at the location, and press a button to record the three-dimensional location. Approximately 30 landmark locations will be measured in about one minute as the participant holds their posture. We will also capture the participant's posture using an UMTRI-developed system that uses 3D cameras. This process is instantaneous. The participant will also be measured using the FARO Arm in a laboratory "hardseat," a specially constructed seat that provides access to posterior spine and pelvis landmarks. Data from this seat are used to aid in the estimation of the skeletal posture in the vehicle seats where the posterior landmarks are not accessible.

In-Vehicle Study

Overview

The goal of the vehicle study is to gather realistic data on driving postures to validate and extend the laboratory measurements. Participants recruited from among those who participate in the lab study will drive an instrumented vehicle in place of their own vehicle over the course of a 7 to 10-day period where data is collected whenever the participant drives, but the on-site study time is only 2 hours. If future budget appropriations limit data collection efforts, data will only be collected over a 2-hour planned route. The total burden hours will be a total of two hours regardless of budget appropriations.

Data Collection

The consent process will be conducted during the vehicle pick-up appointment. Investigators will explain the procedure and answer any questions. As with the lab study, we will position the adjustable components in the vehicle in a specified manner for all participants. All adjustments will be placed in their middle position (steering wheel tilt and telescope and D-ring location, for example) except that the driver fore-aft seat position and seat back angle will be set based on our driver-selected seat position model for that subject's stature. This minimizes the bias produced by the initial seat position.

Participants will be trained on the vehicle-specific safety and advanced driver assistance systems (ADAS) features (we plan to select vehicles with adaptive cruise control; other ADAS systems may also be present). The training will include video and presentations of the vehicle technologies obtained from the manufacturer, relevant excerpts from the owner's manual, and materials developed by the research team that demonstrate the performance of the vehicle functions. Participants will also be asked to complete an initial questionnaire about their demographics, typical commute and driving practices, previous experiences with a range of vehicle technologies (e.g., cruise control, ADAS features), and their typical footwear preferences when driving. Once seated in the vehicle, participants will be prompted to select a comfortable seat position and posture. We will use a prescribed adjustment procedure with prompting for each component to ensure that the subject adjusts everything and doesn't just accept what they were provided.

We will record their posture, belt fit, and position of selected vehicle components using a FARO Arm coordinate measurement system and the vehicle data acquisition system (DAS). Naturalistic driving data collection will occur over a 7-to-10-day period where participant's active data collection time will be a total of two hours. Participants will be asked to drive as they normally would in their everyday driving. After the data collection period, participants will return the vehicle to UMTRI, and we will measure their posture and belt fit before they exit the vehicle. During the vehicle drop-off appointment, participants will be asked debriefing items to obtain feedback about their experience in the study. We will also ask participants to rate the vehicle comfort and fit.

B.5 Provide the name and telephone number of individuals consulted on statistical aspects of the design.

Matthew Reed, PhD, University of Michigan, 734-936-1111
Elizabeth Lafferty, NHTSA, 202-366-6222