

UMTRI-91-29

**AN INVESTIGATION OF PREFERRED STEERING WHEEL LOCATIONS
AND DRIVER POSITIONING IN LATE-MODEL VEHICLES**

FINAL REPORT

Lawrence W. Schneider
Miriam A. Manary

University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, Michigan 48109-2150

Submitted to:

CPC and BOC Divisions
General Motors Corporation

May 1991

Technical Report Documentation Page

1. Report No. UMTRI-91-29		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle AN INVESTIGATION OF PREFERRED STEERING WHEEL LOCATIONS AND DRIVER POSITIONING IN LATE-MODEL VEHICLES				5. Report Date May 1991	
				6. Performing Organization Code	
7. Author(s) L.W. Schneider and M.A. Manary				8. Performing Organization Report No. UMTRI-91-29	
9. Performing Organization Name and Address University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, MI 48109-2150				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address CPC and BOC Divisions General Motors Corporation 895 Joslyn Avenue Pontiac, MI 48058-1493				13. Type of Report and Period Covered FINAL REPORT	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract <p>This study investigated several aspects of driver seating and positioning in late-model vehicles. The study was conducted using vehicles with different seat-package dimensions and geometries including a 1987 Camaro, a 1987 Monte Carlo, a 1987 Cadillac Sedan Deville, a 1986 Pontiac 6000, a 1987 Oldsmobile Touring Sedan, and a 1987 Chevrolet Blazer. Five of the six vehicles were modified to allow longer fore/aft seat travel than the production vehicles and all were provided with readout scales for seat position and seat recline angles. All vehicles were also provided with tilt steering wheels with readout scales, and three of the vehicles were equipped with adjustable (fore/aft) pedals. Subjects tested included males and females representing the U.S. population stature range from 5th-percentile female to 95th-percentile male. Data collected included three-dimensional eye position, preferred seat detent, seat recline angle, tilt-wheel angle, and estimates for preferred steering wheel fore/aft locations.</p> <p>Eye position distributions show decreased lateral variability and mean values closer to the seat centerline than currently defined by SAE J941. In addition, the eyellipse centroids are slightly higher relative to H-point and the major axes are longer than those specified in J941, even after adjustment for seatback recline angle. An unexpected finding was for the estimated population distributions of preferred seat position to be further rearward in many of the vehicles than predicted by the SAE Seating Accommodation Model J1517. Seatback recline angle usage patterns suggest that drivers generally tend to sit more upright than the design back angles and that many drivers would prefer a more inclined seatback position than allowed by the recliner mechanism.</p>					
17. Key Words Vehicle packaging; Driver seating; Driver eye position; Steering wheel location; Seat recliner usage; Seat positioning			18. Distribution Statement Limited Distribution		
19. Security Classif. (of this report)		20. Security Classif. (of this page)		21. No. of Pages 255	22. Price

Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The authors would like to acknowledge the invaluable input and guidance provided to this project by Ron Roe, Pete Kobrehel, Larry Gidell, and John Buglione of the CPC Human Factors Engineering Staff. In particular, much of the experimental design for this project was developed by Ron Roe and most of the vehicle modifications and calibrations (e.g., extended seat track adjustability and readouts) were designed and implemented by CPC engineering and technical staff.

Appreciation is also expressed to James Embach, formerly of the Buick, Oldsmobile, Cadillac (BOC) Division of General Motors, who provided additional input to the project and who was instrumental in obtaining financial support from BOC which helped greatly to enhance the research effort and ensure successful continuation of the project to completion.

The authors would also like to thank and acknowledge the many members of the UMTRI staff who contributed to the successful completion of this study. These include Eric Olson and Scott Orr who performed most of the subject testing and stereophotogrammetric data processing; Ernest Lueder and Brian Eby who fabricated special fixtures required throughout the experimentation; Jeff Lehman who created computer programs for the processing of eye position data; and Leda Ricci who assembled and prepared this report.

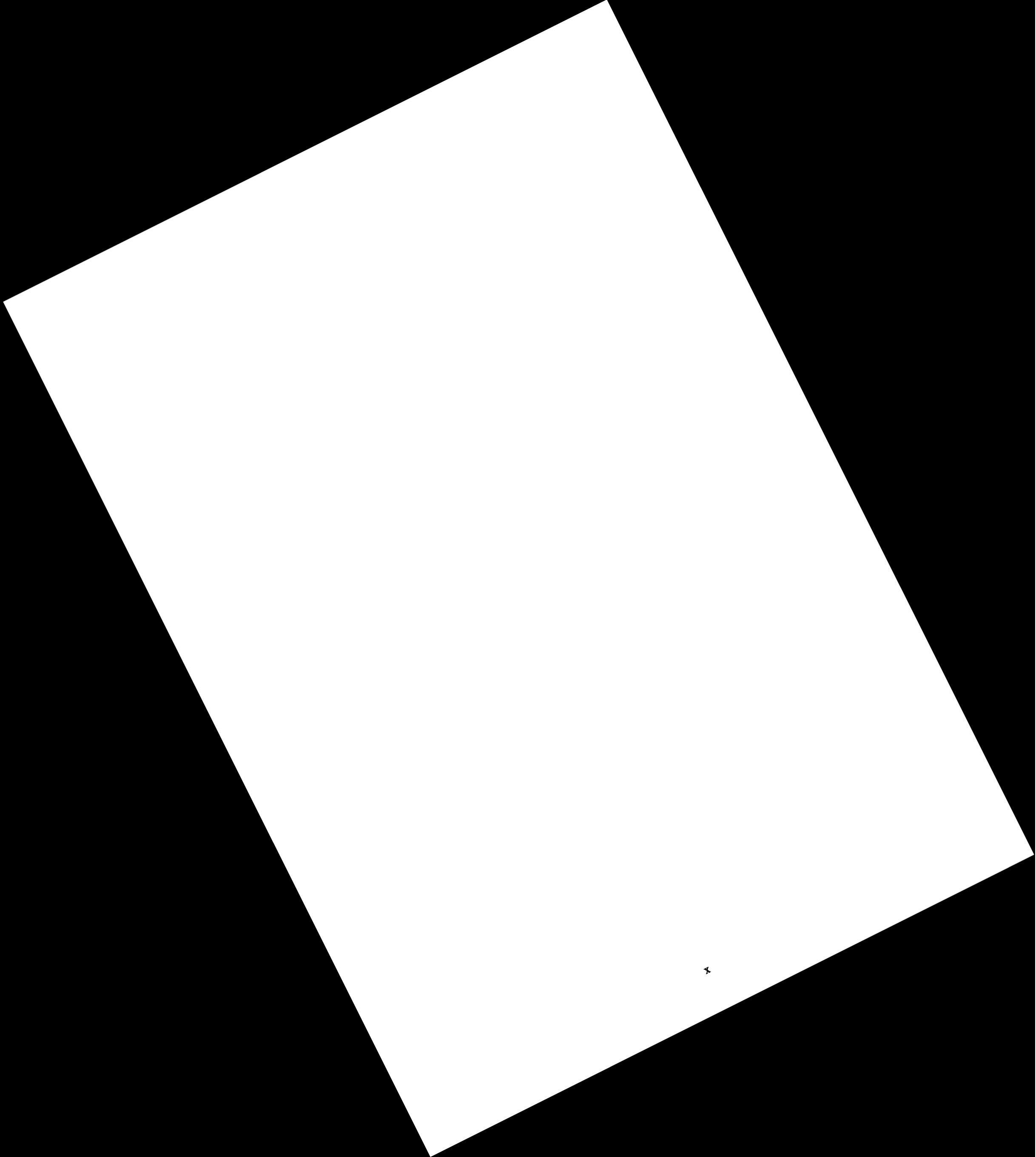
CONTENTS

ACKNOWLEDGEMENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	xi
SUMMARY	1
I. INTRODUCTION AND OBJECTIVES	3
II. PROCEDURES	5
2.1 Pilot Study Re: Preferred Steering Wheel Location	5
2.2 Phase I Procedures	7
2.3 Phase II Procedures	13
2.4 Phase III Procedures	14
2.5 Data Processing and Analysis	15
III. RESULTS	17
3.1 Wheel Position Pilot Study (Monte Carlo and Camaro)	17
3.2 Phase I Anthropometry and Preferred Wheel/Seat Results (Camaro, Cadillac, Monte Carlo, Blazer)	19
3.3 Preferred Wheel Position	29
3.4 Phase I Eye Position Results	34
3.5 Phase II Results	34
3.6 Phase III Results	40
IV. SUMMARY AND DISCUSSION OF KEY FINDINGS	43
REFERENCES	47
APPENDICES	49
A. Modified Monte Carlo Pedals and Test Vehicle Readout Scales ..	51
B. Summary of Package and Test Vehicle Coordinates, Dimensions, and Features	65
C. Data Collection Forms	73
D. Preferred Wheel Position Pilot Study Results	79
E. Phase I Results—Part I: Anthropometric Results by Subject Group	97
F. Phase I Results—Part II: Preferred Seat Positions, Seatback Angles, and Steering Wheel Angles	119

G.	Phase I Preferred Wheel Position Results	147
H.	Phase I Eye Position Results	171
I.	Phase II Results	183
J.	Phase III Results: Dynamic versus Static Seat and Eye Position in Pontiac 6000	213
K.	Data by Subject	223

LIST OF TABLES

		Page
1.	Subject Group Definitions by Stature	8
2.	Subject Weighting Factors Used for Computing Distributions of Seat Position	23
3.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Blazer Phase I	24
4.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Cadillac Phase I	25
5.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Camaro Phase I	26
6.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Monte Carlo Phase I	27
7.	Summary of Preferred Cadillac Six-Way Seat Adjustments	29
8.	Phase I Comparison of Wheel-to-Pedal Distances	33
9.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Camaro Phase II	37
10.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Oldsmobile Phase II	38
11.	Comparison of Actual and Predicted H-Point-to-BOF Distances: Static Test Results for Pontiac 6000 Phase II	39
12.	Comparison of SAE J1517 to Observed H-Point-to-BOF Distances: Static and Dynamic Results for Pontiac 6000 Phase III	41



LIST OF FIGURES

		Page
1.	Vehicle stereophotogrammetry calibration targets on Chevy Blazer and Cadillac Sedan Deville	10
2.	Camera/vehicle setup for eye position data collection	12
3.	Overall mean seatback angles for Camaro, Monte Carlo, Cadillac, and Blazer	21
4.	Overall mean values for wheel-tilt angle	22
5.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Blazer, Phase I	24
6.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Cadillac, Phase I	25
7.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Camaro, Phase I	26
8.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Monte Carlo, Phase I	27
9.	Preferred seatback angle relative to vertical by subject group for Cadillac six-way power seat in Phase I testing	30
10.	Preferred seatback angle relative to seat by subject group for Cadillac six-way power seat in Phase I testing	30
11.	Preferred seat height adjustment by subject group for Cadillac six-way power seat in Phase I testing	31
12.	Preferred seat pan adjustment by subject group for Cadillac six-way power seat in Phase I testing	31
13.	Preferred hip angle adjustment by subject group for Cadillac six-way power seat in Phase I testing	32
14.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Camaro, Phase II	37
15.	Comparison of SAE J1517 to observed H-Point-to-BOF distances for Oldsmobile, Phase II	38
16.	Comparison of SAE J1517 to observed H-Point-to-BOF distances: Static test results for Pontiac 6000 Phase II	39
17.	Comparison of SAE J12517 to Observed H-Point-to-BOF distances: Static and dynamic test results for Pontiac 6000 Phase III	41

SUMMARY

This study investigated several aspects of driver seating and positioning in late-model vehicles. The study was conducted using vehicles with different seat-package dimensions and geometries including a 1987 Camaro, a 1987 Monte Carlo, a 1987 Cadillac Sedan Deville, a 1986 Pontiac 6000, a 1987 Oldsmobile Touring Sedan, and a 1987 Chevrolet Blazer. Five of the six were modified to allow longer fore/aft seat travel than the production vehicles and all were provided with readout scales for seat position and seat recline angles. All vehicles were also provided with tilt steering wheels with readout scales, and three of the vehicles were equipped with adjustable (fore/aft) pedals. Subjects tested included males and females representing the U.S. population stature range from 5th-percentile female to 95th-percentile male. Data collected included three-dimensional eye position, preferred seat detent, seat recline angle, tilt-wheel angle, and estimates for preferred steering wheel fore/aft locations.

Eye position distributions show decreased lateral variability and mean values closer to the seat centerline than currently defined by SAE J941. In addition, the eyellipse centroids are slightly higher relative to H-point and the major axes are longer than those specified in J941, even after adjustment for seatback recline angle. An unexpected finding was for the estimated population distributions of preferred seat position to be further rearward in many of the vehicles than predicted by the SAE Seating Accommodation Model J1517. Seatback recline angle usage patterns suggest that drivers generally tend to sit more upright than the design back angles and that many drivers would prefer a more inclined seatback position than allowed by the recliner mechanism.

I. INTRODUCTION AND OBJECTIVES

This study¹ was initiated to investigate several factors related to driver position and preference for seat and steering wheel locations in late-model vehicles. In particular, it was desired to determine:

1. driver preference for steering wheel front/back location with respect to the pedals;
2. patterns and preference in seatback recliner use;
3. the potential influence of seatback recline angles and usage patterns on driver eyellipses and head position in the X-Y (i.e., lateral) plane; and
4. the influence of contoured bucket seats and late-model vehicle geometry on lateral eyellipse variability and location.

The full-scale study was preceded by two pilot studies. In the first, an investigation of the effect of contoured bucket seats on driver lean during straight-ahead driving was conducted using videotape monitoring of drivers' head and shoulder lateral positions in two vehicles equipped with bench and bucket seats, respectively. The procedures and results are described and reported in a separate document (Lee and Schneider 1988) and will not be described in detail here. The general findings from this preliminary investigation were that:

- There is little difference in lateral lean measured either by frequency or magnitude of movement for drivers sitting in bench and bucket seats during straight-ahead driving.
- In the mean, drivers tend to center their head and torso on the seat centerline, or just inboard, and not outboard of the seat centerline as suggested by the current location of the SAE eyellipse centroid (SAE J941).

The second pilot study was conducted to develop and validate a procedure for estimating driver preference for steering wheel location (with respect to the pedals) in unmodified production vehicles. These procedures and the results obtained for two vehicles were subsequently used in the primary investigation which utilized a total of six vehicles and fifty-five subjects spanning the stature range from 5th-percentile female to 95th-percentile

¹The rights, welfare, and informed consent of the volunteer subjects who participated in this study were observed under guidelines established by the U.S. Department of Health, Education, and Welfare Policy (now Health and Human Services) on Protection of Human Subjects and accomplished under medical research design protocol standards approved by the Committee to Review Grants for Clinical Research and Investigation Involving Human Beings, Medical School, The University of Michigan.

male. This report describes and presents the results from the pilot study on preferred steering wheel location and the primary investigation which is divided into three data-collection phases described in Section II.

II. PROCEDURES

2.1 PILOT STUDY RE: PREFERRED STEERING WHEEL LOCATION

Because of the cost of modifying a vehicle so that the steering wheel-to-pedal distance can be easily adjusted, it was considered advantageous to find a means to estimate driver preference for steering wheel-to-pedal front/back distance in production, or unmodified, vehicles. Assuming that a driver has a preferred or optimal seating position relative to the steering wheel as well as an optimal seating position relative to the pedals, it was hypothesized that the optimal steering wheel-to-pedal distance would allow a driver to achieve his/her optimal locations to the pedals and steering wheel simultaneously.

If this is the case, then it was also hypothesized that it might be possible to determine the optimal steering wheel-to-pedal relationship for any driver by determining his/her preferred seat position with respect to the pedals and with respect to the steering wheel independently. The primary question then becomes: How well can a driver estimate his/her preferred seat location with respect to one set of controls (i.e., pedals or steering wheel) while ignoring the other set of controls when the vehicle is, necessarily, in a static or non-moving condition?

In order to evaluate this static seat-positioning method for estimating the optimal steering wheel position in unmodified vehicles, the procedure was tried with eighteen subjects in two automatic transmission vehicles—a Monte Carlo and a Camaro—whose front/back pedal locations relative to the steering wheel could also be easily adjusted. In the Monte Carlo, the pedals were adjustable by interchanging among five sets of accelerator and brake pedals having different length shafts as indicated in Figures A.1 through A.3 of Appendix A. In the Camaro, the brake and accelerator pedals were adjustable by toggling a switch on the driver console which activated a power adjuster mechanism.

Both vehicles were equipped with seat tracks having both manual and power front/back seat adjuster mechanisms. The manual seat adjusters enabled the seats to travel over the normal or production ranges while the electric or power seat adjusters enabled travel beyond the normal range. The seat adjusters, tilt steering wheels, and seat recliners were instrumented with indicator scales to provide manual readout of seat detent, back angle, and wheel position selected by drivers (see Figures A.7 and A.8 of Appendix A). Because of the extended travel on the seat tracks, two scales were provided to read both the *standard* and *extended* seat adjuster positions. Tables B.3 and B.4 in Appendix B summarize the package coordinates and dimensions as well as other features of these two test vehicles.

The subject population consisted of eighteen subjects with equal numbers of males and females, and was further divided according to stature into three groups of six persons each as follows:

1. Females: 5'2" and shorter
2. Females or Males: 5'4" to 5'8"
3. Males: 5'11" and taller

Height was the primary criterion for subject selection but an attempt was also made to recruit a subject population for which age and weight were distributed over a reasonable and "normal" range.

Measurements were taken of each subject when seated in each of the vehicles in order to define his position and posture relative to the controls. These included upper and lower arm angles relative to the horizontal, and the distance from sternum (i.e., chest) to steering wheel center while the subject was in a normal driving position with hands on the wheel at three- and nine-o'clock positions.

Figure C.1 of Appendix C illustrates the data collection form used in this pilot study. Subject testing took place in warm weather to avoid the influence of heavy garments and subjects were instructed to wear comfortable driving clothes and shoes. Prior to the arrival of a subject, the seats were positioned to the most rearward detent, the seatback recliners were positioned to the most vertical position, and the tilt wheels were tilted up to the highest (i.e., most horizontal wheel) positions.

After briefing each subject about the general goals and procedures of the experiment, he/she was instructed to enter one of the two vehicles selected at random in order to become familiar with the component adjustments and to make preliminary adjustments of the seat, seatback angle, and tilt-wheel position. After the investigator recorded these pre-drive positions on the data sheet, the subject was instructed to drive the car over a 1.7-mile route to become more familiar with the seating package and to make any additional adjustments in their statically-selected seat and wheel positions.

Upon return of the subject to the UMTRI parking lot from the initial drive, the investigator recorded the final seat and wheel positions selected. With the seatback angle maintained at the established preferred position, static testing for seat-to-pedals and seat-to-steering wheel relationships was conducted. The subject was first instructed to ignore the steering wheel, which was positioned in the most upward and out-of-the-way location, and to adjust the seat for optimal (i.e., preferred) positioning to the pedals. He/she was then instructed to position the seat, in turn, to the positions considered to be as close to (forward limit) and far from (rearward limit) the pedals that would be acceptable for driving. Following this, the subject repeated two trials of his/her preferred seat-to-pedal location,

exiting the vehicle between trials. The steering wheel was then tilted back to the post-drive preferred position and a similar process was repeated for the subject adjusting the seat to the steering wheel while ignoring the pedals.

As indicated previously and on the data sheet, the extended seat tracks provided with these vehicles resulted in two readouts for position—a *standard* track readout and an *extended* track readout. Combining of the two readouts was necessary to obtain the actual or *resultant* seat position. After a subject had completed the static testing, the detent values for the three preferred seat positions for the seat-to-pedal and seat-to-steering-wheel tests, respectively, were averaged and the difference of the average was taken as the amount of shortening or lengthening of the steering wheel-to-pedal distance required to obtain a more ideal wheel-to-pedal distance for that driver.

If the subject's data suggested that he would prefer a shorter wheel-to-pedal distance (i.e., ideal seat-to-wheel detent further rearward than ideal seat-to-pedal detent), a final test drive was added to the session in which the shorter wheel-to-pedal distance was established in the vehicle (by power adjustment of the Camaro pedals or interchanging of Monte Carlo pedals to achieve the nearest approximation). The subject was then asked to evaluate the new geometry.

2.2 PHASE I PROCEDURES

2.2.1 Study Design, Sampling Strategy, and Vehicles. Upon completion of the two pilot studies (i.e., driver lean and preferred steering-wheel-position protocol), the study moved into the primary phase of data collection—Phase I Testing—in which the primary objectives of the study were addressed in four vehicles. These included:

- using the test protocol developed and validated in the pilot study to estimate preferred steering wheel-to-pedal distances;
- determining driver preferences and patterns of front/back seat position and seatback recline angle; and
- measuring three-dimensional eye location under quasi-dynamic driving conditions.

These data were collected for a population of fifty-five subjects spanning the U.S. adult stature range from 5th-percentile female to 95th-percentile male. Table 1 shows the subject group definitions by gender, stature, and sample size where the percentiles shown are based on the 1971–1974 Health and Nutrition Examination Survey (HANES, Abraham et al. 1979a, 1979b). The sampling strategy sought to obtain equal numbers of subjects in each group rather than to match the stature distribution of the U.S. population. This approach is easier to implement when using relatively small sample sizes and allows each stature group to be represented by persons of varying body proportions, weight, and driving experiences,

thereby reducing biases at the population extremes where only one or two individuals would represent these segments of the population if a representative sample by stature were selected. While stature was considered to be the most important factor in subject selection, an effort was made to maintain a reasonable distribution in weight and age within each group and over the total sample.

TABLE 1
SUBJECT GROUP DEFINITIONS BY STATURE

Group No.	N	Category	Mean %ile	%ile Range	Stature Range		Mean Stature	
					(in.)	(cm)	(in.)	(cm)
Females								
1	5	Short	10th	5-15	59.5-61.0	151.1-154.9	60.3	153.0
2	6	Medium-Short	25th	15-40	61.0-62.8	154.9-159.5	61.9	157.2
3	5	Medium	50th	40-60	62.8-64.5	159.5-163.8	63.7	161.7
4	5	Medium-Tall	75th	60-85	64.5-66.2	163.8-168.1	65.4	166.0
5	6	Tall	90th	85-95	66.2-67.8	168.1-172.2	67.0	170.2
Males								
6	5	Short	10th	5-15	64.4-66.1	163.6-167.9	65.3	165.7
7	6	Medium-Short	25th	15-40	66.1-68.0	167.9-172.7	66.9	169.9
8	6	Medium	50th	40-60	68.0-69.9	172.7-177.5	69.0	175.1
9	6	Medium-Tall	75th	60-85	69.9-71.9	177.5-182.6	70.9	180.1
10	5	Tall	90th	85-95	71.9-73.6	182.6-186.9	72.8	184.8

An additional sampling criteria imposed was to recruit half of the subjects in each group to be drivers of late-model (i.e., 1985 to 1988) import vehicles including Hondas, Acuras, BMWs, and Mercedes 300 or 500 sedans. These are vehicles known to have shorter steering wheel-to-pedal distances than most domestic vehicles and it was of interest to include and examine the differences in preferred steering wheel locations that may result from drivers familiar with this control geometry.

Subjects were recruited from the Washtenaw County area using classified ads, public notices, and flyers placed on cars in public parking lots. Respondents were screened with a health questionnaire and those who qualified for one of the subject groups based on gender, stature, age, and vehicle type were measured for the anthropometric dimensions previously noted for the pilot study (see page 6). In addition, intrapupillary distance was measured for use in estimating right-eye position from the measured left-eye position.

Data were collected for four vehicles spanning the range of passenger car seat heights and package geometries including the Camaro and Monte Carlo used in the pilot study as

well as a Chevy Blazer and Cadillac Sedan Deville. The package dimensions and other features of these test vehicles are given in Appendix B. As in the pilot study, all cars offered extended seat travel (fore and aft) accomplished by means of an added seat adjuster, as well as a tilt steering wheel. In the Blazer and Monte Carlo, the seatback recliners were modified to allow an additional range in seatback recline angle toward the more upright (i.e., vertical) direction. Only the Cadillac featured a six-way adjustable seat. Figures A.4 through A.8 of Appendix A show the seat and wheel readout scales for these vehicles.

2.2.2 Stereophotogrammetry and Vehicle Calibrations. After considerable discussion, it was decided to use a two-camera stereophotogrammetry system to collect three-dimensional eye location data of drivers immediately upon the return from driving a specified route in which they had been instructed to achieve their preferred locations for the seat, seatback recliner, and tilt-wheel angle. Direct Linear Transformation (DLT) techniques (Abdel-Aziz and Karara 1971) were used, whereby a set of targets whose three-dimensional coordinates are precisely known is used to calibrate vehicle eye space. Nineteen high-contrast calibration targets were attached to the outside of each vehicle around the driver seating space as indicated in Figure 1. In addition, a pseudo-eye target was established at a position inside the vehicle by fabricating a cross beam that spanned between the left- and right-front window sills of each vehicle (as shown in the lower photo of Figure 1). The ends of the beam were fitted with tracks that inserted into the sill slot on each side to enable precise positioning of the "eye" target each time the beam was placed in position. The "eye" target itself was placed on a vertical post attached to the cross beam at the centerline of the driver's seat.

Once the calibration targets were attached, the vehicles were taken to General Motors to determine their 3D vehicle coordinates using the precise vehicle measurement platforms and measurement tools available. The pseudo-eye target attached to the cross beam was also calibrated at this time thereby providing a means of validating the eye position data determined from the nineteen calibration targets attached to the outside of the vehicle.

To collect eye position data, two Pentax cameras were mounted on heavy-duty tripods and rigged to fire simultaneously by means of solenoid actuators by a twelve-volt power supply and a push-button switch. For a given measurement session the cameras were positioned in the parking lot so that each camera could "see" all calibration targets of each vehicle when it pulled into the test area as well as the left eye of each test subject. In general, this meant that the cameras were oriented at about 70° to each other with one camera angled about 10° to the right of head-on and the other about 10° to the left of lateral, with both cameras aimed at the driver space. While it was possible to move the cameras for each vehicle and subject if necessary, an attempt was made to position the cameras so that a



FIGURE 1. Vehicle stereophotogrammetry calibration targets on Chevy Blazer (top) and Cadillac Sedan Deville (bottom).

minimal amount of movement was needed for the different vehicles. Figure 2 illustrates these data collection procedures and camera/vehicle relationships.

Processing of the photo data consisted of cutting and mounting the developed films (i.e., color slides) between two glass plates and digitizing the calibration targets and left eye of each subject using a Hitachi Tablet Digitizer (model HDG-2436S) interfaced with an IBM XT computer equipped with software for processing the film coordinates into vehicle X,Y,Z coordinates using the DLT algorithms. In addition to processing film containing subject eye data, the film of pseudo-eye targets was processed for each subject as a check on the accuracy and consistency of the photo data acquisition system.

2.2.3 Phase I Testing. In Phase I testing, each subject drove each of the four vehicles over a specified local route of about two miles to establish their preferred locations for the seat, seatback recliner, and tilt-wheel position. The subjects were asked to wear comfortable driving shoes and were not allowed to wear unusually heavy clothing during the drive. The route was chosen for its low traffic density and the availability of frequent stopping areas which allowed subjects to stop and try different positions before establishing their preferred locations. The cars were tested in random order and the subjects drove alone in the cars.

Before a subject entered a vehicle, the seat was positioned full rearward, with the seatback and steering wheel in the full-up positions. The subject was instructed on the use of the different seat adjustments and was asked to determine comfortable positions for the seat and wheel prior to driving. These pre-drive data were recorded on the Phase I data sheet shown in Figure C.2 of Appendix C and the subject was sent on the route. The investigator encouraged the subject to experiment with the different options and to stop as many times as necessary to achieve the optimal geometry. Subjects were also requested to take note of their driving posture and head position during their drive so that they could maintain or re-establish that position when the eye position photographs were taken on return to the UMTRI parking lot.

When the drivers returned, they were guided into a coned parking space and were asked to assume their driving posture and head position. When the subject was ready and looking straight ahead in his relaxed, normal driving posture, the two cameras were triggered to record the driver's eye position with stereophotographs. The dynamic positions of the seat, seatback, and steering wheel were then recorded from the readout scales and the subject was asked to comment on the overall comfort of the car, his ease in finding a comfortable position, how many times he stopped on the drive, his process of finding the optimal configuration, and any other comments he may have had.

The subject was then instructed to complete the static seat-to-pedal and seat-to-wheel adjustments to determine his/her preference for steering wheel-to-pedal distance. These

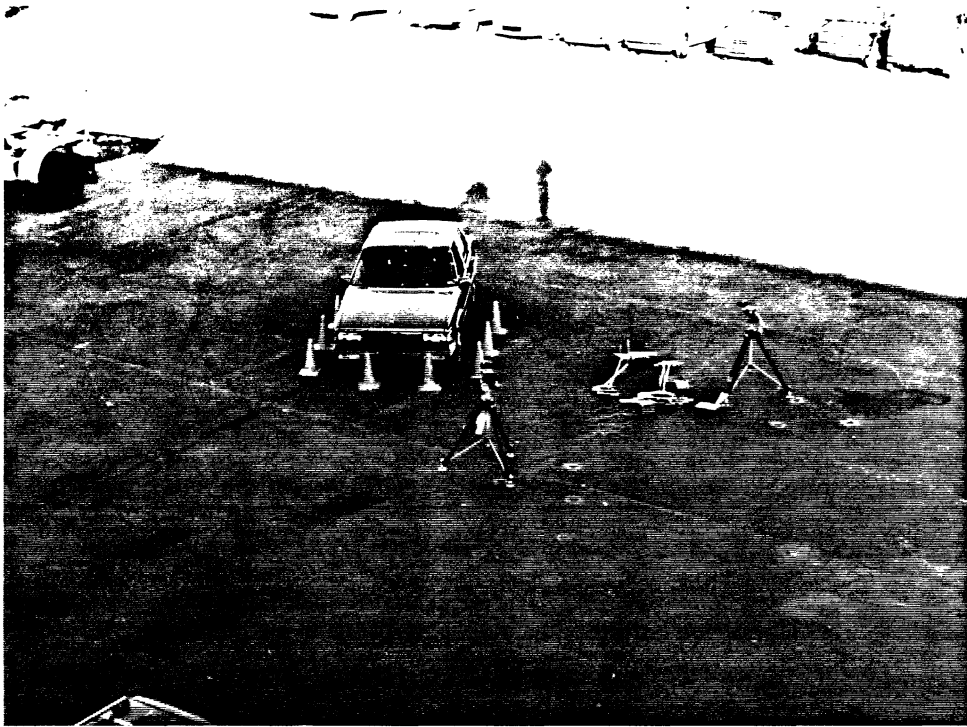


FIGURE 2. Camera/vehicle setup for eye position data collection.

procedures were essentially the same as those described previously for the pilot study (see Section 2.1) except that, due to time constraints involved in testing four cars in one session, only one trial for preferred positions was done for the wheel and pedals, respectively. Subjects were also instructed to move the seat to their acceptable front/back limits to both the steering wheel and pedals independently.

Upon completion of static seat positioning, the subject was moved to the next vehicle and the process was repeated until data were collected in all the cars. Without moving the car or cameras, and after the subject had begun testing in the next vehicle, the beam with the pseudo-eye target was positioned in the vehicle and the set of pseudo-eye position photos was taken.

2.3 PHASE II PROCEDURES

While photogrammetric data from Phase I were being processed, subjects were rescheduled and tested in Phase II of the study. The goals of this phase of the testing were twofold. First, it was desired to further validate the static test procedures used to estimate driver preference for steering wheel location by having subjects drive and adjust the pedals for two vehicles in which the pedals (brake and accelerator) could be adjusted front to back by means of a toggle or rocker switch on the center console. One of these vehicles was the Camaro used in the pilot study and in Phase I testing. The other was an Oldsmobile Touring Sedan that closely matched the Cadillac Sedan Deville in package geometry and that had been modified by DeCouper Industries to allow power adjustment of pedal position. The six-way power seat track with extended travel and readout scales that was used in the Cadillac during Phase I was installed in the Oldsmobile but the tilt options on the seat were disabled during Phase II testing so that subjects could only adjust the seat horizontally front and back. Tables B.3 and B.6 of Appendix B summarize the features of these vehicles.

The second goal of Phase II testing was to obtain eye position data in a static vehicle with a bench seat under similar conditions to those used in the collection of the original eye position data by Meldrum in 1965. For this purpose, the Pontiac 6000 with a front bench seat used in the "lean" study (Lee and Schneider 1988) was parked inside the UMTRI high-bay area and a road scene was projected in front of the driver in a manner similar to the mural road scenes used in the Meldrum (1965) study. The Pontiac was targeted and calibrated as previously described for Phase I stereophotogrammetry and the same two-camera/tripod system was used for data collection.

The subject pool for Phase II testing was essentially the same as that used in Phase I with the exception of two subjects recruited to replace subjects who were unable to return. Any subject who had not participated in Phase I underwent anthropometric measurements and completed consent and health forms. As usual, all subjects were instructed to wear

comfortable driving shoes and were not allowed to wear heavy winter coats while driving even though this portion of the testing took place in cooler fall weather.

During a test session, each subject was first taken to the Pontiac 6000, instructed to sit in the vehicle and adjust the seat and tilt wheel to his preferred positions, and to then assume a “normal” straight-ahead driving posture looking at the projected road scene while the photographs were taken. As in previous tests, subjects were encouraged to try several seat positions before selecting the one that they felt was optimal.

The subject was then taken to one of the other two test vehicles (i.e., Camaro or Oldsmobile) which were parked inside the building. The investigator explained the procedures and the 4.5-mile course of low-traffic, residential driving that they were to follow. The subjects entered each vehicle with all the options in the “start” positions: seat track full rear with tilt wheel and seatback full up and pedals in design position. After instructing the subjects on how to operate the various adjustment controls and mechanisms, they were asked to make initial estimates for their preferred seat and pedal positions and the tilt wheel and seat recliner angles. Again, the investigator encouraged the subjects to experiment with different positions. After recording the subject’s initial or pre-drive positions on the Phase II data sheet illustrated in Figure C.3 of Appendix C, the subject was sent out on the drive.

When the subject returned from the drive, the final seat pedal and wheel locations were read and recorded. The subject was asked to comment on the vehicle’s overall comfort, his ability and procedure for finding a comfortable position, and his thoughts on the adjustable pedal option and its value to the driver. The process was then repeated in the second vehicle to complete the Phase II testing.

2.4 PHASE III PROCEDURES

In Phase III, dynamic eye position and seat position were measured in the Pontiac 6000 for direct comparison with the static Pontiac seat and eye results. It should be noted that while the ten-group, 50–55 subject sample pool criteria were maintained, it was not the identical subject pool from Phases I and II. Sixty-four percent of the drivers tested had participated in both of the previous phases and the rest of the drivers were newly recruited. This change was not specifically intended, and was due to the difficulty of retaining a constant subject pool over the long duration of the study.

These 51 subjects were tested by repeating the procedures outlined for Phase I. The only change made in the process was the elimination of the static seat-to-pedal and seat-to-wheel preference testing. Only pre- and post-drive seat and wheel adjustments and dynamic eye position data were collected. New subjects also went through the battery of full anthropometric measurements prior to the test drive.

2.5 DATA PROCESSING AND ANALYSIS

The quantitative data collected during vehicle testing can be divided into two basic categories: (1) eye coordinate data from film analysis, and (2) hand-recorded seat- and wheel-position data. Eye position data collected for the left eye were first converted to eye centroid data by moving each Y-coordinate value toward the center of the vehicle by one half the intrapupillary distance measured for each subject. The data were weighted according to the percentile of the population that each subject represented based on his/her group's stature percentile range and the number of subjects in that group, and the weighted data were used to compute the centroid eyellipses according to procedures used by Hammond and Roe (1972). The arctangent of the slope of the corresponding X-Z, X-Y, or Y-Z plane regression line was used as the angle of the major axis of the eyellipse centroid in each two-dimensional view. The appropriate bivariate standard deviations were the basis for the axes lengths. For example, the 95th-percentile eyellipse semi-axis equals the standard deviation multiplied by the number of standard deviations associated with 95% of the population, assuming a normal distribution. Eyellipses were drawn in side and top views for each of the six (four in Phase I, one in Phase II, and one in Phase III) vehicles for which three-dimensional eye position data were collected, and are graphically and numerically compared to the current SAE eyellipse centroids for each car.

The seat position data files were entered into the Michigan Computer System (MTS) and analyzed using the MIDAS statistical package. The raw data were inspected for "bad" or outlying data points. Corrections were made when the error could be identified or the data point was deleted (i.e., changed to missing data) if the correction could not be determined. Resultant seat detent values were computed from the standard and extended detent readings from each vehicle according to the illustrations shown in Figure A.11 and were subsequently converted into vehicle H-point X-coordinate values by using the design H-point X-coordinate and corresponding resultant detent from each vehicle as a reference. Percentile distributions for seat position were computed by weighting the data as previously described. These experimental distributions were then compared to expected distributions based on the SAE J1517 Seating Accommodation Model. Seatback recline data were converted to J826 H-point back angles, and statistics for seatback recline angle were computed and compared across vehicles. Other comparisons between Phase I through III data were made as appropriate and correlations between measured variables and subject characteristics were sought. These comparisons and correlations were made in an attempt to help explain differences between observations and results of this study and those of previous studies, and to determine the factors influencing driver positioning.

III. RESULTS

3.1 WHEEL POSITION PILOT STUDY (Monte Carlo and Camaro)

3.1.1 Pilot Study Results. Figures D.1 through D.4 of Appendix D show plots of the statically-determined seat to steering-wheel-center (Hpt to WCtr) and seat to ball-of-foot (Hpt to BOF) for the eighteen subjects tested in the Camaro and Monte Carlo vehicles. For each subject, the preferred distance is shown by the *X* and the acceptable limits are indicated by the horizontal line. As expected, in each case there is a general trend with stature whereby the taller subjects prefer to be further from both the steering wheel and the pedals. It is interesting to note, however, that this trend is quite weak, if not absent, for females in the Camaro with regard to seat-to-center-of-steering-wheel distance.

Using the acceptable range data, the frequency-of-acceptability distributions for different seat-to-wheel and seat-to-pedal distances were determined for increments of distance taken at 10-mm intervals. Plots of these results are shown in Figures D.5 through D.8. By subtracting the seat-to-BOF distance at peak acceptance from the seat to WCtr at peak acceptance, an estimated optimal steering wheel-to-BOF distance was determined for each vehicle. For the Camaro this optimal distance was calculated to be 640 mm while for the Monte Carlo it was calculated at 600 mm.

Figures D.9 and D.10 show scatter plots of the preferred steering-wheel-center-to-BOF (WCtr-to-BOF) distances versus stature, where the WCtr-to-BOF distance was calculated from preferred static seat-to-pedal and seat-to-steering wheel adjustments for each subject. In each plot, data points for drivers of import vehicles are surrounded by a box and points considered to be outliers for averaging purposes are circled. The solid line in each plot indicates the linear regression for the scatter plot and the dashed lines indicate the current design distance, the mean of the calculated values for the sample population, and the maximum-acceptable distance determined as described above.

For the Monte Carlo, it is seen that the distances for the import drivers tend to be less at all stature levels than those for the domestic car drivers. This trend is not seen for the Camaro. Also, for both vehicles the sample mean and also the maximum acceptable WCtr-to-BOF distances are significantly less than the design distance.

Recall that subjects were able to adjust the pedal front-to-back locations in the Camaro while driving (i.e., push-button control) and that each subject drove this vehicle on an additional test drive in order to determine his/her preferred wheel-to-pedal spacing by this

method. Figure D.11 shows the results of these adjustments versus subject stature while Figure D.12 plots the subject-adjusted WCtr-to-BOF versus the calculated WCtr-to-BOF for each subject. Again the boxes indicate data points for import vehicle drivers while the circles are considered outliers for purposes of calculating a linear regression fit to the data. It will be noted that the WCtr-to-BOF distances tend to be smaller when the subject adjusted the pedals than when the distances were calculated from the static seat position results. This is particularly evident from Figure D.12 where it is seen that most of the data points are above the 45° line (i.e., the line of equivalent distances). It thus appears that the WCtr-to-BOF distances calculated from independently conducted static seat-to-wheel and seat-to-pedal adjustments are conservative (i.e., greater than) what a subject will select if he/she can actually adjust the distance.

As an additional check on how subjects were adjusting *statically* to the steering wheel in the test vehicles, measurements of sternum (i.e., chest) to center of steering wheel were made after the subject adjusted the seat relative to the steering wheel and for the subject sitting in his own vehicle. The results are compared in Figures D.13 and D.14 for the Camaro and Monte Carlo. There is generally good correlation between the test-vehicle distances and the subject-vehicle distances. It can also be noted, however, that the linear regression lines in each case are shifted upward and are more horizontal than the 45° equivalency line, indicating that people who sat closer to the wheel (i.e., shorter people) tended to sit further from the wheel in the static adjustments than they did in their own vehicle. This observation suggests that shorter drivers may sit closer to the steering wheel in their own vehicle than they would like, probably due to a larger than desired steering-wheel-to-pedal distance and a need to operate the pedals comfortably.

Table D.1 and Figure D.15 show the means and standard deviations of the observed arm angles in both vehicles. It is interesting to note that driver arm orientation was quite similar between vehicles.

3.1.2 Pilot Study Summary and Conclusions. It was generally concluded from the results of this pilot study that independent and static adjustments of the seat to the pedals and steering wheel could be used to estimate and determine more optimal steering wheel locations relative to the pedals. For both seat-to-wheel and seat-to-pedal distances, a relationship between distance and stature was found whereby taller drivers prefer larger distances. Similarly, a relationship between stature and calculated preferred wheel-to-pedal distance was determined whereby taller drivers prefer larger distances. For the Camaro, the calculated preferred wheel-to-pedal distances for each subject were generally found to be greater than the distances determined when subjects adjusted the distances during driving. It was therefore decided to use these static, independent seat-positioning procedures in Phase I testing to determine steering wheel locations in four vehicles (including the Monte

Carlo and Camaro) using a larger sample of test subjects. For the Camaro and Monte Carlo, the pedal positions used in Phase I were adjusted rearward from design by 63 mm and 42 mm, respectively.

3.2 PHASE I ANTHROPOMETRY AND PREFERRED WHEEL/SEAT POSITIONS (Camaro, Cadillac, Monte Carlo, Blazer)

3.2.1 General Observations and Patterns. Figures E.1 through E.15 in Appendix E present and compare the differences in anthropometric measurements and age for the ten subject groups. These results are summarized in Tables E.1 and E.2 for these ten stature groups, for all females, all males, and for all subjects combined. Table E.1 presents the results in metric units while results in Table E.2 are in English units.

The plots and tables in Appendix F present results for preferred seat position, seatback angle, and steering wheel tilt angle obtained subsequent to each subject's test drive of the four vehicles. Tables F.1 and F.3 in Appendix F summarize results by subject group, and for all females, all males, and all subjects combined for the four vehicles. Appendix K contains listings of these data by individual subject. The first set of plots (Figures F.1 through F.12) presents and compares the mean results by subject group while the second set of plots (Figures F.13 through F.24) shows distribution histograms of the test results. The last set of plots (Figures F.25 through F.28) shows scatter plots of subject preferred seat position versus stature and indicates how these distributions compare with the production seat travel ranges.

Results for preferred seat position (Figures F.1 through F.4) show the expected relationship with subject size. While the mean values for seatback angle (Figures F.5 through F.8) and tilt-wheel angle (Figures F.9 through F.12) vary somewhat among subject groups, in general there are no obvious or consistent trends with driver size that would suggest that this variability is due to anything other than small sample sizes in each group. A possible exception is seatback angle in the Cadillac (Figure F.8) where the results demonstrate a slight trend for taller drivers to prefer more reclined angles. Note, however, that the Cadillac is the only vehicle with a six-way power seat and that the seatback angle for this vehicle includes an adjustment for tilt of the complete seat including the seat cushion. Thus, this trend may reflect a tendency for taller drivers to tilt the seat cushion to a more inclined pan angle. It should also be noted that the seatback angles for the Cadillac are generally more upright than for any of the other vehicles, even after adjusting for seat tilt.

Examining the frequency histograms for seat position, seatback angle, and wheel tilt angle (Figures F.13 through F.24) it is observed that the distributions of wheel tilt angle and seat position are normally distributed in every case with little or no piling up at the limits of adjustability. (Note that the seat tracks provided significant additional travel beyond production limits, particularly in the rearward direction.) For seatback angle, however, in both the Monte Carlo and Blazer, the highest percentage of subjects preferred the most upright position while, in the Camaro, the second highest percentage of subjects chose the most upright position. The data clearly suggest that many subjects would have inclined the seatback more upright if additional range had been provided, even though, in both the Blazer and Monte Carlo, the seatback was modified so that the most upright position was more vertical than in production vehicles. Only the Cadillac, with additional adjustability in back angle by use of the power seat adjuster, showed a normal distribution in seatback angle.

3.2.2 Mean Seatback Angles. Figure 3 compares the overall mean seatback angles for the four vehicles obtained from the *All Subjects* row of Table F.2. The data are plotted in order of increasing seat height and show a general trend of greater recline angle with lower seat height with the exception of the Cadillac. From this figure and the group values of Table F.2, it is seen that the mean seatback angles for the Cadillac tend to be significantly lower (i.e., more upright) than for any of the other vehicles and that lower or more vertical positions are preferred by females. Both may be due to adjustability of the seat pan in the Cadillac. Drivers, particularly shorter ones, could tilt the seat cushion forward to relieve pressure on the thighs, which also enabled them to obtain a more upright seatback angle while maintaining their desired hip angle.

For the three other vehicles, the mean values of seatback recline angle are nearly the same for males and females, with the males preferring a slightly greater recline angle (about 0.5°) in each case. It is also seen that the largest overall mean recline angle was for the Camaro with an angle of 27.8°. The Monte Carlo had the next largest recline angle with an overall mean of 24.4°, and the Blazer had a mean recline angle of 22.9°. As previously indicated, the Cadillac seatback angle was the most upright with an overall mean angle of 19°. The bottom row in Table F.2 shows the weighted mean values which were derived by applying weighting factors to the value for each subject. These weighting factors were based on the percentage of the population that each subject represents according to the population percentile represented by each gender/stature group and the number of subjects in that group (see Table 2). The weighted mean values are seen to be insignificantly different from the unweighted values.

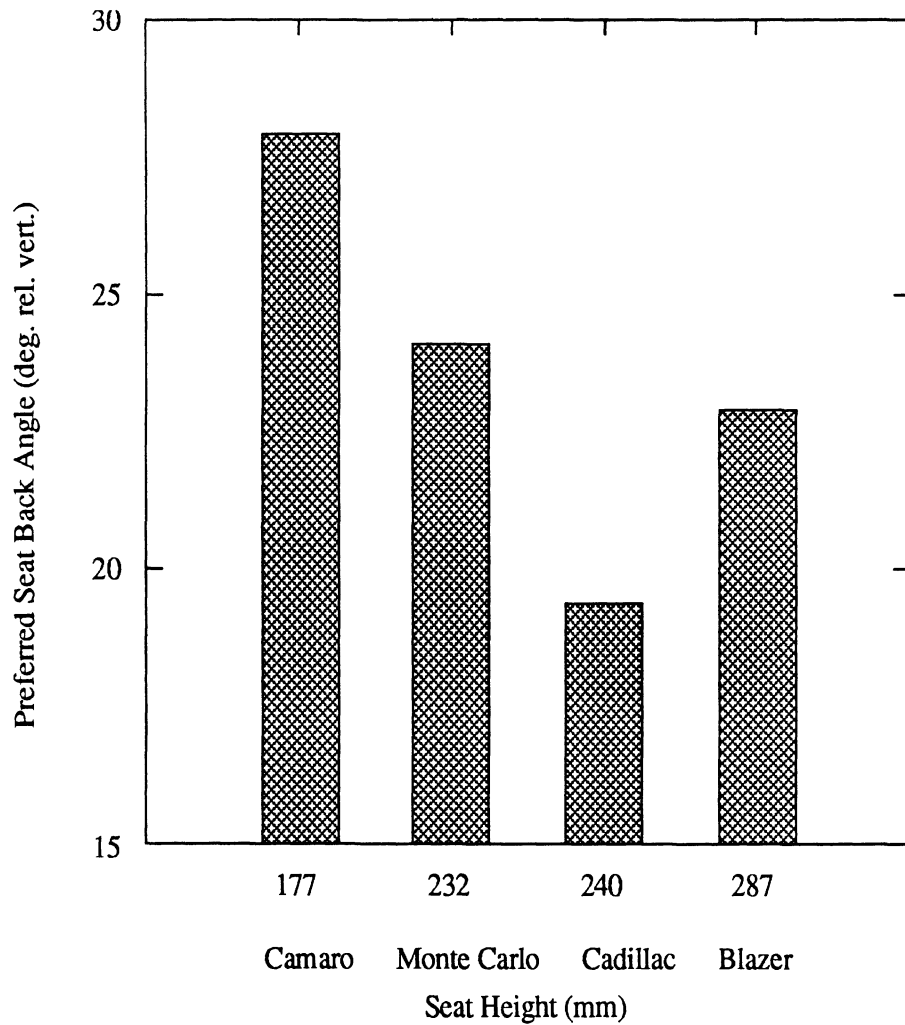


FIGURE 3. Overall mean seatback angles for Camaro, Monte Carlo, Cadillac, and Blazer.

3.2.3 Mean Wheel-Tilt Angles. Figure 4 plots the overall mean values for wheel-tilt angle taken from the *All Subjects* row of Table F.3 for the four vehicles. The results are plotted in order of increasing seat height and show a general trend of more vertical wheel position with decreasing seat height with the exception of the Cadillac. The mean wheel-tilt angle for the Cadillac is more vertical than for all the other vehicles. This may result from the ability to tilt the seat cushion forward which enables the driver to get the knees lower by sitting further rearward and inclining the seatback angle to reach the steering wheel. From Table F.3, it is seen that wheel-tilt angles are similar for males and females although males tend to position the wheel less vertical on the average.

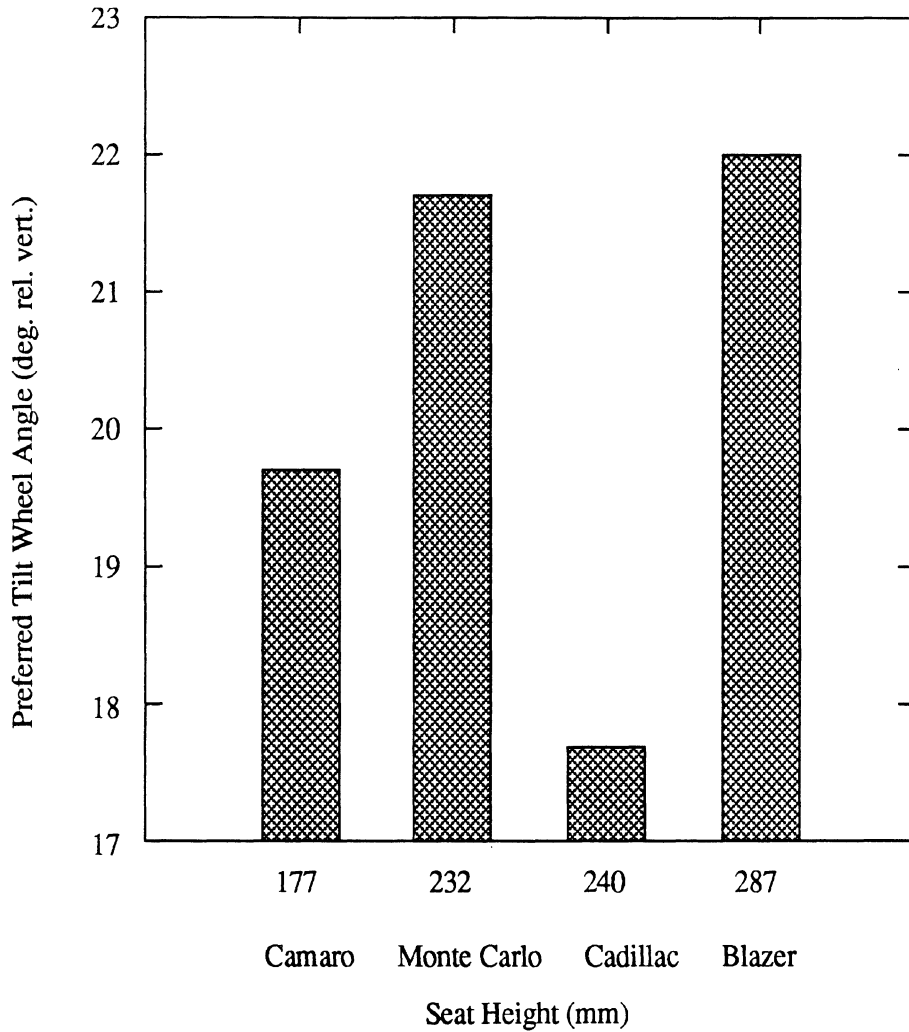


FIGURE 4. Overall mean values for wheel-tilt angles.

3.2.4 Distributions of Driver Seat Position and Comparison with Seating Accommodation Model. For each vehicle, the percentiles of preferred seat position for the sample population were determined after weighting each subject's data according to the proportion of the U.S. population represented by each stature/gender group and the number of subjects in that group. Table 2 shows the weighting factors used while Tables 3 through 6 show the resulting percentile seat position distances relative to the ball-of-foot (BOF) point in each vehicle.²

Figures 5 through 8 and Tables 3 through 6 compare these results with the seat distributions expected from the SAE J1517 Seating Accommodation Model, in which the

²It should be noted that the BOF points in the Camaro and Monte were translated rearward the same distance that the pedals were moved rearward prior to testing.

TABLE 2
SUBJECT WEIGHTING FACTORS USED FOR COMPUTING
DISTRIBUTIONS OF SEAT POSITION

Group	N	%ile of Population Represented	Weighting Factor
FEMALES			
1	5	7.5	1.5
2	6	12.5	2.08
3	5	10.0	2.0
4	5	12.5	2.5
5	6	7.5	1.25
MALES			
6	5	7.5	1.5
7	6	12.5	2.08
8	6	10.0	1.67
9	6	12.5	2.08
10	5	7.5	1.5

percentiles of driver seating positions relative to BOF are determined by seat (i.e., H-point) height (H-30) according to the following equations:

$$\begin{aligned}
 97.5\text{th Percentile} &= 936.6 + .613879(H-30) - .00186247(H-30)^2 \\
 95.0\text{th Percentile} &= 913.7 + .672316(H-30) - .00195530(H-30)^2 \\
 90.0\text{th Percentile} &= 885.0 + .735374(H-30) - .00201650(H-30)^2 \\
 50.0\text{th Percentile} &= 793.7 + .903387(H-30) - .00225518(H-30)^2 \\
 10.0\text{th Percentile} &= 715.9 + .968793(H-30) - .00228674(H-30)^2 \\
 5.0\text{th Percentile} &= 692.6 + .981427(H-30) - .00226230(H-30)^2 \\
 2.5\text{th Percentile} &= 687.1 + .895336(H-30) - .00210494(H-30)^2
 \end{aligned}$$

In each case, the model results were determined using the actual test vehicle seat height determined by H-point calibration of the vehicle, rather than the seat height from the package drawings. Recall that the seat of the Blazer was raised approximately 41 mm (1.6 in.) to accommodate the extended seat track adjusters.

For all vehicles, the actual distributions of seat positions are seen to be rearward of the model predictions for the full range of seat positions from full forward to full rearward. The difference between model and experiment is greatest in the Cadillac, again perhaps due to the ability to adjust pan angle. These findings of significant and consistent differences (across vehicles and for all driver sizes) were unexpected and are cause for reexamining the seating accommodation model used for predicting driver preferences for seat positioning and range of seat tracks in future vehicles.

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
BLAZER—PHASE I

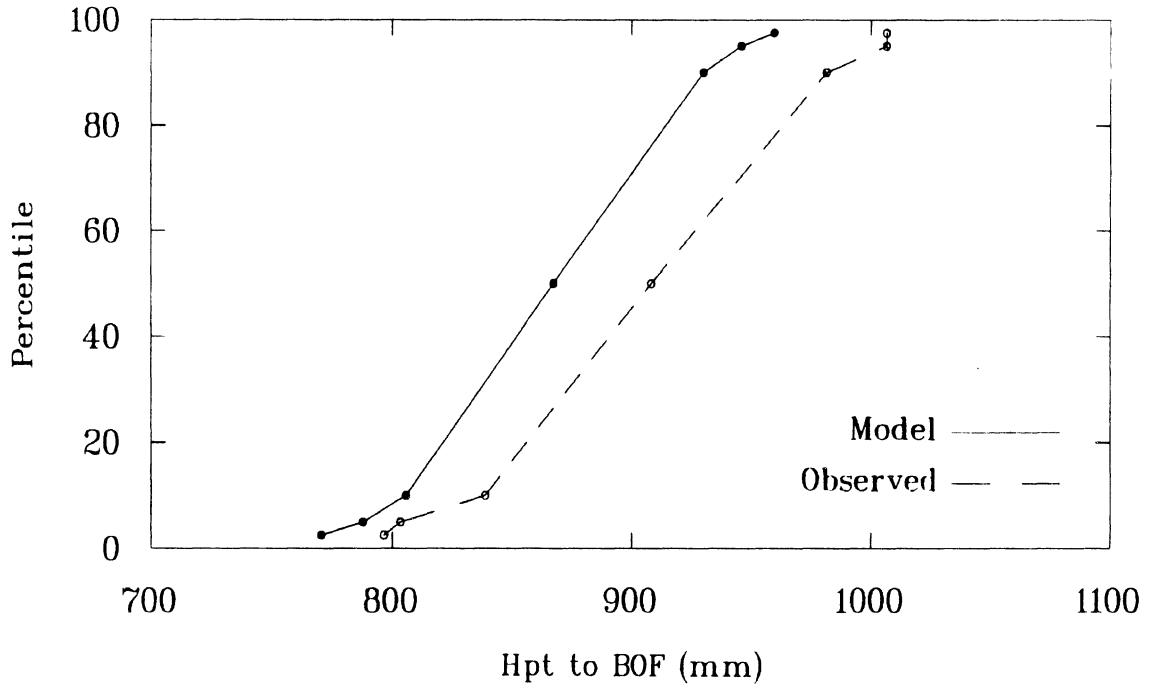


FIGURE 5

TABLE 3

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
BLAZER PHASE I

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2229	797	771	26
5.0	2236	804	788	16
10.0	2271	839	806	33
50.0	2341	908	867	41
90.0	2414	981	930	51
95.0	2439	1007	946	61
7.5	2439	1007	959	48

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
 CADILLAC—PHASE I

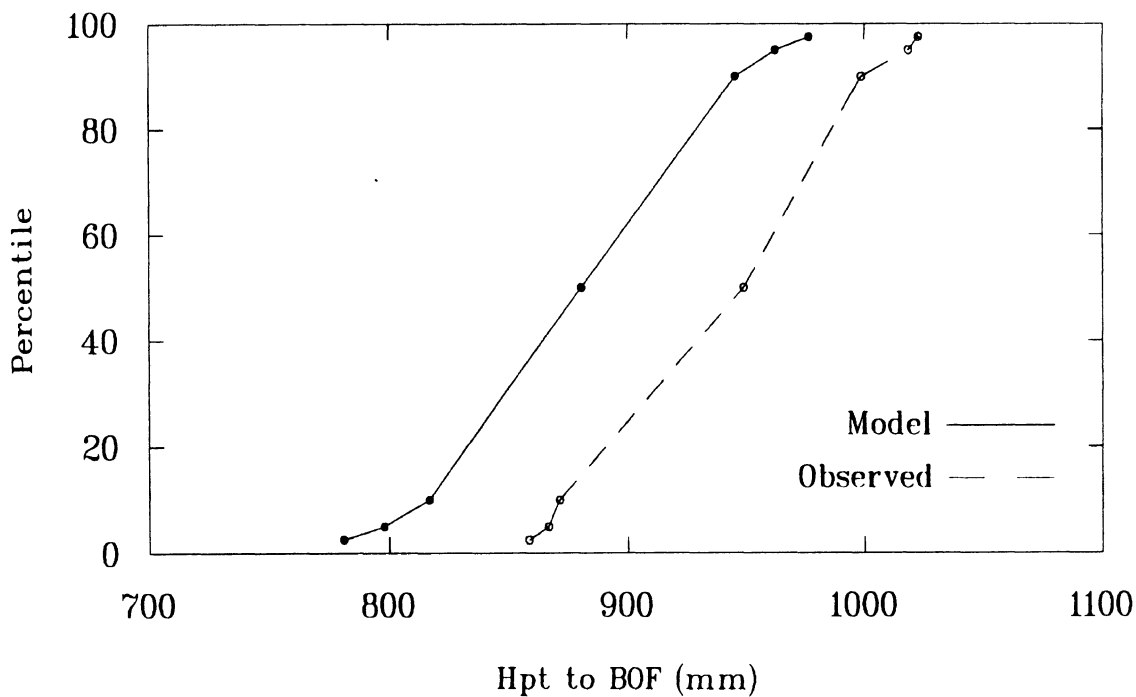


FIGURE 6

TABLE 4

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
 CADILLAC PHASE I

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	3031	859	781	78
5.0	3039	867	798	69
10.0	3044	872	817	55
50.0	3121	949	881	68
90.0	3171	999	945	54
95.0	3191	1019	962	57
97.5	3195	1023	977	46

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
CAMARO—PHASE I

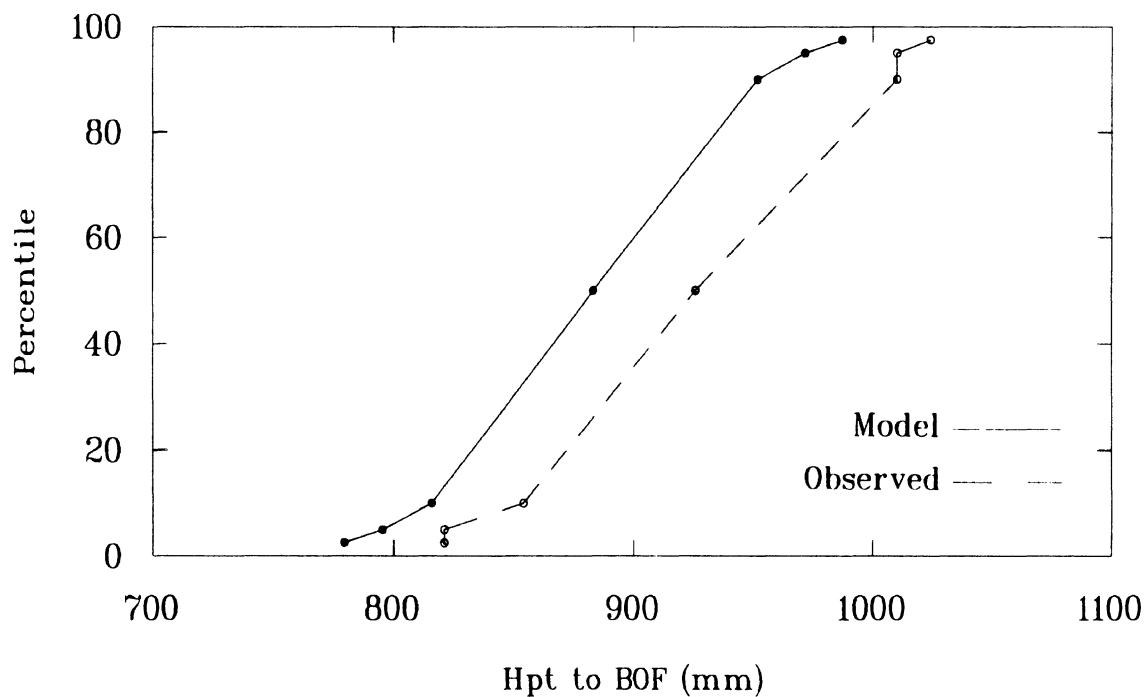


FIGURE 7

TABLE 5

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
CAMARO PHASE I

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2939	821	780	41
5.0	2939	821	795	26
10.0	2972	854	816	38
50.0	3044	926	883	43
90.0	3128	1010	952	58
95.0	3128	1010	971	39
97.5	3142	1024	987	37

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
MONTE CARLO—PHASE I

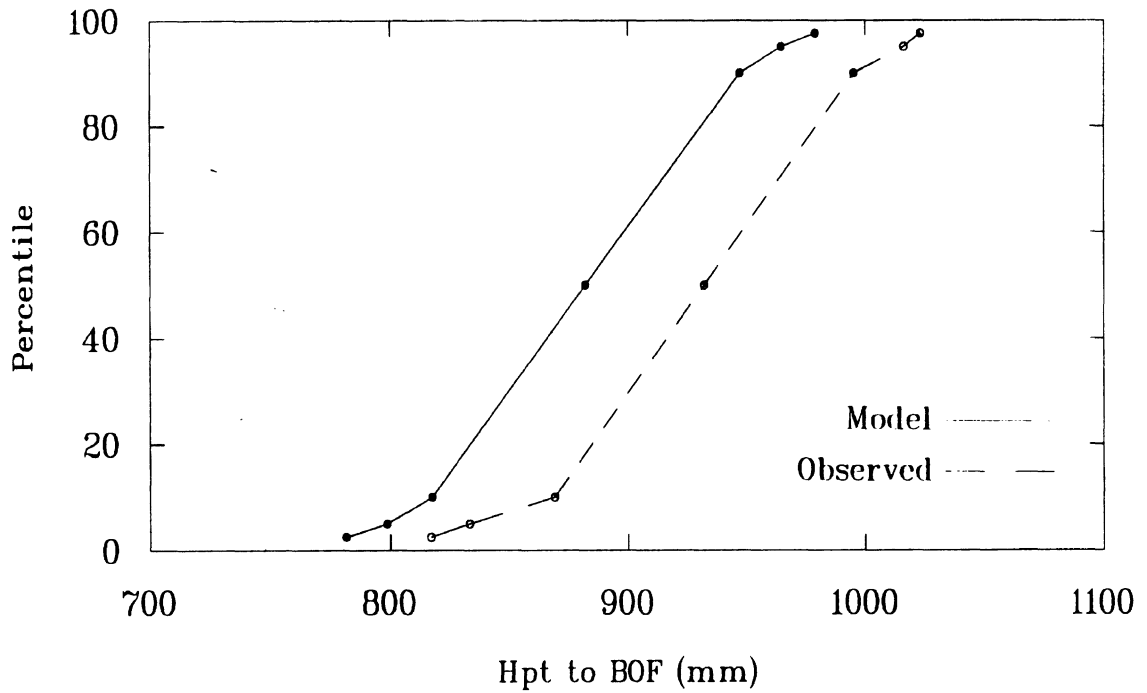


FIGURE 8

TABLE 6

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
MONTE CARLO PHASE I

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2972	817	782	35
5.0	2988	833	799	34
10.0	3024	869	818	51
50.0	3087	932	882	50
90.0	3150	995	947	48
95.0	3171	1016	964	52
97.5	3178	1023	979	44

Figures F.25 through F.28 of Appendix F show scatter plots of preferred seat position, given by the translated H-point in vehicle coordinates, versus subject stature. Also shown on the plots by vertical dashed lines are the forward and rearward limits of the production seat travel ranges, the location of the package design H-point, and the actual vehicle H-point (i.e., test H-point). In each case, the actual or test H-point is seen to be rearward of the design H-point and the difference is largest for the Cadillac. For the Camaro and Monte Carlo, both the shifted production seat travel limits prior to rearward pedal translation and after pedal translation are shown by horizontal dashed lines labelled *A* and *B*, respectively.

The usual relationship of taller drivers sitting further rearward is again observed from these scatter plots. For the Blazer, Camaro, and Monte Carlo, the distributions of seat positions cover the full range of production seat travel and include some taller drivers who prefer to sit further rearward than allowed by the production seat track. For the Cadillac, however, the distribution of seat positions is displaced rearward relative to the range-of-production travel so that a significant number of subjects preferred to sit rearward of the production travel limit and no subject wanted to sit even close to the forward limit of seat travel.

3.2.5 Summary of Cadillac Six-Way Power Seat Results. Table 7 and Figures 9 through 13 summarize the observed preferred six-way seat adjustments and corresponding recliner back angles for the Cadillac. The seat pan and seat height data are given relative to the design orientation of the seat. For example, a seat pan adjustment of + 2° means that the seat cushion was positioned with a pan angle 2° greater than design. Increasing pan angle is defined as an increase in the height of the front of the cushion relative to the back. A seat height adjustment of 2 mm means that the seat was 2 mm higher than the design height. Seatback angle is provided in Table 7 in two forms: seat recliner angle relative to the seat recliner mechanism (direct recliner reading) and the recliner angle relative to vertical, which incorporates the pan angle adjustment's effect on the seatback angle. The design seat height (H-30) is 240 mm but the design seat pan angle is unknown.

From Table 7 and Figures 9 through 13 it is seen that there are no strong correlations between these adjustment parameters and subject size although some weak trends can be observed. The seatback recliner angle adjustment data plotted in Figure 9 show a trend for taller subjects to recline the seatback further relative to vertical. However, when these data are corrected for pan angle, as seen in Figure 10, the recliner angles are nearly constant across all subject groups with smaller sample standard deviations. This decrease in variability for the corrected data suggests that the subjects were adjusting to achieve an optimal angle between upper and lower torso. Because the design seat pan angle for the Cadillac was unknown, this upper to lower torso angle or "hip angle" cannot be precisely determined. However, the assumption of an 8° design seat pan angle allows the calculation

TABLE 7

SUMMARY OF PREFERRED CADILLAC SIX-WAY SEAT ADJUSTMENTS

Group	Height (mm from design)		Pan Angle (deg. from design)*		Seatback Angle (rel. to seat)		Seatback Angle (rel. to vertical)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	-6.0	9.6	-4.8	4.4	19.2	2.2	14.4	2.7
2	2.5	11.5	0.7	2.6	20.6	2.4	21.3	3.5
3	5.5	10.4	-1.2	2.2	18.6	1.3	17.4	1.5
4	3.5	7.8	-1.8	2.6	18.4	0.9	16.6	3.4
5	0.8	10.3	-1.3	1.5	19.3	1.5	18.0	0.6
6	6.5	9.9	1.3	2.6	19.6	2.3	20.9	3.8
7	7.1	4.6	-0.3	2.7	20.0	2.6	19.7	4.8
8	12.8	14.9	1.7	3.1	18.2	0.4	19.8	3.0
9	11.7	11.3	1.8	1.5	20.4	1.2	22.2	2.4
10	16.5	11.4	1.0	2.5	22.0	2.0	23.0	3.0
All	6.2	11.4	-0.3	3.1	19.6	2.0	19.4	3.8

*Data is given in degrees relative to the design seat pan angle. A negative value designates a smaller, flatter seat pan angle than design while a positive value reflects a larger, more inclined seat pan angle than design.

of an estimated "hip angle" between the seatback and seat pan. Figure 13 shows the group means and standard deviations for estimated preferred hip angle.

Figure 11 plots selected seat height by group. Here there is a slight trend for increased selected seat height with increasing subject stature. The differences in group means, however, are small compared to the group standard deviations. This increase in seat height is counterbalanced by the 40-mm slope downward of the seat track as the seat moves from full forward to full rear. Therefore, taller subjects who generally sit further rearward, are not necessarily sitting at higher seat heights than shorter subjects.

For seat cushion (i.e., seat pan) angle data plotted in Figure 12, the results are similar for all subject groups except for the small females who selected a more flattened pan angle than all other groups (although the large standard deviation for this data point indicates that the low value may be due to one or two subjects who moved the seat angle to an extreme position). Overall, the subjects' selected pan angles are close to the design pan angle of the seats indicated by 0.

3.3 PREFERRED WHEEL POSITION

The preferred seat-to-pedal and seat-to-wheel data were compiled to estimate an optimal wheel-to-pedal distance for each Phase I vehicle. As in the pilot study, the

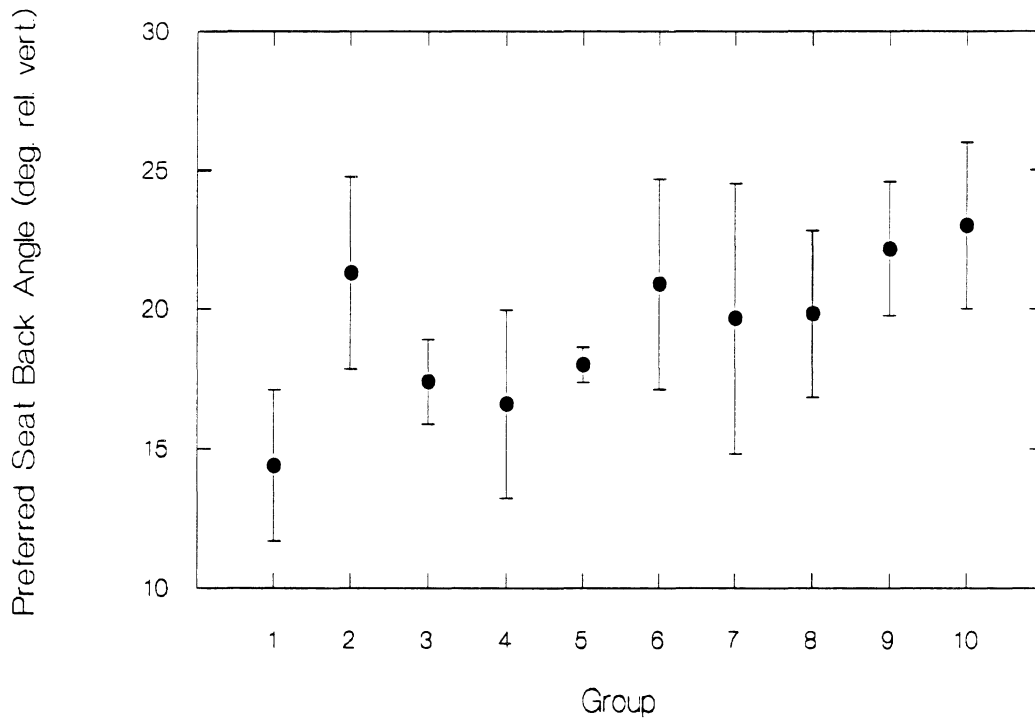


FIGURE 9. Preferred seatback angle relative to vertical by subject group for Cadillac six-way power seat in Phase I testing.

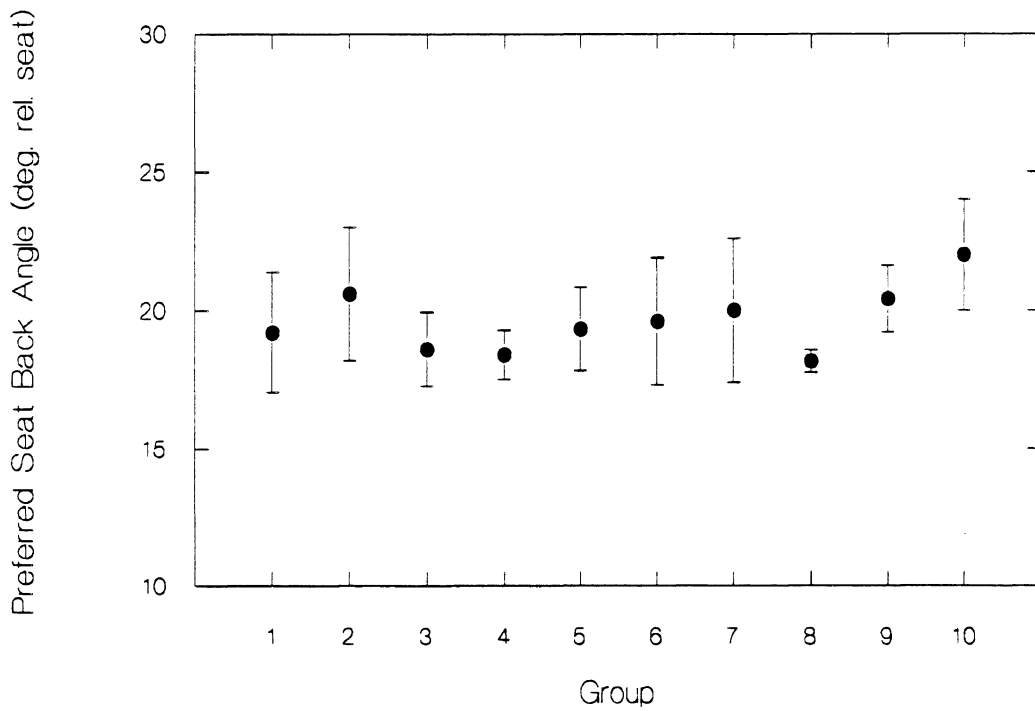


FIGURE 10. Preferred seatback angle relative to seat by subject group for Cadillac six-way power seat in Phase I testing.

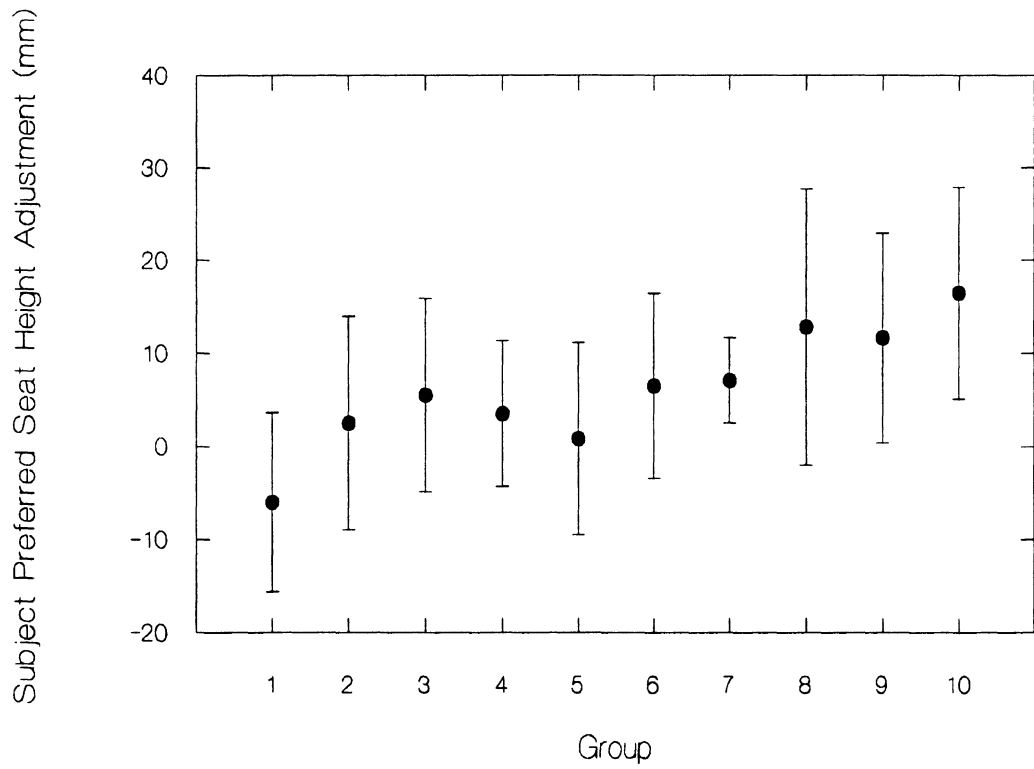


FIGURE 11. Preferred seat height adjustment by subject group for Cadillac six-way power seat in Phase I testing.

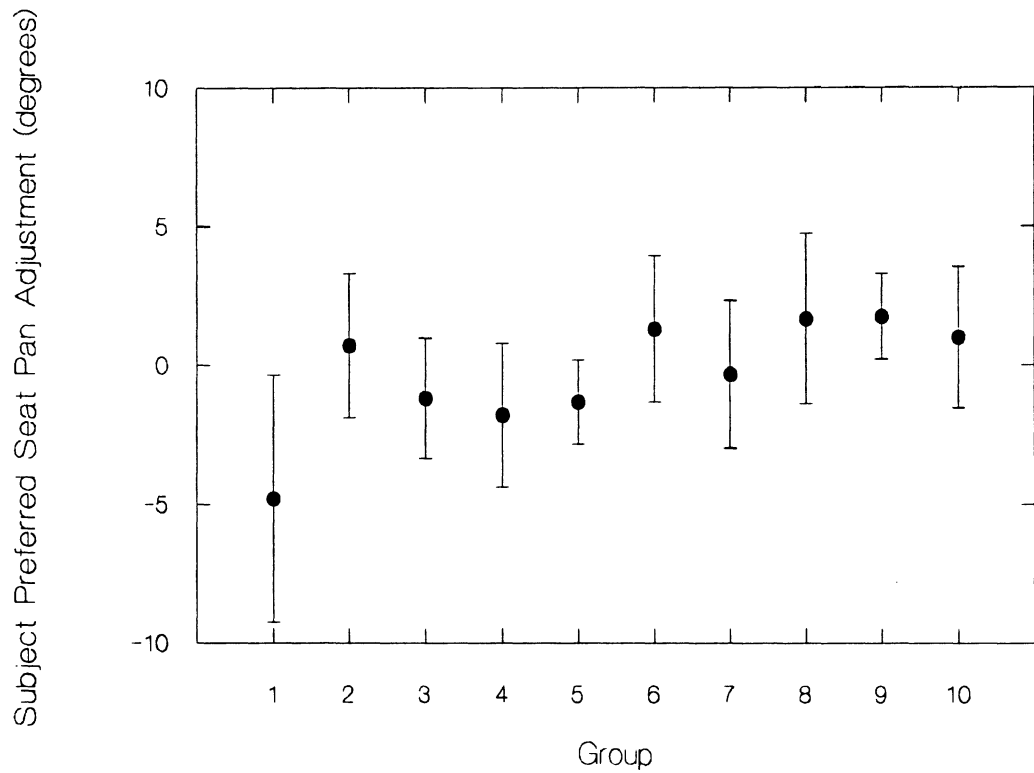


FIGURE 12. Preferred seat pan adjustment by subject group for Cadillac six-way power seat in Phase I testing.

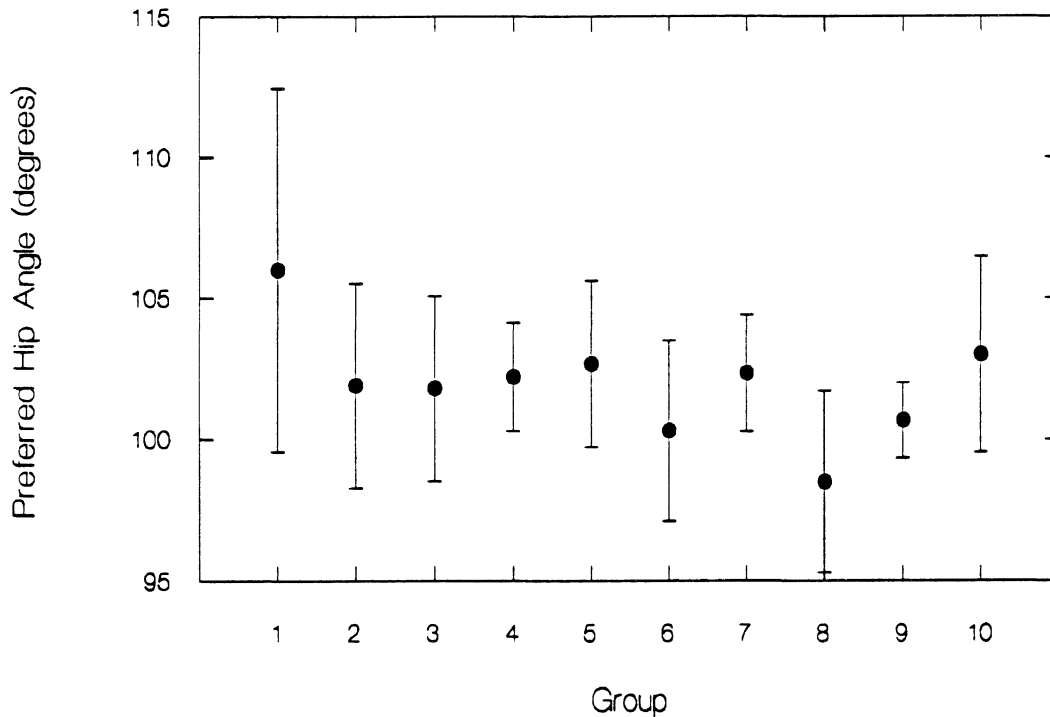


FIGURE 13. Preferred hip angle adjustment by subject group for Cadillac six-way power seat in Phase I testing.

acceptability ranges for each driver's independent seat adjustments to the wheel and pedals, were used to calculate an ideal pedal-to-wheel distance for each subject in each vehicle. Figures G.1 through G.4 of Appendix G show preferred locations and acceptable ranges of the seat to the steering wheel for all the subjects in each of the four vehicles. Figures G.5 to G.8 show similar data for seat adjustment to the pedals, independent of the steering wheel. From these data the number of subjects "accommodated" at different seat-to-wheel and seat-to-pedal distances were calculated. Figures G.9 to G.16 show frequency plots of the number of drivers "satisfied" at each 10-mm increment of distances. The "maximally-acceptable" wheel-to-seat and seat-to-pedal distances were defined as the peaks of the least-squares regression curves to the frequency plots as shown in the figures.

Figures G.17 to G.20 plot each subject's calculated preferred wheel-to-pedal distance versus his/her stature. Boxed data points on these graphs indicate data from drivers of import vehicles, whereas circled data points denote outliers. The solid line on each plot is the linear regression between the two variables while dashed lines indicate the design, mean, and maximum acceptable values for the wheel-to-pedal distance.

As in the pilot study, only the results for the Monte Carlo show a significant difference for import and domestic drivers. In this vehicle, all but one of the import driver's calculated

preferred wheel-to-pedal distances were smaller than the actual test vehicle distance and a large percentage of the maximum-acceptable distances for import drivers are below the distance/stature regression line.

Table 8 summarizes these preferred wheel-to-pedal distances and compares them to the actual adjusted distances in the test vehicles, the distances in the vehicles before adjustment, the package design distances, and the optimal distances from the pilot study (Camaro and Monte Carlo only). Note that the unadjusted distances in the test vehicles are different than the design distances taken off the package drawings. In the Blazer and Cadillac, the actual distances are 10 and 13 mm less than the package design distances, while in the Camaro and Monte Carlo the actual distances are 36 and 23 mm larger. As previously noted, the actual wheel-to-pedal distances were adjusted in the Camaro and Monte Carlo to be approximately 63 mm and 42 mm less than the actual distances. It will be noted, however, that the adjusted distances are only 23 mm (Camaro) and 20 mm (Monte Carlo) less than the package design distances.

TABLE 8
PHASE I COMPARISON OF WHEEL-TO-PEDAL DISTANCES (mm)

Test Vehicle	Phase I		Pilot Study Maximum Acceptable	Actual Adjusted	Actual Unadjusted	Package Design
	Mean Preferred	Maximum Acceptable				
Blazer	578	590	—	593	593	606
Cadillac	589	590	—	590	590	600
Camaro	605	600	640	616	675	639
Monte Carlo	587	590	600	597	640	617

For all four vehicles, the maximum-acceptable wheel-to-pedal distances are equal to (Cadillac) or slightly smaller than the actual adjusted distances, with the larger difference being for the Camaro where the maximum-acceptable distance is 16 mm (5/8 in) less. For the Camaro, the Phase I maximum-acceptable distance of 600 mm is significantly less than the maximum-acceptable value of 640 mm found in the pilot study. For the Monte Carlo, the Phase I maximum-acceptable distance of 590 mm is nearly the same as (only 10 mm less than) the maximum acceptable distance found in the pilot study.

These results suggest that the actual wheel-to-pedal distance may provide some influence or bias to drivers when using the static seat-to-pedal and seat-to-wheel methods for determining preferred wheel-to-pedal relationships. In this regard, it is also interesting to note that the actual, adjusted wheel-to-pedal distances for the four vehicles are all very

similar as are the maximum-acceptable distances. The Camaro has the largest actual adjusted distance and also has the largest maximum-acceptable distance.

3.4 PHASE I EYE POSITION RESULTS

The processed eye location data were used to construct eyellipses that represent the distribution of eye locations in a relaxed, straight-ahead driving posture. The figures of Appendix H show top and side views of these new eye position results compared to the predicted eyellipses for each of the Phase I vehicles. In each case, the centroid of the eyellipse from the study is more rearward, further inboard, and slightly higher than the centroid predicted using SAE J941, even after adjusting the latter for the mean seatback recliner angles observed in each vehicle.

These data also reveal lower variability in the lateral (side-to-side) location for the eye positions. This decrease is indicated by the smaller calculated minor axis in the top view of the ellipses for each car. An increase in the fore/aft range is observed in the increased length of the major axis in both views for each car. Table H.1 summarizes the differences in the eye location values and distributions observed and those predicted by SAE J941.

3.5 PHASE II RESULTS

3.5.1 General Observations and Patterns. Phase II data consist of seat, steering wheel, and pedal adjustment data for the Camaro and Oldsmobile, as well as static eye, seat, and steering wheel position data for the Pontiac 6000, the only vehicle in the study without a seat recliner option. All testing done in this vehicle was with a fixed seatback angle of 26°. In tests with the Camaro and Oldsmobile, the subjects were again instructed to find their preferred seat position, seatback angle, and tilt-wheel adjustment with the additional option of pedal fore-and-aft adjustment under the driver's control.

Tables I.1 through I.4 and Figures I.1 through I.9 of Appendix I show each group's mean and standard deviation for seat position, seatback recliner angle, tilt-wheel angle, and pedal position. There is a readily-observed and expected relationship between subject height and selected seat position with taller subjects preferring more rearward seat placement. No trends are seen between preferred pedal position and subject height and, as seen previously in Phase I results, recliner-angle and tilt-wheel data show no relationship to stature.

The corresponding histograms in Figures I.10 through I.19 show the data distributions for the four variables. The data for seat position, seatback angle, and tilt-wheel angle for the Oldsmobile and Camaro reveal no "piling-up" of subject preferred positions, suggesting that the adjustability for these variables in these test vehicles was sufficient to accommodate the driver population. The only difference in sensing between the Phase I and Phase II data was for the Camaro seatback recliner results. In Phase I data, the Camaro distribution

shows that some subjects desired to sit more upright than the seat would allow. This was not evident in the Phase II data. It is interesting to note, however, that the mean seatback angle in the Phase I Camaro data is more reclined at 27.9°, than is the seatback angle in the Phase II Camaro data which has a mean value of 24.8° (see Table I.2).

Censoring is observed, however, in the pedal adjustment for the Oldsmobile. These histograms indicate that additional forward travel of the pedals was necessary to fully accommodate the driver population even though the mean preferred wheel-to-pedal distance is less than the design- or test-vehicle distance (see Section 3.5.2). The Camaro pedal distribution shows no “piling-up” of subjects at either end of the adjustability range limits. For the Pontiac 6000, which was not equipped with extended seat track travel, the static seat position data do reflect a need for additional seat adjustability both forward and rearward of the production range. Attempts to estimate an uncensored data set for this vehicle are impeded by the non-normal (i.e., skewed) characteristics of the sample distribution.

3.5.2 Comparison of Phase I and Phase II Preferred Wheel-to-Pedal Results.

Preferred wheel-to-pedal relationships were also examined in Phase II. Instead of estimating the ideal wheel-to-pedal relationship, as in the Phase I testing, the Oldsmobile and Camaro were equipped with movable power pedals, and subjects were able to adjust the pedals backward and forward to achieve their preferred wheel-to-pedal distance while on their test drive. The results are summarized in Figures I.9 and I.10 and Table I.4 of Appendix I. A trend for taller drivers to prefer longer wheel-to-pedal distances is not found but these results do indicate that, overall, a shorter wheel-to-pedal distance is desired. The overall mean pedal translations from production locations for the two cars are 25.5 mm rearward for the Oldsmobile and 59.6 mm rearward for the Camaro. As previously noted, the mean adjusted rearward translation for the pedals in Phase II for the Camaro closely matches the estimated preferred rearward pedal position of 63 mm used in Phase I.

3.5.3 Comparison of Phase I and Phase II Results for Seat Position, Seat Recliner Angle, and Tilt-Wheel Angle.

Figures 14 through 16 and Tables 9 through 11 show the weighted distributions of seat position in the Camaro, Oldsmobile, and Pontiac 6000, respectively, compared to the SAE J1517 model prediction for these vehicles. The model was calculated using the actual seat height and the mean adjusted BOF derived from the use of the movable pedal option. The result is virtually the same for the Camaro used in Phase I since the mean preferred pedal adjustment in Phase II differed only a few millimeters from the test design of Phase I (59.6 mm rearward of design for Phase II versus 63 mm rearward of design for Phase I). For the Oldsmobile J1517, however, the model distribution is significantly different from the Cadillac in Phase I primarily because of more

than 25 mm difference in the BOF location between the two cars (see Section 3.5.2), but also perhaps because of a small difference in seat heights (i.e., H-point heights).

The more rearward (than predicted) seat distribution found in Phase I for the Camaro was repeated in the Phase II testing. The Camaro weighted mean seat position in Phase II is only 4 mm further rearward from the weighted mean in Phase I and the rearward shift of the seating accommodation curve is repeated, as evident in Figure 14. As already noted, the mean observed seatback angle differed by 2.9° (more recline in Phase I) and the mean preferred tilt-wheel angle differed by 0.3° between the two phases of testing.

The Oldsmobile Touring Sedan was intended to be of similar seating package geometry to the Cadillac Sedan Deville used in Phase I, but the test results for these two vehicles were quite different. In the Oldsmobile, the mean selected seat position is 22 mm further forward than that of the Cadillac and, when the observed seated distribution is compared to that of the J1517 model, as seen in Figure I.26 of Appendix I, the two curves match closely. In contrast, the seat distribution in the Cadillac is shifted rearward an average of 61 mm from the model.

The mean observed seatback angle is 5.6° more reclined in the Oldsmobile than in the Cadillac and the mean preferred tilt-wheel angle is 4.6° further from vertical. A primary difference between the Cadillac and Oldsmobile is the seat pan angles. During testing in the Cadillac, subjects were encouraged to use the six-way power seat to adjust the orientation and height of the seat cushion. For tests in the Oldsmobile, the six-way adjustment option was “locked out” and the design pan angle was approximately 18 degrees³. This angle is considered to be the upper limit of acceptability for a seat pan angle and several subjects commented on the excessive height of the front edge of the seat which caused increased pressure on the back of the thighs. Although the pan angle of the Cadillac seat was never measured, it is estimated to have a much flatter pan angle. It is hypothesized that the large pan angle of the Oldsmobile influenced subjects to sit further forward in order to relieve the pressure exerted on their legs by the seat cushion.

3.5.4 Pontiac 6000 Static Test Results. Seat position and tilt-wheel angle data were also gathered from the subjects in the Pontiac 6000 but these adjustments were made under static conditions only. These data are summarized in Tables I.1 and I.3 of Appendix I. Here the rearward shift in seat distribution observed in all but the Oldsmobile noted above, does not exist. As seen in Figure I.27 of Appendix I, the plot for seat position distribution is close to the seat distribution predicted by SAE J1517.

³Pan angle of this seat was measured sometime later through a procedure developed at GM using the J826 H-point machine.

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
CAMARO—PHASE II

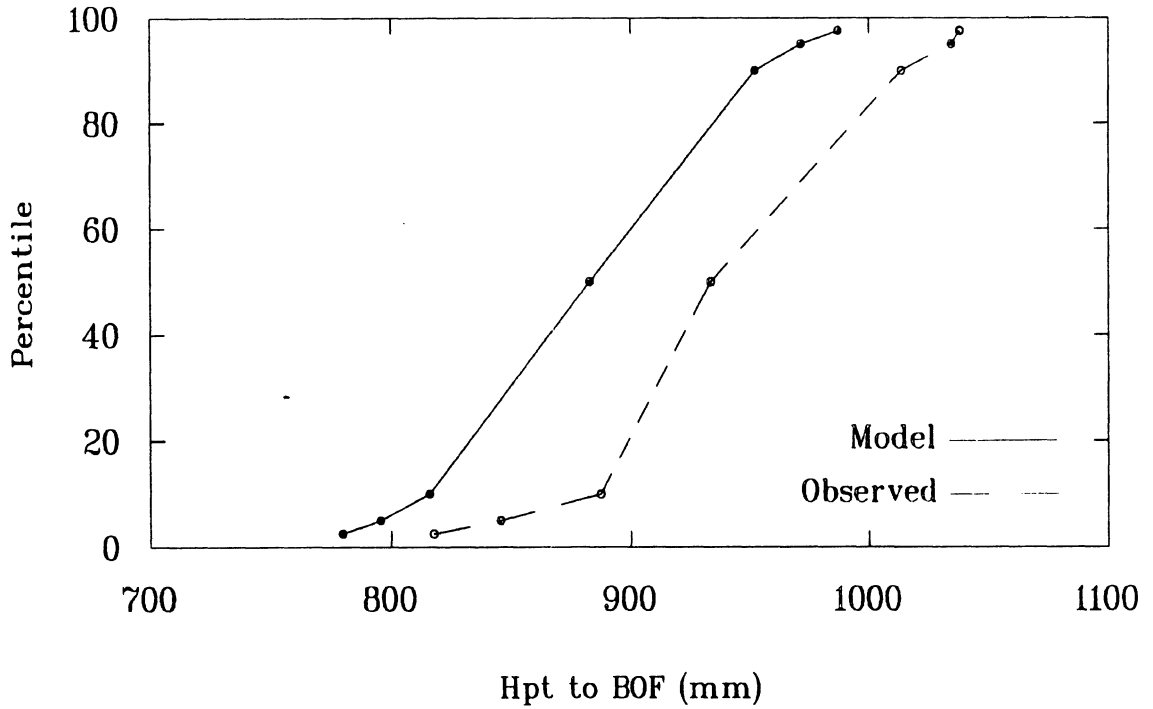


FIGURE 14

TABLE 9

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
CAMARO PHASE II

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2932	818	780	33
5.0	2960	846	795	51
10.0	3002	888	816	72
50.0	3048	934	883	51
90.0	3128	1014	952	62
95.0	3149	1035	971	64
97.5	3152	1038	987	51

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
OLDSMOBILE—PHASE II

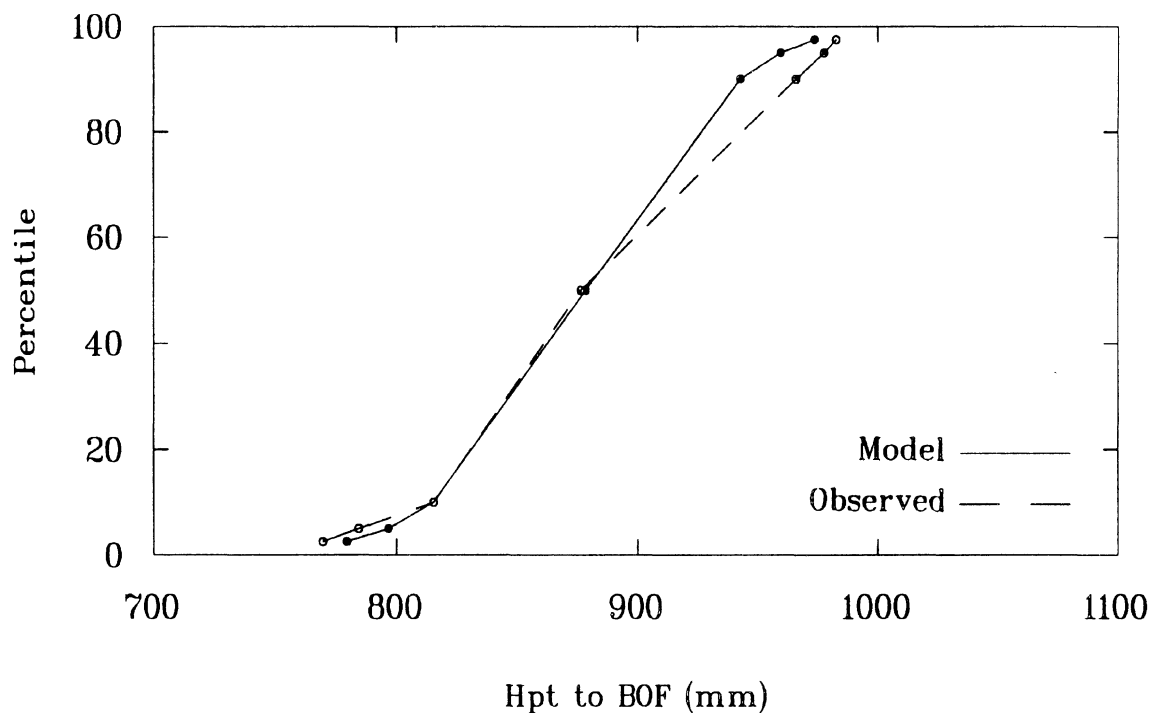


FIGURE 15

TABLE 10

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
OLDSMOBILE PHASE II

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2981	770	779	-9
5.0	2996	784	797	-13
10.0	3027	815	815	0
50.0	3088	877	879	-2
90.0	3177	966	943	23
95.0	3189	978	960	18
97.5	3194	983	974	9

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
 STATIC TEST RESULTS FOR PONTIAC 6000 PHASE II

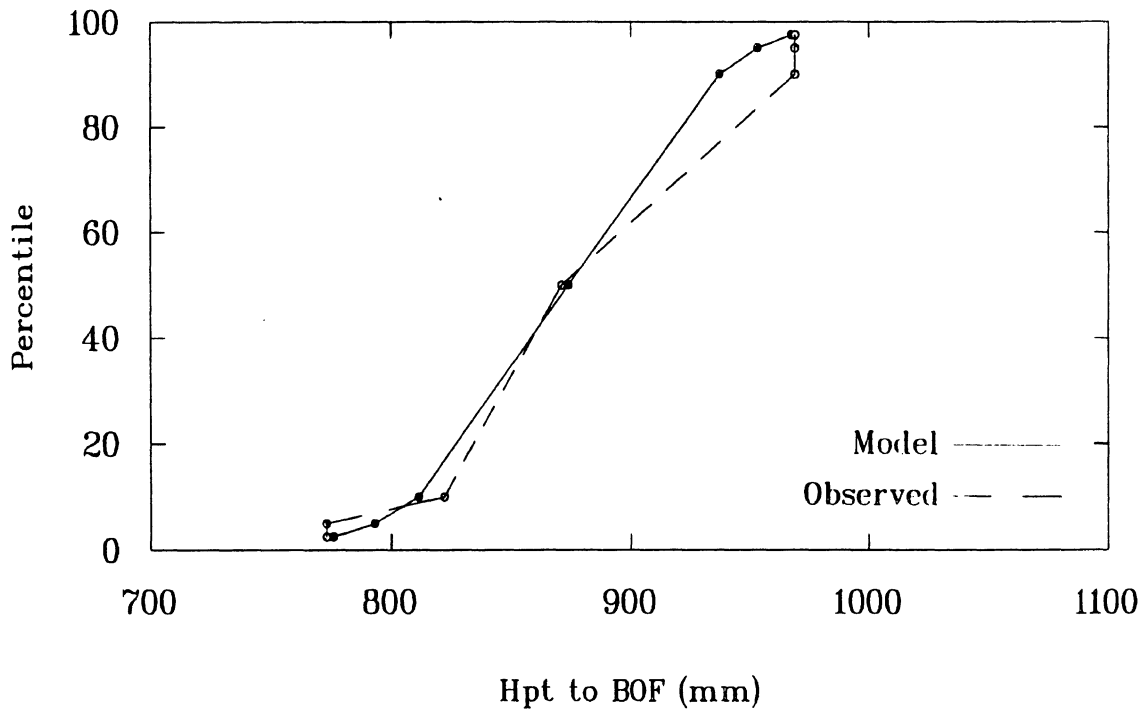


FIGURE 16

TABLE 11

COMPARISON OF ACTUAL AND PREDICTED H-POINT-TO-BOF DISTANCES:
 STATIC TEST RESULTS FOR PONTIAC 6000 PHASE II

Percentile	Observed Seat Position	Observed Hpt-to-BOF Distance	Model Predicted Hpt-to-BOF Distance	Difference Observed-Model
2.5	2959	773	776	-3
5.0	2959	773	793	-20
10.0	3008	822	811	11
50.0	3057	871	874	-3
90.0	3155	969	937	32
95.0	3155	969	953	16
97.5	3155	969	967	2

Eye position was measured in the Pontiac 6000 under static conditions similar to those used in the original eye position study by Meldrum (1965) which led to the development of the eyellipse model. It was hypothesized that, by reproducing the original conditions under which the eye measurements were made, similar results would be produced. Plots and tables of the resulting data are found in Figures I.23 and I.24 of Appendix I. As with the dynamic data in other vehicles, it was found that the drivers' eyes in the Pontiac 6000 under static conditions were further rearward, higher than, and inboard of the location predicted by SAE J941. Similarly, the observed eyellipse has less side-to-side variability and more front-to-back variability than the SAE eyellipse. These differences between observed and predicted eye locations are consistent with the previous data even though the eye positions were collected statically in a car with no seat recliner option and no extended rearward travel.

3.6 PHASE III RESULTS

Phase III data include preferred seat fore/aft position, tilt-wheel, and eye locations collected in driving sessions with the same Pontiac 6000 used in Phase II static tests. The seat and tilt-wheel results are presented in Figures J.1 to J.2 and in Table J.1 of Appendix J. Again the trend of taller subjects preferring more rearward seat positions is observed while the tilt-wheel results reflect little dependence upon stature.

The Pontiac 6000 was the only car in the study without an extended travel option on the seat track. These limits on seat travel resulted in censoring of both data sets (Phase II and Phase III) collected in this vehicle. The results show drivers who would have liked to sit further forward and drivers who would have preferred to sit further back from the steering wheel and pedals. Additionally, the Pontiac 6000 was the only car without a seatback recliner adjustment option. The seatback was fixed at 26° for all testing.

A comparison of static and dynamic seat position results is shown in Figures J.3 and J.3 of Appendix J. Figure J.3 plots dynamic versus static preferred seat position and shows little difference between the two conditions. Similarly, Figure J.4 shows dynamic versus static tilt-wheel adjustments. This graph reflects that, on the average, subjects inclined the wheel more (i.e., more vertical) for actual driving than for static tests.

Figure 17 and Table 12 show the observed seat positions for both dynamic and static conditions compared with the seat positions predicted by SAE J1517. It is seen that the differences between static and dynamic seat distributions are small with no consistent trend or shift rearward for the dynamic data. The new data do not support the idea that the J1517 seat accommodation curves are shifted forward solely because they were not gathered under actual driving conditions.

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCE
 STATIC AND DYNAMIC TEST RESULTS FOR PONTIAC 6000 PHASE III

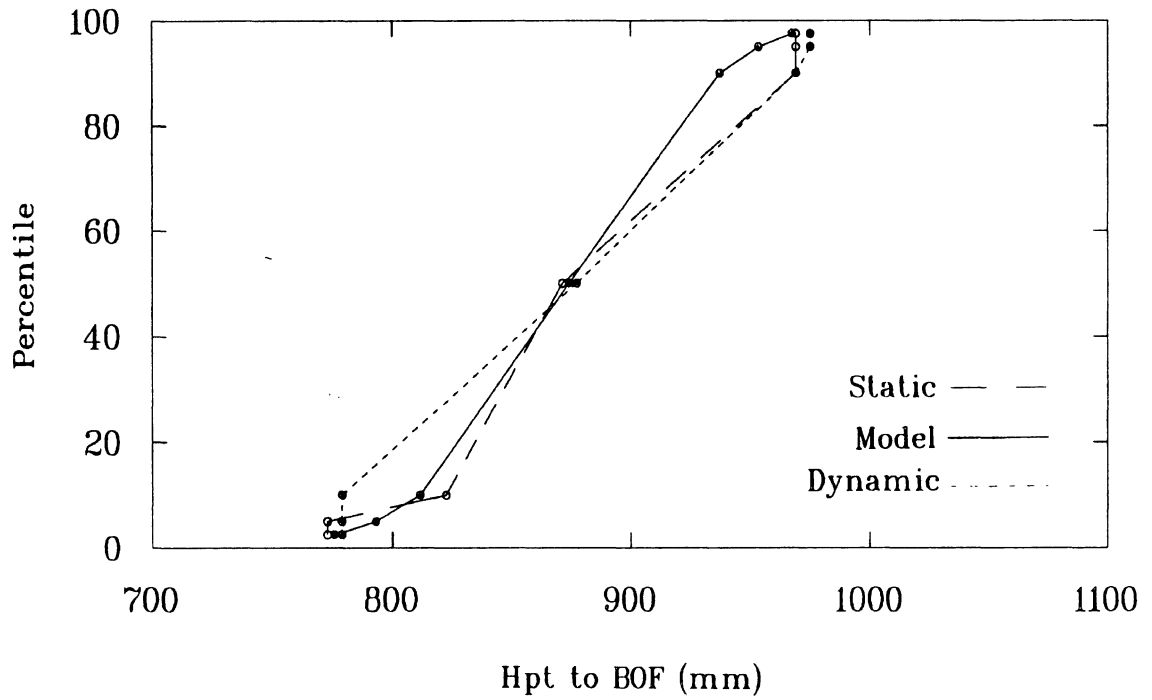


FIGURE 17

TABLE 12

COMPARISON OF SAE J1517 TO OBSERVED H-POINT-TO-BOF DISTANCES:
 STATIC AND DYNAMIC RESULTS FOR PONTIAC 6000 PHASE III

%tile	Observed Seat Position		Observed Hpt-to-BOF		Seat Ht. (H-30)	Model Predicted Hpt-to-BOF	Difference Observed-Model	
	Static	Dynamic	Static	Dynamic			Static	Dynamic
2.5	2959	2965	773	779	268	776	-3	3
5.0	2959	2965	773	779	268	793	-20	-14
10.0	3008	2965	822	779	268	811	11	-32
50.0	3057	3063	871	877	268	874	-3	3
90.0	3155	3155	969	969	268	937	32	32
95.0	3155	3161	969	975	268	953	16	22
97.5	3155	3161	969	975	268	967	2	8

One explanation for the absence of more rearward seat positions is the seat-pan angle of the Pontiac. Like the Oldsmobile of Phase II, this car had a high pan angle (about 16°) which is considered higher than average for an automobile. It is possible that this high pan angle and the resulting increase in thigh support encourages drivers to sit further forward to relieve excess pressure on the back of the legs.

Eye position was collected in Phase III using the two-camera stereophotogrammetry techniques previously described. The results are presented in Figures J.5 and J.6 of Appendix J. The eye position data recorded immediately upon return from the test drive are represented by an eyellipse that is further rearward, higher, and more inboard than the SAE eyellipse, but is lower than the eyellipse based on the static data in this vehicle. Both sets of eye position data collected in the Pontiac 6000 show less lateral variability and more fore/aft variability than estimated by SAE J941. This additional front/back variability and a more rearward eyellipse centroid, seen in each vehicle, is perhaps least expected in the Pontiac 6000 where there was no additional rearward travel and no seatback angle recliner to allow the driver to be sitting in a more rearward than expected position.

IV. SUMMARY AND DISCUSSION OF KEY FINDINGS

This study was initiated to investigate driver preference for seat fore/aft position, seatback recliner angle, and tilt-wheel adjustments; to determine where driver eyes are located in the vehicle under straight-ahead driving conditions; and to examine preferred steering-wheel-to-pedal distances for several vehicles of different package geometry and chair height. The results obtained provide new insight with regard to driver positioning within the vehicle workspace and point out shortcomings of the present SAE models.

A method by which the ideal pedal-to-wheel geometry can be estimated without the addition of movable pedals or wheel was developed and tested. The results suggest that this method offers a good approximation of what a driver may actually prefer under dynamic conditions, although there are also indications that the wheel-to-pedal distance established in the vehicle may influence results. In Phase I testing, for example, this static adjustment method was used for the Camaro to calculate an optimal population pedal-to-wheel relationship of 600 cm. When the subjects were allowed to adjust the pedals while driving in Phase II, the weighted mean preferred pedal-to-wheel distance was 610 mm. The agreement in results for these different test conditions increases confidence in the static adjustment method.

Using this static seat positioning method in Phase I and the adjustable pedals in Phase II, optimal population wheel-to-pedal geometries were determined for five vehicles. In four of the five, a maximally-acceptable wheel-to-pedal distance that is shorter than the production vehicles was determined.

Analysis of seatback recliner usage patterns shows little correlation with other variables in the vehicle, but does reveal a strong trend for subjects to prefer more upright recliner angles than expected. Seatback recliner angles also show no trends with preferred seat position, pan angle, or tilt-wheel angle. Furthermore, the hypothesis that drivers use the seatback recliner option to help achieve an optimal distance from the wheel is not well supported by the data. The trend for subjects to sit more erect than expected was reflected in mean preferred recliner angles that were smaller than design in three of the five cars tested. Censoring of the Phase I data in the Blazer, Monte Carlo, and Camaro indicates that some subjects wanted to sit even more upright than the recliner adjustment would allow. If this additional travel were available, even smaller mean preferred recliner angles for these vehicles would be expected.

Dynamic seat position was recorded and examined in all vehicles and comparisons were made between the distributions of observed seat-to-ball-of-foot (BOF) distances and those distributions predicted by SAE J1517. In four of the six cars, the estimated population seat distributions were more rearward of BOF than the model predicts. In the remaining two cars, the Oldsmobile and the Pontiac 6000 (tested dynamically and statically, respectively), the model more closely fit the observed distributions of preferred Hpt-to-BOF distances. In all cars, a portion of the subjects made use of the extended fore-and-aft travel provided in the test vehicle. It does not appear that differences between the model and study seat distributions can be attributed to increasing stature of the U.S. population since the driver sampling strategy used in the study replicated the population stature distribution in the 1974 HANES database (Abraham et al. 1979a, 1979b) which is similar to the populations used to develop the model.

It is hypothesized that seat-pan angle may be an important factor influencing selected seat position and that differences in pan angle may account for the noted differences in the J1517 seat distributions and the study distributions. Although pan angle was not one of the aspects of seating targeted in the beginning of the study, and was therefore not measured in many of the cars, in retrospect it seems to explain some of the seat position results. The Oldsmobile and Pontiac 6000 are vehicles with large pan angles of 18° and 16°, respectively.⁴ In these cars, the seat distributions of the study matched closely to the model predictions. The Cadillac is estimated to have the smallest design pan angle, but this is not verifiable due to disposal of the car before pan angle was considered a factor. Nevertheless, study drivers sat the most rearward in the Cadillac in comparison to the model than in any other vehicle in the study. The remaining vehicles were estimated to have average pan angles (about 13°) and, in these cases, seat distributions were rearward of the model, but not as rearward as in the Cadillac. A subsequent controlled study of pan angle and its effects on driver selected seat and wheel adjustments is now underway at UMTRI and will yield more conclusive data as to the relationship of these factors.

Eye location measurements also reveal shortcomings of the SAE J941 model in size and location predictions. A study of lateral lean, documented separately (Lee and Schneider 1988), determined that drivers do not lean outboard as reflected in the SAE model, but instead sit almost central on the seat, if not slightly inboard. The examination of eye locations in this study consistently places the eyes higher than, more rearward than, and more inboard than the SAE model. These differences do not appear to be attributable to differences between static and dynamic data collection techniques. In the Pontiac 6000, where eye location data were collected both statically as in the Meldrum (1965) study and immediately after driving, the latter data came closer to matching the SAE eyellipse model

⁴Measured by GM procedure.

than the statically-collected data. Along with differences in centroid location of the eyellipse, a decrease in the lateral variability and an increase in fore/aft variability was observed.

REFERENCES

- Abraham, S.; Johnson, C.L.; and Najjar, M.F. (1979a) Weight and height of adults 18–74 years of age. *Vital and Health Statistics*, Series 11, Number 211.
- Abraham, S.; Johnson, C.L.; and Najjar, M.F. (1979b) Weight and height and age for adults 18–74 years. *Vital and Health Statistics*, Series 11, Number 208.
- Abdel-Aziz, Y.I.; and Karara, H.M. (1971) Direct linear transformation from comparator coordinates into object-space coordinates in close-range photogrammetry. In *Proc. of ASP Symposium on Close-Range Photogrammetry*. Urbana, Ill.
- Hammond, D.C.; and Roe, R.W. (1972) *Driver head and eye positions*. SAE paper no. 720200. Society of Automotive Engineers, Warrendale, Pa.
- Lee, N.S.; and Schneider, L.W. (1988) *A preliminary investigation of driver lean in late model vehicles with bench and bucket seats*. Report no. UMTRI-88-49. University of Michigan Transportation Research Institute, Ann Arbor.
- Meldrum, J. (1965) *Driver eye position*. Technical report no. S-65-3. Ford Motor Company, Automotive Safety Office, Dearborn, Mi.
- Stoudt, H.W.; Damon, A.; McFarland, R.; and Roberts, J. (1965) Weight, height, and selected body dimensions of adults. *Vital and Health Statistics*, Series 11, Number 8.

APPENDICES

APPENDIX A
MODIFIED MONTE CARLO PEDALS AND TEST VEHICLE READOUT SCALES



FIGURE A.1 Modified pedal linkage for changing pedal location in Monte Carlo.



FIGURE A.2 Removable pedals installed in Monte Carlo vehicle.

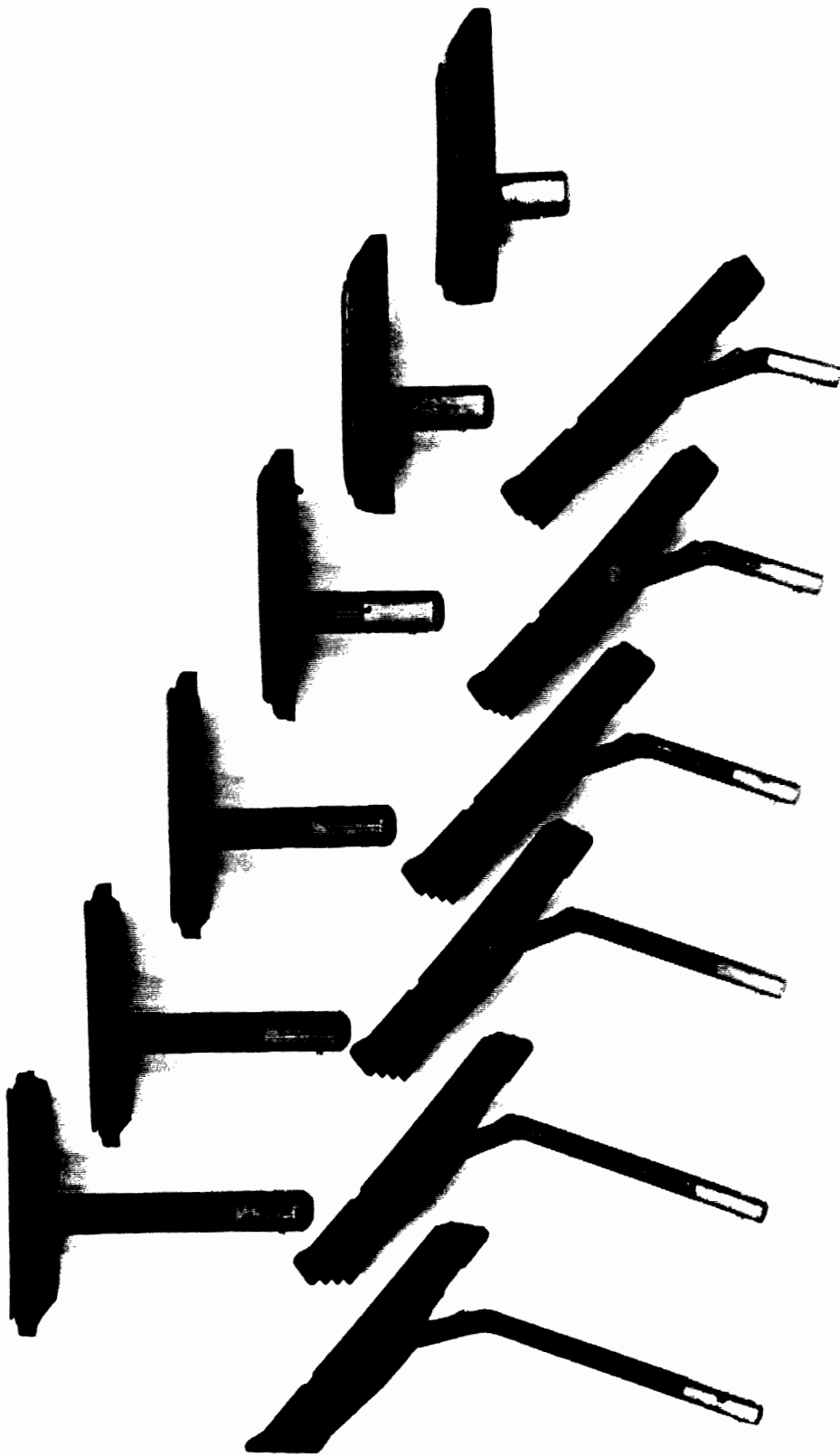


FIGURE A.3 Assortment of Monte Carlo brake and acceleration pedal pads with varying shaft lengths.

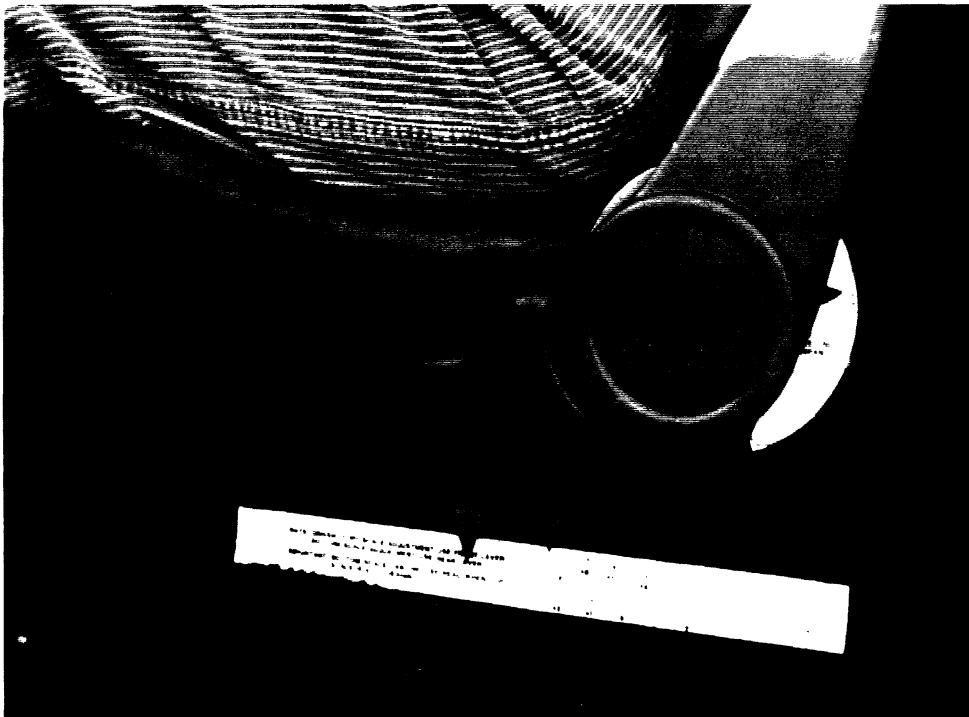
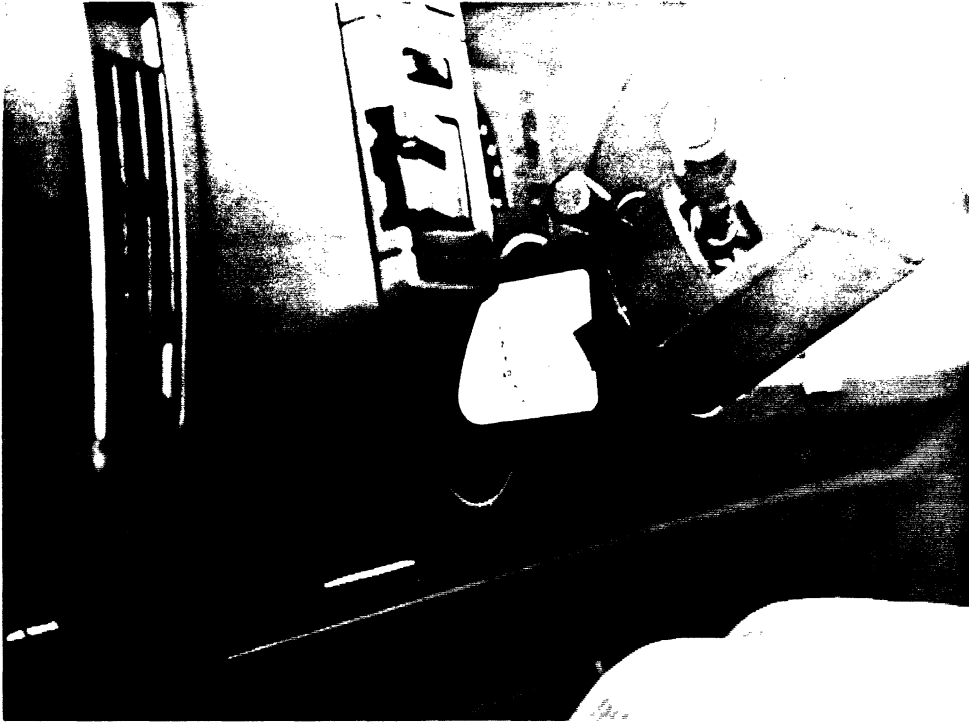


FIGURE A.4 Wheel and seat readout scale for Blazer test vehicle.



FIGURE A.5 Steering wheel-tilt readout scale for Cadillac (top) and seat and seatback readout scales for Cadillac and Oldsmobile (bottom).



FIGURE A.6 Seat height and pan angle readout scales for Oldsmobile and Cadillac with six-way power seats.

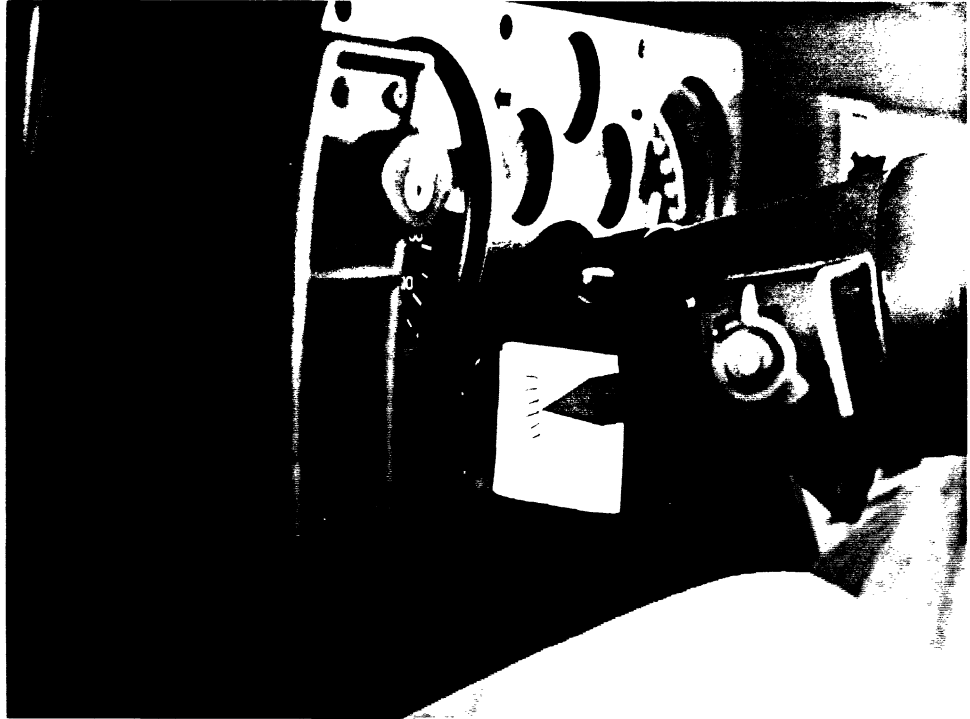


FIGURE A.7 Steering wheel-tilt and seat readout scales for Camaro test vehicle.

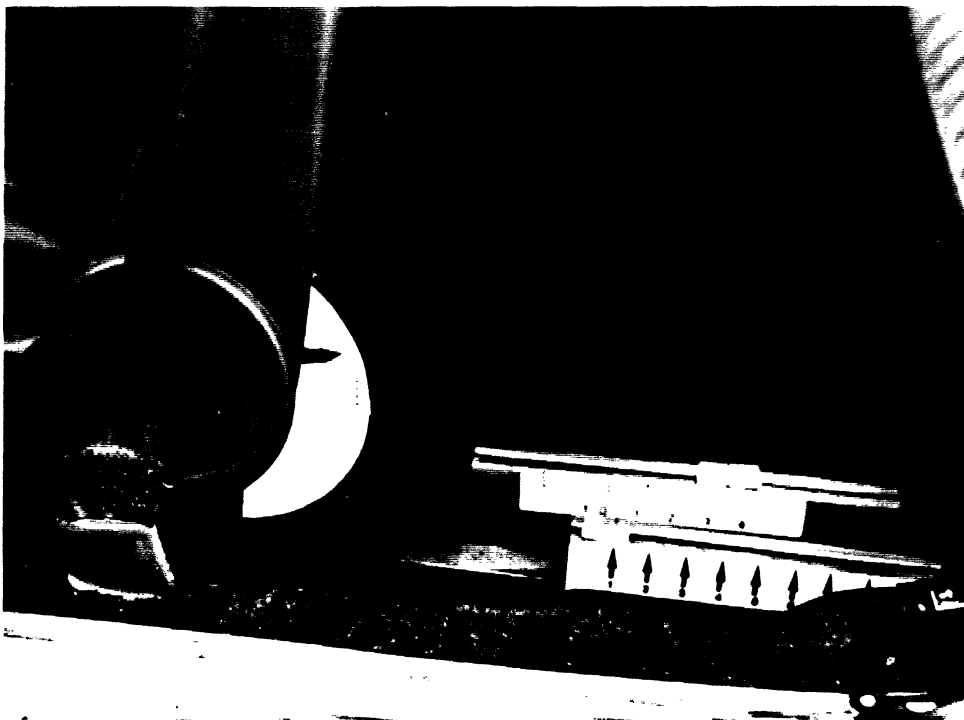
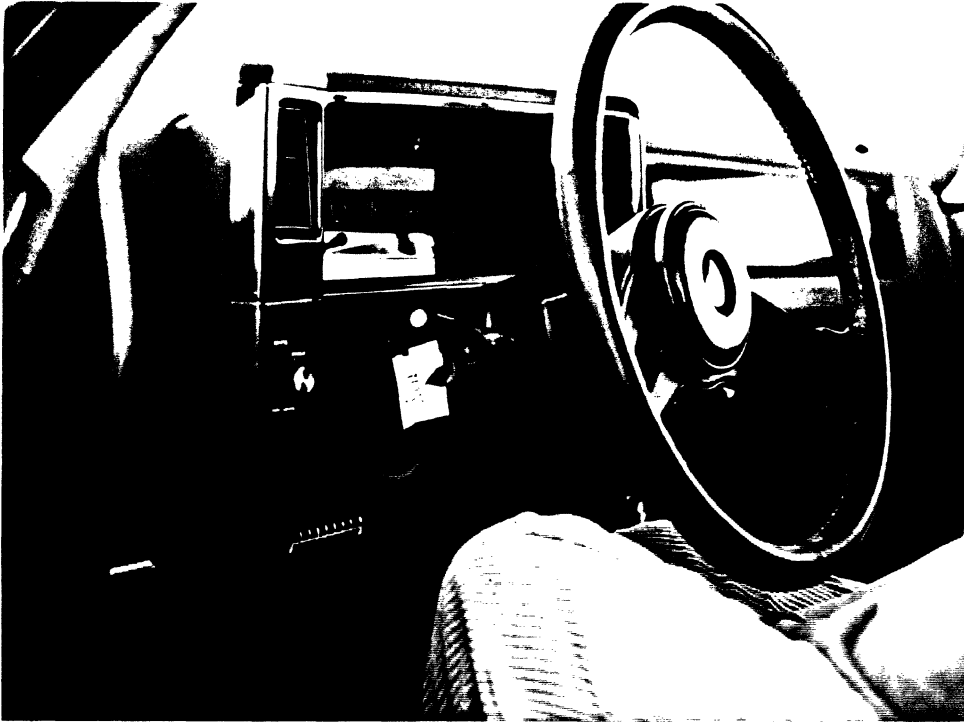


FIGURE A.8 Steering wheel-tilt and seat readout scales for Monte Carlo test vehicle.

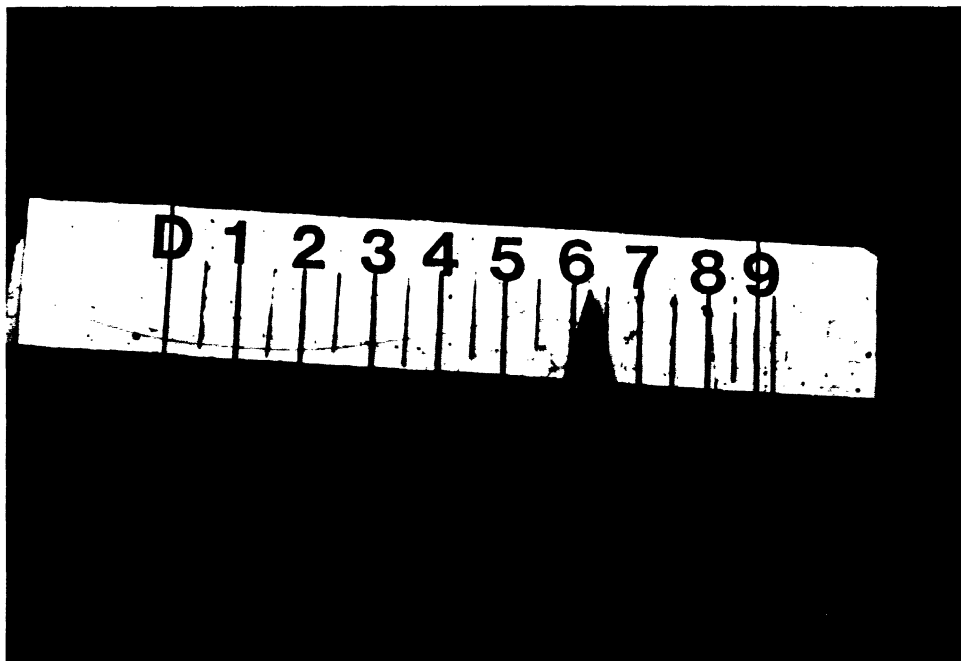
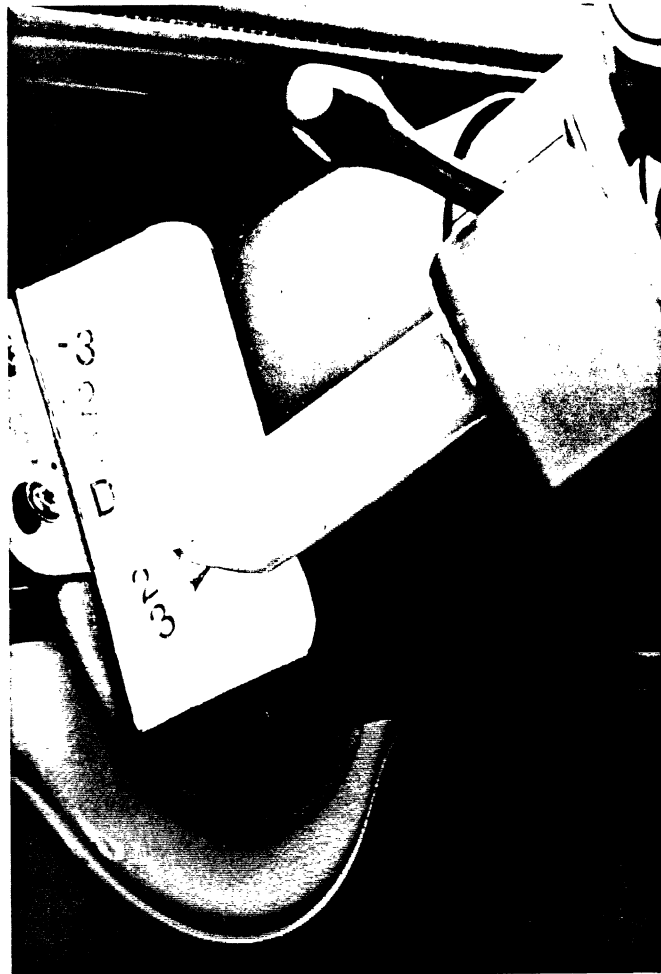


FIGURE A.9 Steering wheel-tilt and seat readout scales for Oldsmobile test vehicle.

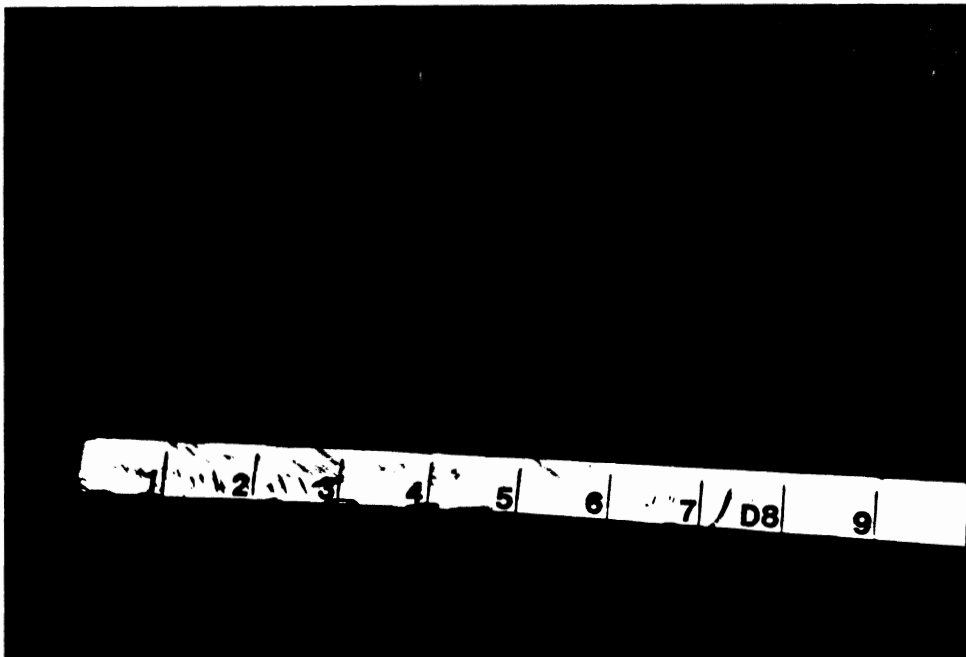
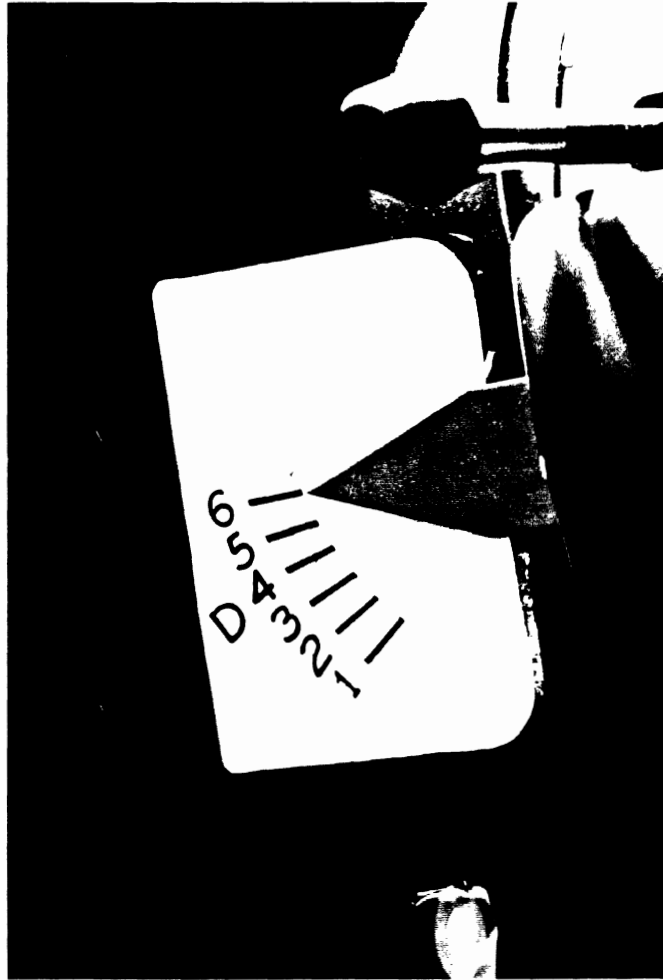
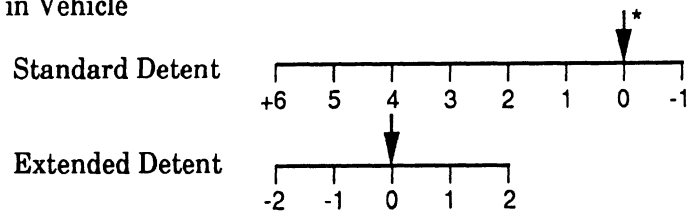


FIGURE A.10 Steering wheel-tilt and seat readout scales for Pontiac 6000 test vehicle.

BLAZER

Detent Scales in Vehicle



To make these readings correspond with the other cars, the data was translated as follows:

$$\text{New Standard Detent} = -1 \times (\text{Original Standard Detent}) + 7$$

$$\text{New Extended Detent} = -1 \times (\text{Original Extended Detent})$$

The two detents can now be added to create a resultant scale:

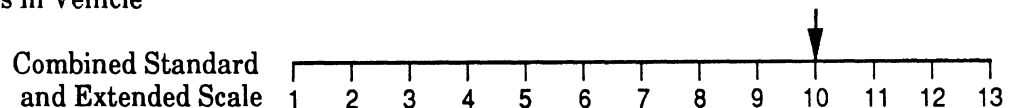


To obtain seat position coordinates relative to H-point this new reading must be changed as follows:

$$\text{Detent Relative to H-Point} = ((\text{Resultant Detent}) - 7) * 21 \text{ mm} + \text{H-Point}$$

CADILLAC

Detent Scales in Vehicle



Although the car seat offers extended travel, all readings are read off one combined scale. To convert this to H-point reading:

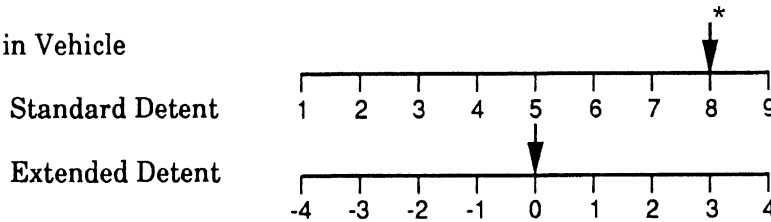
$$\text{Detent Relative to H-Point} = ((\text{Original Detent}) - 10) * 21 + \text{H-Point}$$

*↓ denotes design seat position setting.

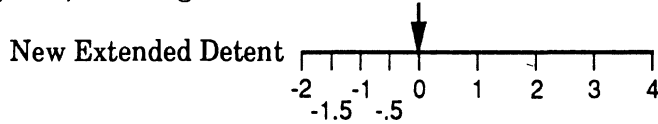
FIGURE A.11 Procedures for calculating seat position from standard and extended seat adjuster scales in test vehicles.

CAMARO

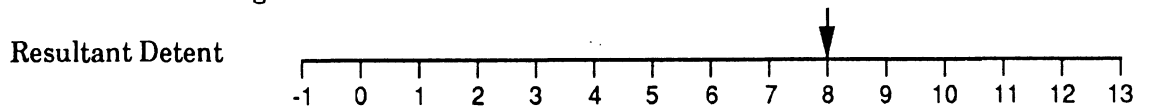
Detent Scales in Vehicle



Because of the different size detents on the extended scale, all readings must be divided by 2 if they are negative, resulting in a new "addable" extended scale:



The standard and extended readings are then added to make a resultant detent:

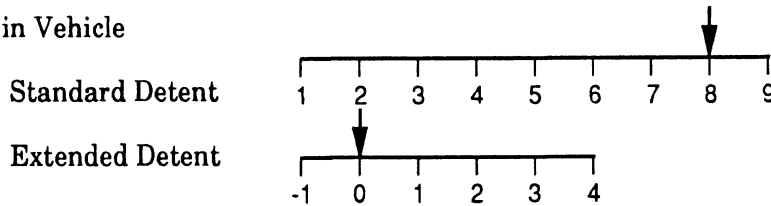


To obtain seat position coordinates relative to H-point this new reading must be changed as follows:

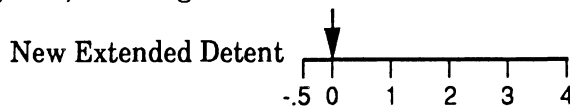
$$\text{Detent Relative to H-Point} = ((\text{Resultant Detent}) - 8) * 21 \text{ mm} + \text{H-Point}$$

MONTE CARLO

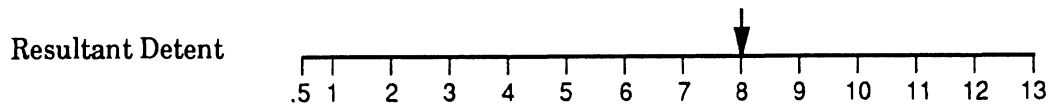
Detent Scales in Vehicle



Because of the different size detents on the extended scale, all readings must be divided by 2 if they are negative, resulting in a new "addable" extended scale:



The two detents can now be added to create a resultant scale:



To obtain seat position coordinates relative to H-point this new reading must be changed as follows:

$$\text{Detent Relative to H-Point} = ((\text{Resultant Detent}) - 8) * 21 \text{ mm} + \text{H-Point}$$

*↓ denotes design seat position setting.

FIGURE A.11 (Continued)

APPENDIX B

SUMMARY OF PACKAGE AND TEST VEHICLE COORDINATES, DIMENSIONS, AND FEATURES

TABLE B.1
CHEVY BLAZER

ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2229	2460	231
Steering Wheel Tilt	Deg rel. vertical	11.5	36.5	25
Seat Recliner Angle	Deg rel. vertical	19	39	20
Pedals—No Adjustment				

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	2397
	Z	836
Steering Wheel Tilt	Deg rel. vertical	21
Seat Recliner Angle	Deg rel. vertical	23
Pedals Accelerator (BOF)	X	1433
	Z	724
Brake (Center Brake Pad)	X	1483
	Z	739
AHP	X	1534
	Z	549
SAE Eyellipse Centroid	X	2334†
	Z	1472†
WCtr	X	2024
	Z	1183

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	310†
	Z	289†
Hpt to SAE Eyellipse Centroid	X	63†
	Z	636†
AHP to Hpt	X	863
	Z	288
BOF to Hpt	X	965
	Z	112
Center Brake Pad to Hpt	X	914
	Z	97
AHP to WCtr	X	490
	Z	634
BOF to WCtr	X	593
	Z	459

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

**TABLE B.2
CADILLAC SEDAN DEVILLE**

ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2970	3232	262
Steering Wheel Tilt	Deg rel. vertical	6	36	30
Seat Recliner Angle	Deg rel. vertical	18	46	28

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	3159
	Z	684
Steering Wheel Tilt	Deg rel. vertical	21
Seat Recliner Angle	Deg rel. vertical	26
Pedals Accelerator (BOF)	X	2172
	Z	630
Brake (Center Brake Pad)	X	2233
	Z	633
AHP	X	2257
	Z	444
SAE Eyellipse Centroid	X	3067†
	Z	1325†
WCtr	X	2762
	Z	1050

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	304†
	Z	276†
Hpt to SAE Eyellipse Centroid	X	93†
	Z	642†
AHP to Hpt	X	902
	Z	240
BOF to Hpt	X	987
	Z	54
Center Brake Pad to Hpt	X	926
	Z	51
AHP to WCtr	X	505
	Z	606
BOF to WCtr	X	590
	Z	420

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

TABLE B.3
CAMARO

ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2877	3170	293
Steering Wheel Tilt	Deg rel. vertical	6	31	25
Seat Recliner Angle	Deg rel. vertical	18	36.5	18.5
Pedals				
Accelerator (BOF)	X	2054	2186	132
		621	608	13
Brake (Center Brake Pad)	X	2133	2263	130
	Z	621	598	23

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	3065
	Z	616
Steering Wheel Tilt	Deg rel. vertical	
Seat Recliner Angle	Deg rel. vertical	26
Pedals		
Accelerator (BOF)	X	2118*
	Z	631
Brake (Center Brake Pad)	X	2202*
	Z	609
AHP	X	2185*
	Z	439
SAE Eyellipse Centroid	X	3081†
	Z	1234†
WCtr	X	2734
	Z	994

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	347†
	Z	240†
Hpt to SAE Eyellipse Centroid	X	16†
	Z	618†
AHP to Hpt	X	880*
	Z	177
BOF to Hpt	X	947*
	Z	15
Center Brake Pad to Hpt	X	863*
	Z	7
AHP to WCtr	X	549*
	Z	555
BOF to WCtr	X	616*‡
	Z	363

*Data reflect dimensions for pedals moved rearward 63 mm from original location.

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

‡Note BOF to WCtr when adjustable pedals are at unadjusted position is 675 mm in X-direction.

TABLE B.4
MONTE CARLO
ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2941	3203	262
Steering Wheel Tilt	Deg rel. vertical	11	34	23
Seat Recliner Angle	Deg rel. vertical	20.5	41.5	21
Pedals				
Accelerator (BOF)	X	2109	2205	96
	Z	626	610	16
Center Brake Pad	X	2282	2276	6
	Z	650	650	0

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	3098
	Z	682
Steering Wheel Tilt	Deg rel. vertical	19
Seat Recliner Angle		26.5
Pedals		
Accelerator (BOF)	X	2155*
	Z	635
Brake (Center Brake Pad)	X	2192*
	Z	650
AHP	X	2234*
	Z	450
SAE Eyellipse Centroid	X	3083†
	Z	1312†
WCtr	X	2752
	Z	1057

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	330†
	Z	255†
Hpt to SAE Eyellipse Centroid	X	15†
	Z	631†
AHP to Hpt	X	864*
	Z	231
BOF to Hpt	X	978*
	Z	58
Center Brake Pad to Hpt	X	906*
	Z	31
AHP to WCtr	X	518*
	Z	607
BOF to WCtr	X	597*‡
	Z	—

*Data reflect dimensions for pedals moved rearward 42 mm from original location.

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

‡Note BOF to WCtr when adjustable pedals are at unadjusted position is 640 mm in X-direction.

**TABLE B.5
PONTIAC 6000**

ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2959	3155	196
Steering Wheel Tilt	Deg rel. vertical	11	36	25

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	3137
	Z	462
Steering Wheel Tilt	Deg rel. vertical	21
Seat Recliner Angle	Deg rel. vertical	26
Pedals		
Accelerator (BOF)	X	2186
	Z	335
Brake (Center Brake Pad)	X	2248
	Z	378
AHP	X	2280
	Z	196
SAE Eyellipse Centroid	X	3126†
	Z	1085†
WCtr	X	2769
	Z	834

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	357†
	Z	252†
Hpt to SAE Eyellipse Centroid	X	11†
	Z	624†
AHP to Hpt	X	857
	Z	266
BOF to Hpt	X	934
	Z	127
Center Brake Pad to Hpt	X	889
	Z	84
AHP to WCtr	X	489
	Z	538
BOF to WCtr	X	566
	Z	499

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

**TABLE B.6
OLDSMOBILE TOURING SEDAN**

ADJUSTMENT RANGES AND LIMITS (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle		
		From	To	Distance
Seat Fore/Aft Travel	X	2949	3198	249
Steering Wheel Tilt	Deg rel. vertical	6	36	30
Seat Recliner Angle	Deg rel. vertical	18	46	28
Pedals				
Accelerator (BOF)	X	2186	2270	84
	Z	634	641	7
Brake (Center Brake Pad)	X	2229	2321	92
	Z	628	628	0

LOCATIONS IN VEHICLE COORDINATES (mm)

Components/Landmarks	Measurement/ Coordinate	Test Vehicle
Seat (H-Point)	X	3135
	Z	694
Steering Wheel Tilt	Deg rel. vertical	21
Seat Recliner Angle	Deg rel. vertical	26
Pedals		
Accelerator (BOF)	X	2186
	Z	634
Brake (Center Brake Pad)	X	2229
	Z	628
AHP	X	2273
	Z	444
SAE Eyellipse Centroid	X	3131†
	Z	1315†
WCtr	X	2774
	Z	1064

DISTANCES (mm)

Components/Landmarks	Coordinate	Test Vehicle
WCtr to SAE Eyellipse Centroid	X	357†
	Z	251
Hpt to SAE Eyellipse Centroid	X	4†
	Z	622†
AHP to Hpt	X	862
	Z	250
BOF to Hpt	X	949
	Z	60
Center Brake Pad to Hpt	X	906
	Z	66
AHP to WCtr	X	501
	Z	620
BOF to WCtr	X	588
	Z	430

†Data reflect eyellipse centroid adjusted for mean subject seatback recliner angle.

APPENDIX C
DATA COLLECTION FORMS

**Steering Wheel Location Pilot Study
Data Collection Sheet**

Vehicle: Monte Carlo _____
Camaro _____

Date: _____

Subject Number: _____
 Vehicle make/model/year: _____
 Steering wheel-to-sternum: _____ Upper arm angle: _____ Lower arm angle: _____
 Gender: _____ Age: _____ Stature: _____ Wt: _____

Preliminary Drive

Detent: _____ Back Angle: _____ Wheel Tilt Angle: _____

Comments: _____

Seat-to-Pedals (Static)

Pedals at 0 mm (design):

		MANUAL DETENT	ELECTRIC DETENT	RESULTANT DETENT
A = _____ (Avg.)	Preferred 1	_____	_____	_____
	Rearward Limit	_____	_____	_____
	Forward Limit	_____	_____	_____
	Preferred 2	_____	_____	_____
	Preferred 3	_____	_____	_____

Seat-to-Steering Wheel (Static)

		MANUAL DETENT	ELECTRIC DETENT	RESULTANT DETENT
B = _____ (Avg.)	Preferred 1	_____	_____	_____
	Rearward Limit	_____	_____	_____
	Forward Limit	_____	_____	_____
	Preferred 2	_____	_____	_____
	Preferred 3	_____	_____	_____

Steering wheel-to-sternum: _____ Upper arm angle: _____ Lower arm angle: _____

Final Drive (with "optimal" pedals)

"Optimal" pedals = (B-A) x 21 mm = _____ mm

If a negative value results, a final drive does not qualify.

CAMARO ONLY { Seat Detent: _____ Back Angle: _____ Wheel Tilt Angle: _____
 { Seat Detent: _____ Back Angle: _____ Wheel Tilt Angle: _____
 { Final Pedals: _____

Comments: _____

FIGURE C.1 Pilot Study: Data collection sheet.

**PHASE I
DATA COLLECTION SHEET**

Subject #: _____ Date: _____ Time: _____ Frame # _____
 Vehicle: _____

Preliminary Drive:

Before: Detent Normal _____ Detent Extended _____ Back Angle _____ Wheel Tilt Angle _____
 Seat Tilt Adjustment, Cadillac Only: Line _____ Letter _____ Angle _____
 After: Detent Normal _____ Detent Extended _____ Back Angle _____ Wheel Tilt Angle _____
 Seat Tilt Adjustment, Cadillac Only: Line _____ Letter _____ Angle _____
 Hand Positions: Right _____ Left _____

Seat to Pedals:

	<u>Normal</u>	<u>Extended</u>	<u>Resultant</u>
Rearward Limit	_____	_____	_____
Forward Limit	_____	_____	_____
Preferred	_____	_____	_____

Seat to Steering Wheel:

Rearward Limit	_____	_____	_____
Forward Limit	_____	_____	_____
Preferred	_____	_____	_____

Comments: _____

Vehicle: _____ Frame # _____

Preliminary Drive:

Before: Detent Normal _____ Detent Extended _____ Back Angle _____ Wheel Tilt Angle _____
 Seat Tilt Adjustment, Cadillac Only: Line _____ Letter _____ Angle _____
 After: Detent Normal _____ Detent Extended _____ Back Angle _____ Wheel Tilt Angle _____
 Seat Tilt Adjustment, Cadillac Only: Line _____ Letter _____ Angle _____
 Hand Positions: Right _____ Left _____

Seat to Pedals:

	<u>Normal</u>	<u>Extended</u>	<u>Resultant</u>
Rearward Limit	_____	_____	_____
Forward Limit	_____	_____	_____
Preferred	_____	_____	_____

Seat to Steering Wheel:

Rearward Limit	_____	_____	_____
Forward Limit	_____	_____	_____
Preferred	_____	_____	_____

Comments: _____

FIGURE C.2 Phase I: Data collection sheet.

**PHASE II
DATA COLLECTION SHEET**

Subject #: _____
Date: _____
Time: _____
Photo #: _____

Driving Sessions Data

Vehicle: _____

	Before Drive	After Drive
Detent Normal:	_____	_____
Detent Extended:	_____	_____
Seat Back Angle:	_____	_____
Wheel Tilt Angle:	_____	_____
Pedal Position:	_____	_____
Hand Position:	Right _____	Left _____

Comments: _____

Vehicle: _____

	Before Drive	After Drive
Detent Normal:	_____	_____
Detent Extended:	_____	_____
Seat Back Angle:	_____	_____
Wheel Tilt Angle:	_____	_____
Pedal Position:	_____	_____
Hand Position:	Right _____	Left _____

Comments: _____

Static Photos Data

Detent _____
Tilt Wheel Angle _____

FIGURE C.3 Phase II: Data collection sheet.

**PHASE III
SUBJECT DATA FORM**

SUBJECT NAME: _____

SUBJECT NUMBER: _____

FRAME NUMBER: _____

DATE: _____

PRE-DRIVE DATA

Wheel Angle: _____

Detent: _____

POST-DRIVE DATA

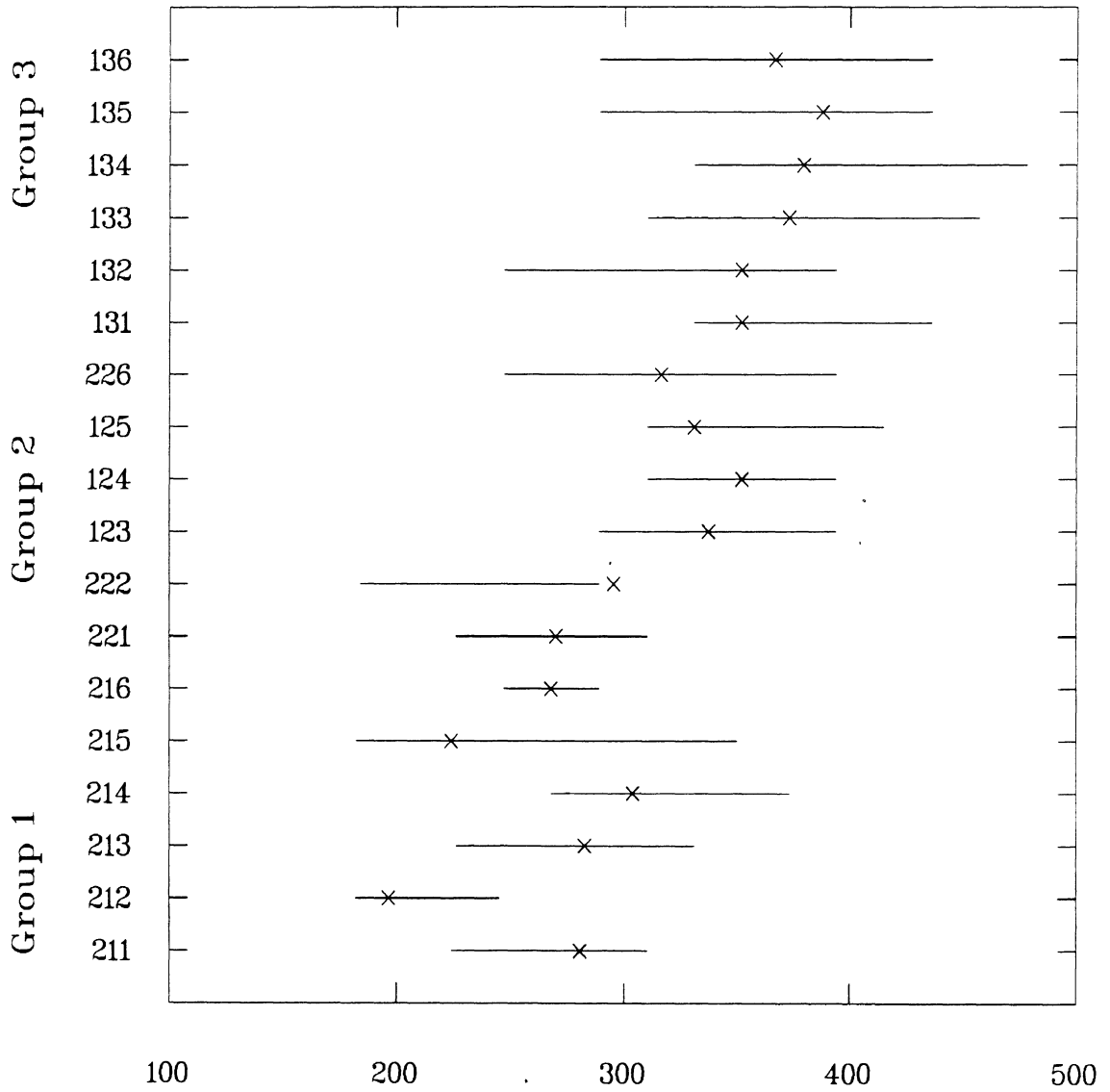
Wheel Angle: _____

Detent: _____

Comments:

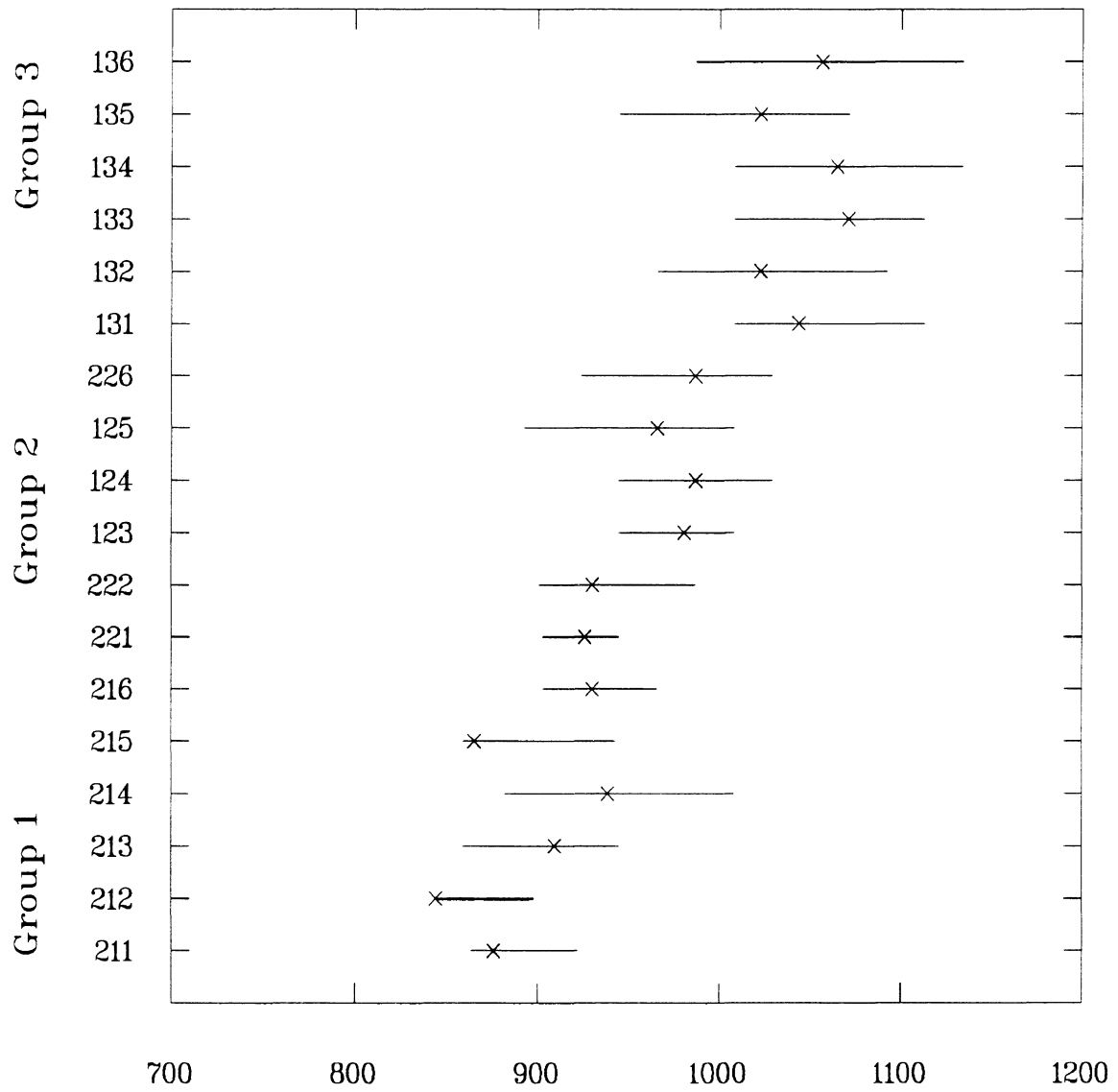
FIGURE C.4 Phase III: Subject data form.

APPENDIX D
PREFERRED WHEEL POSITION PILOT STUDY RESULTS



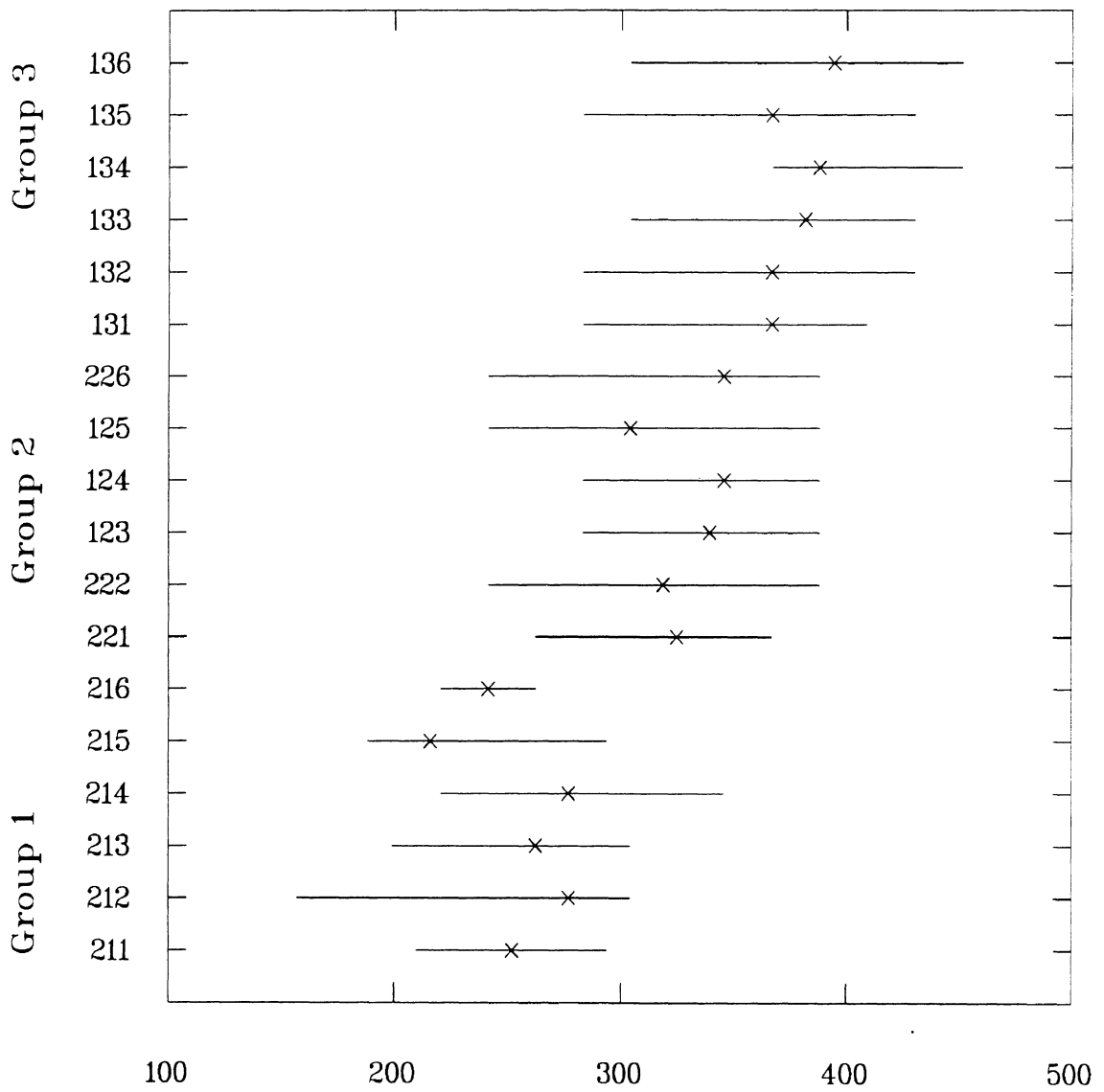
Camaro Hpt to WCtr (mm),
Preferred +/- Acceptable Limits

FIGURE D.1



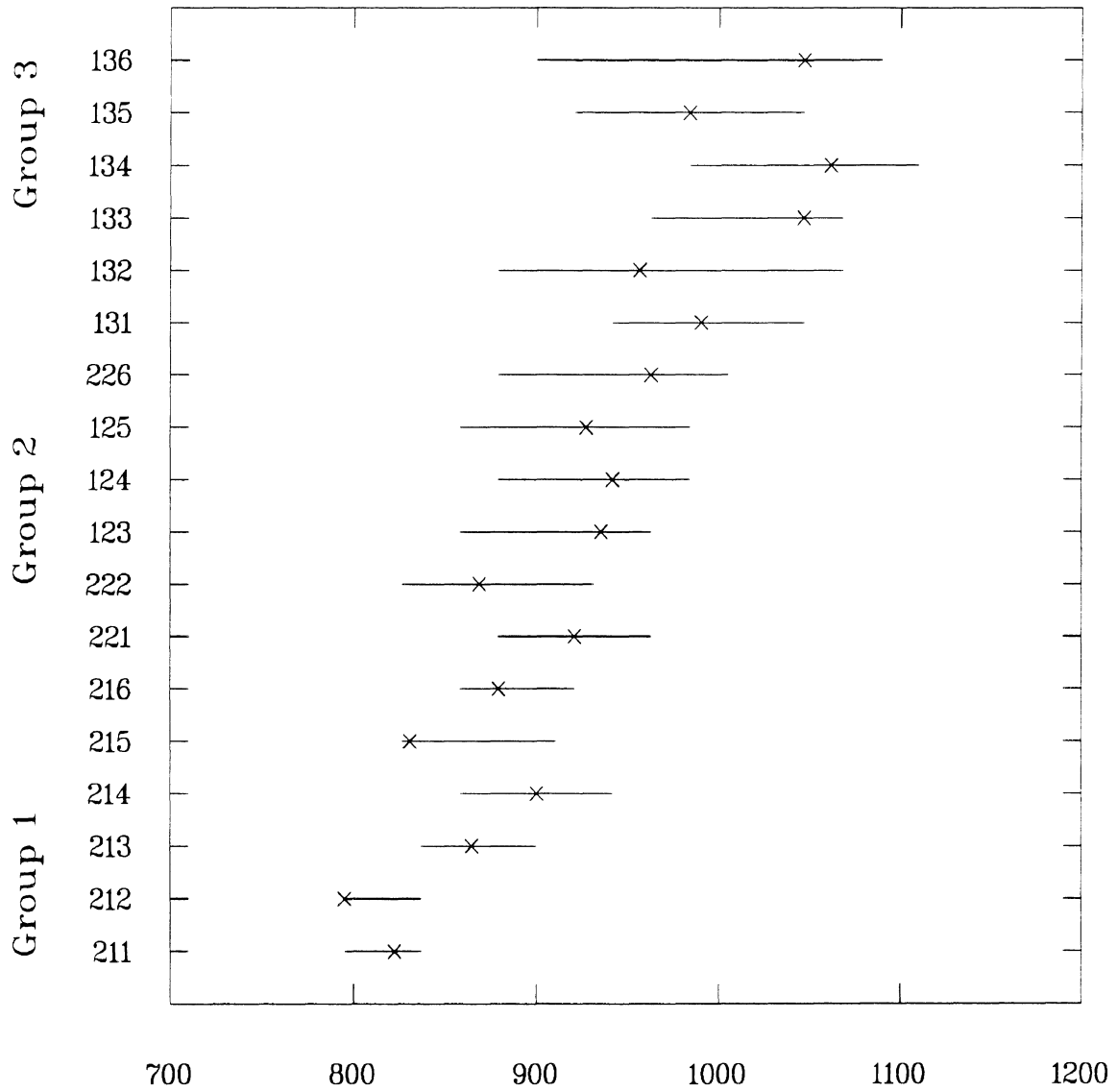
Camaro Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE D.2



Monte Carlo Hpt to WCtr (mm),
Preferred +/- Acceptable Limits

FIGURE D.3



Monte Carlo Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE D.4

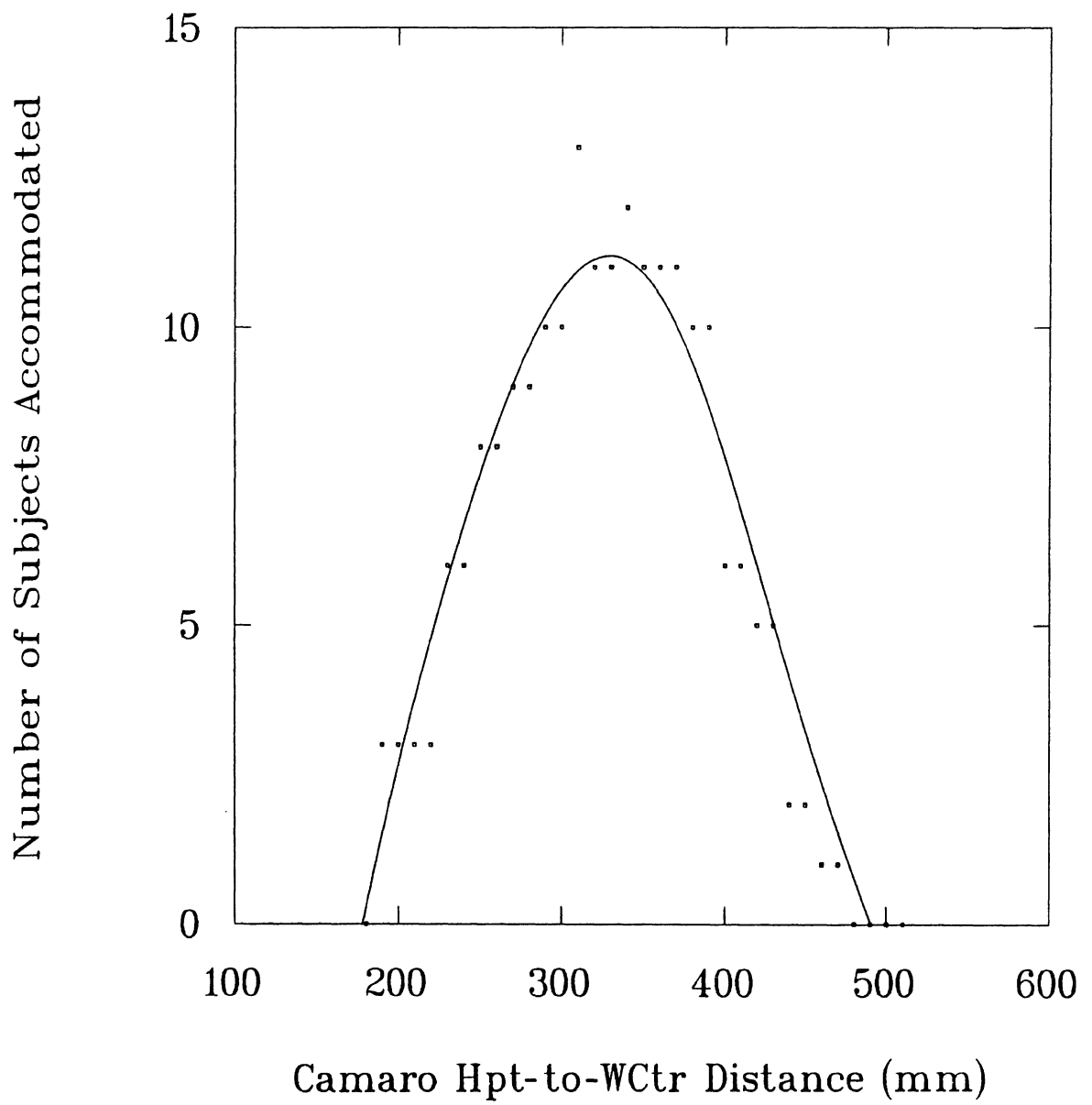


FIGURE D.5

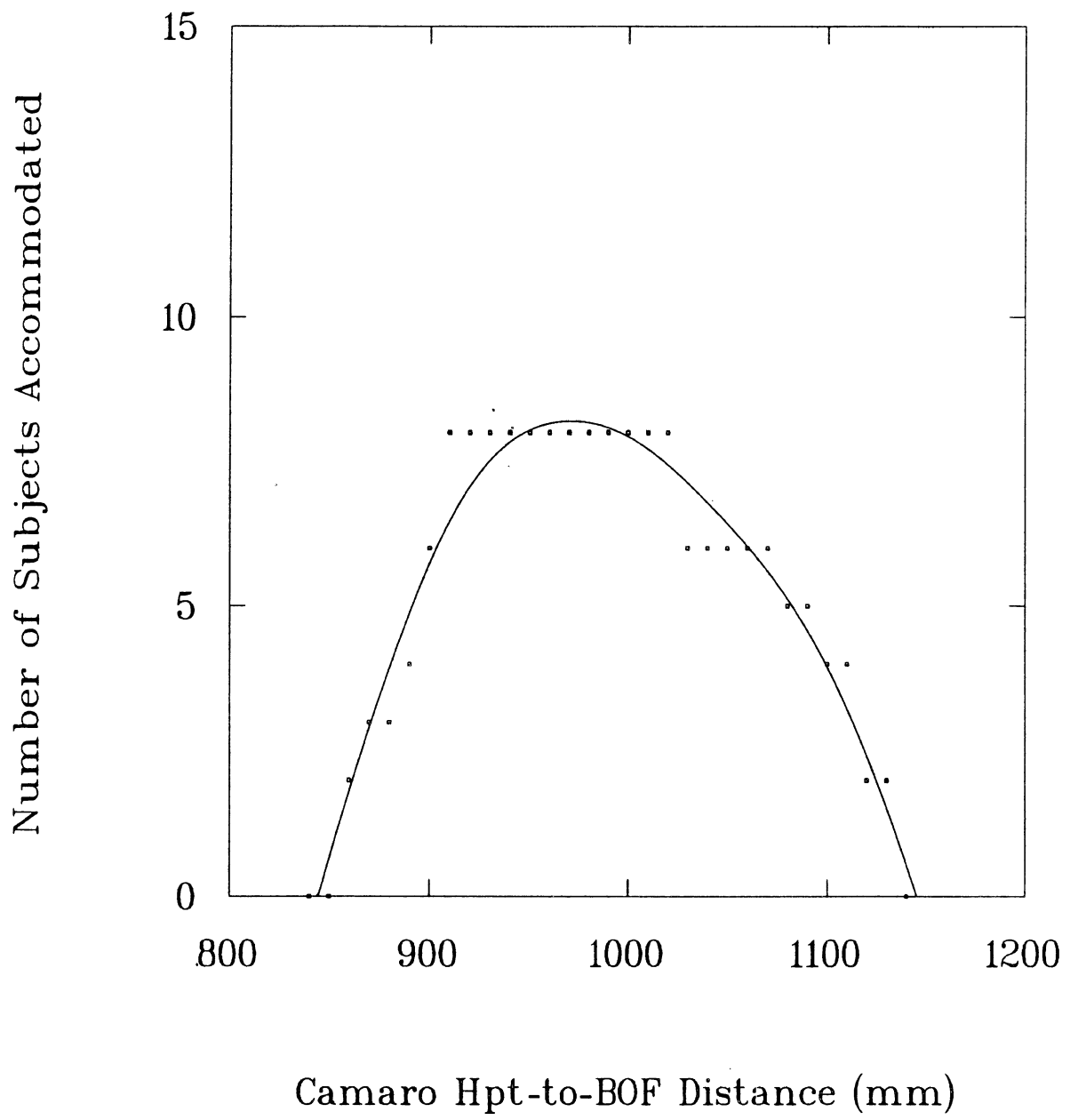


FIGURE D.6

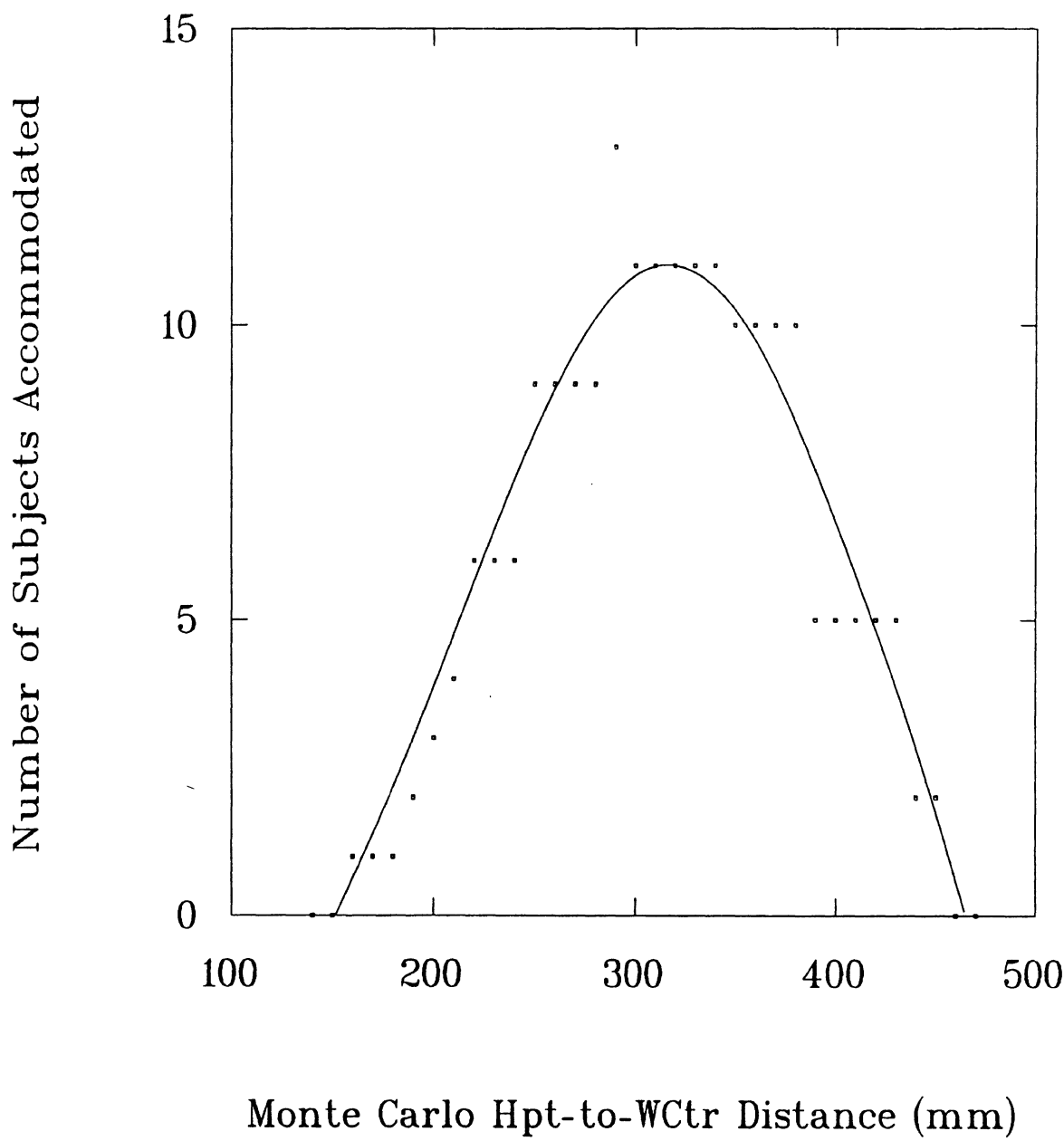


FIGURE D.7

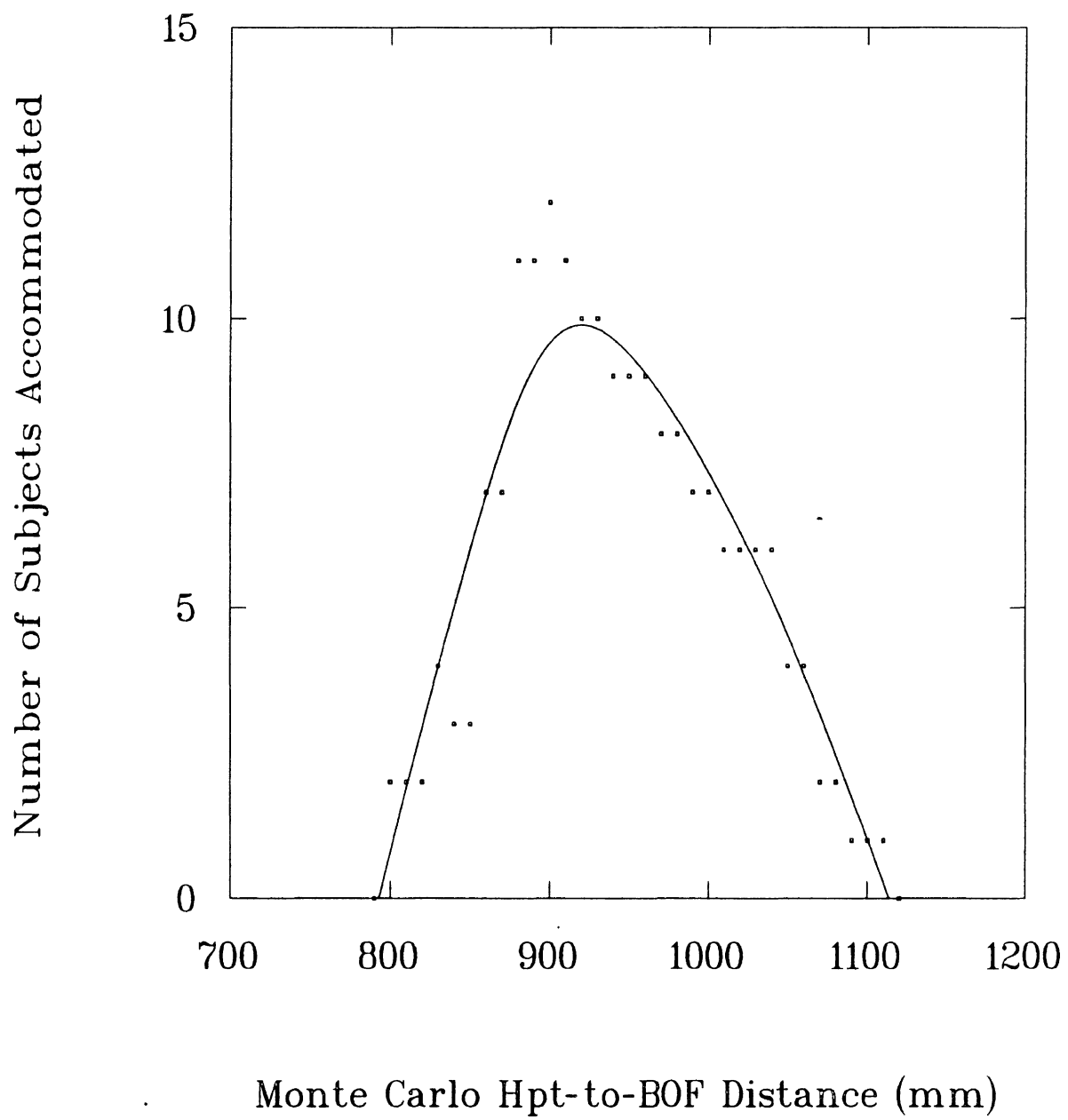


FIGURE D.8

Camaro-Calculated Preferred WCtr-to-BOF Distance vs. Stature

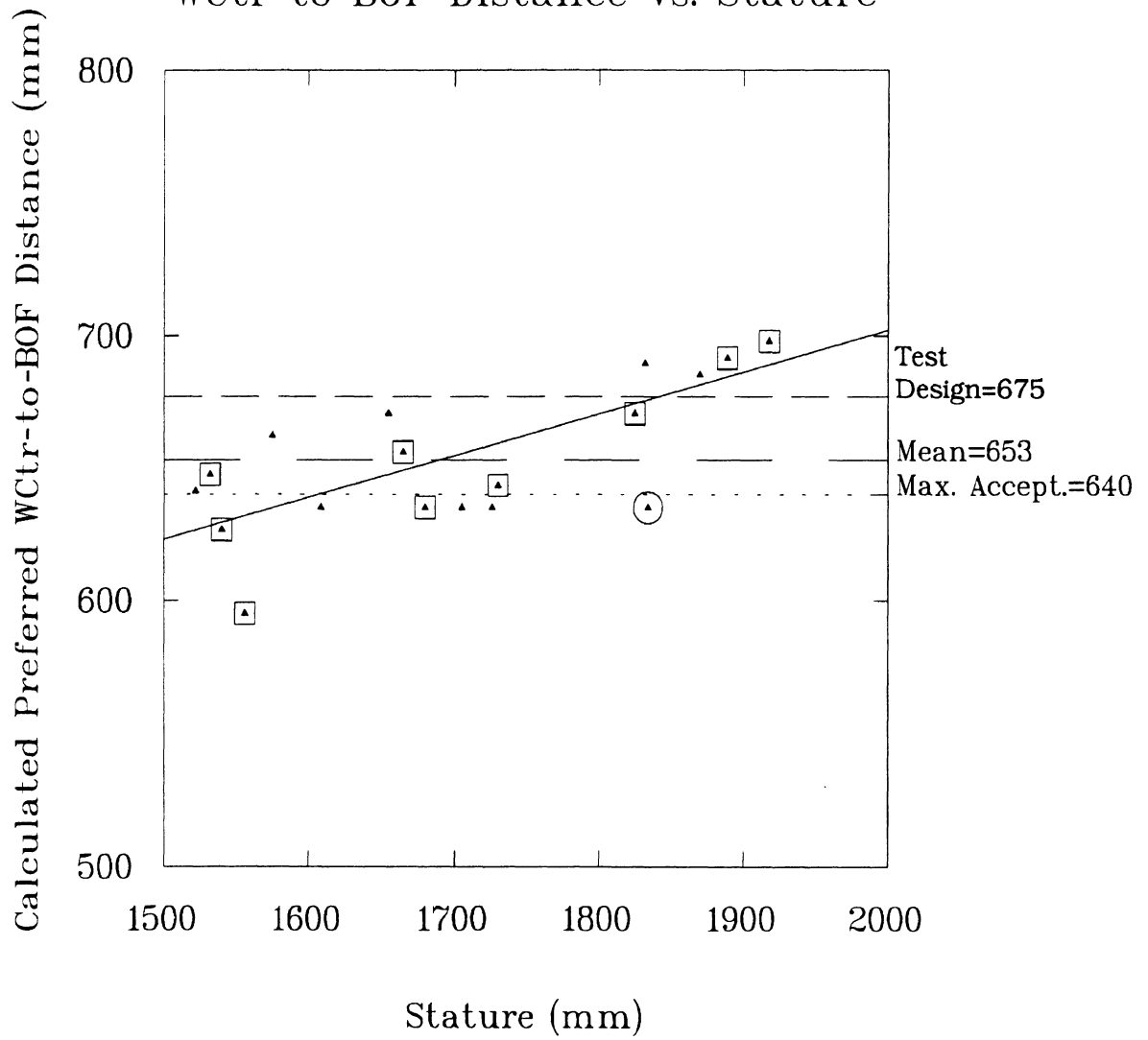


FIGURE D.9

Monte Carlo-Calculated Preferred WCtr-to-BOF Distance vs. Stature

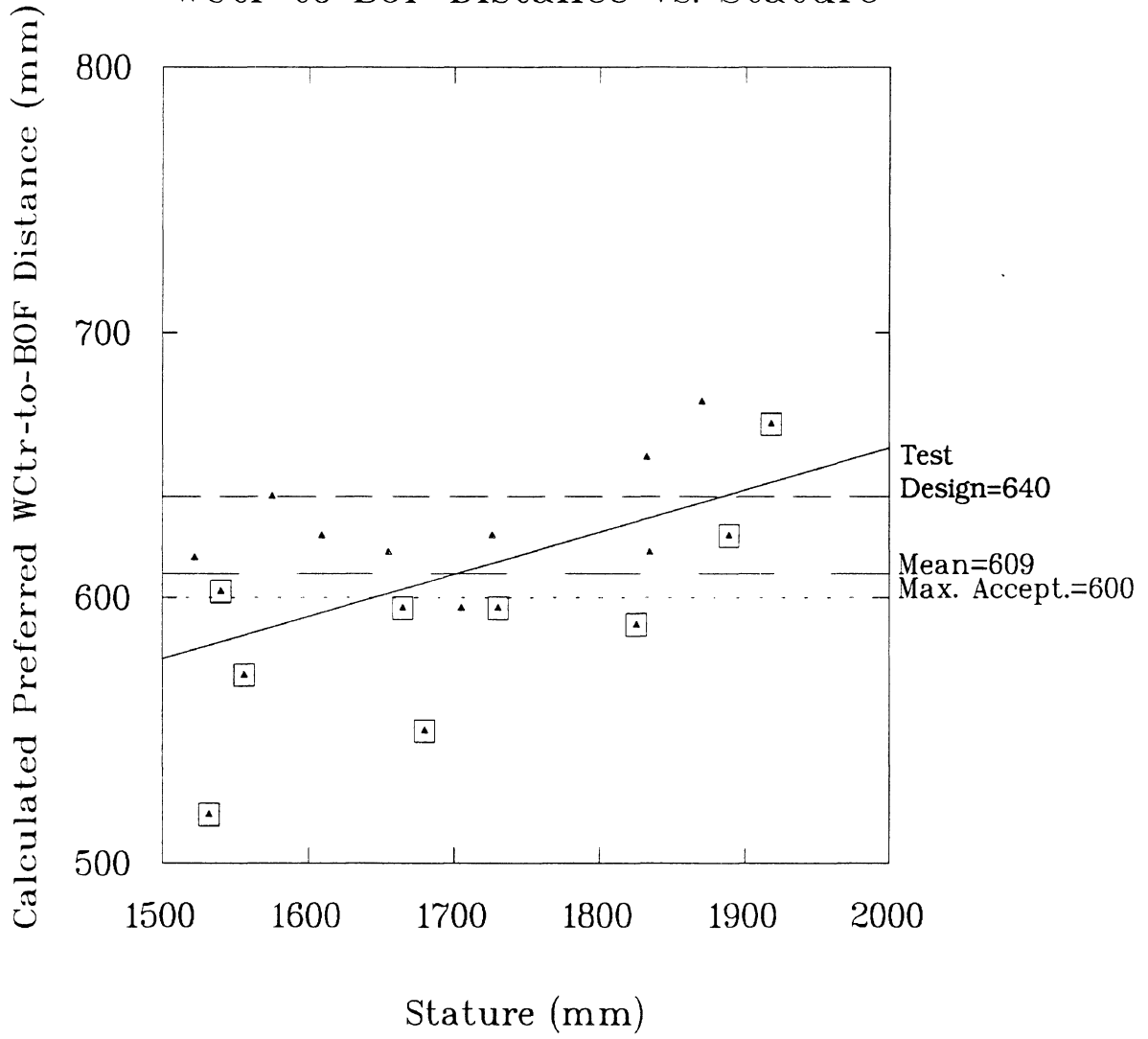


FIGURE D.10

Camaro-Adjusted Preferred WCtr-to-BOF Distance vs. Stature

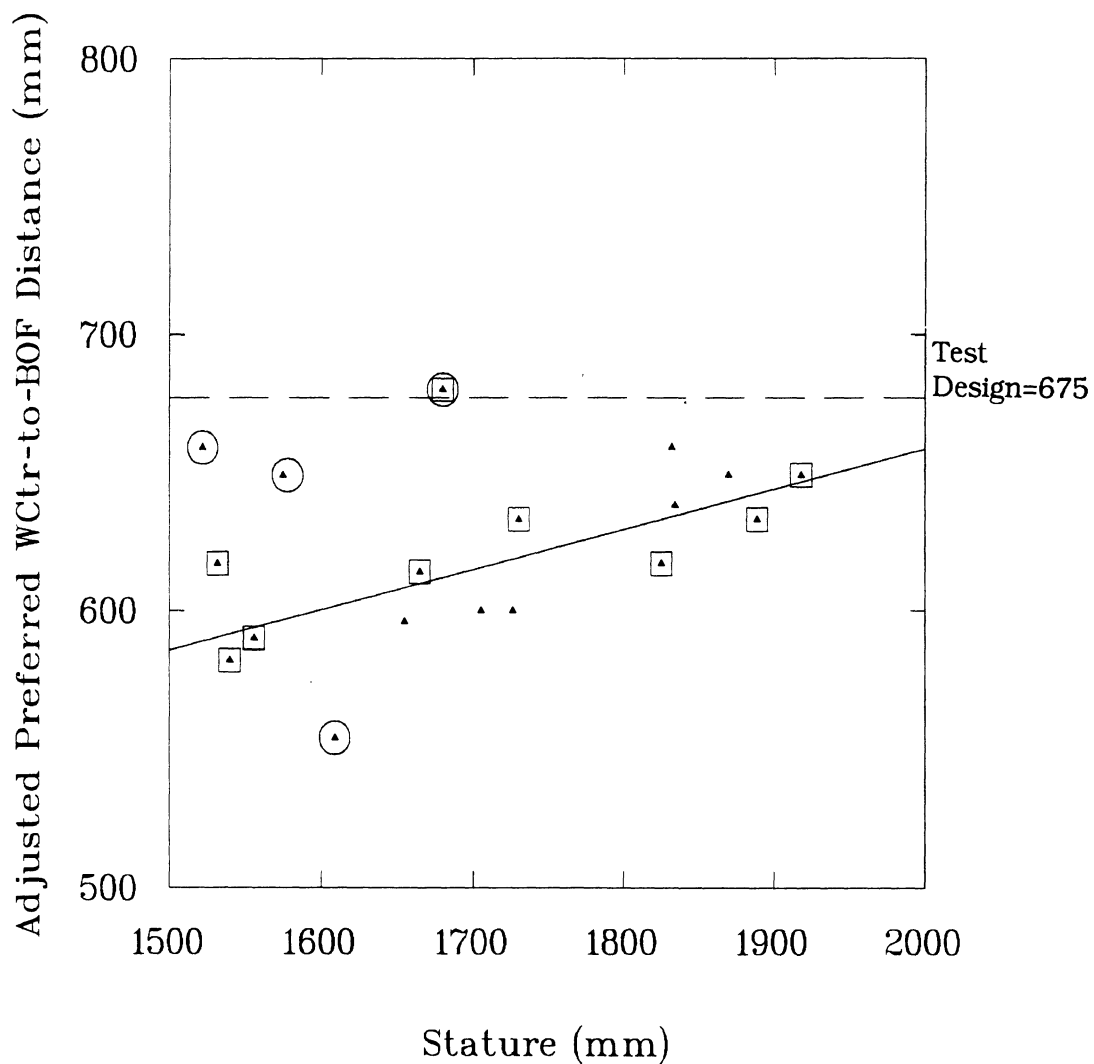


FIGURE D.11

Camaro-Calculated Preferred WCtr-to-BOF vs.
Subject Adjusted Preferred WCtr-to-BOF

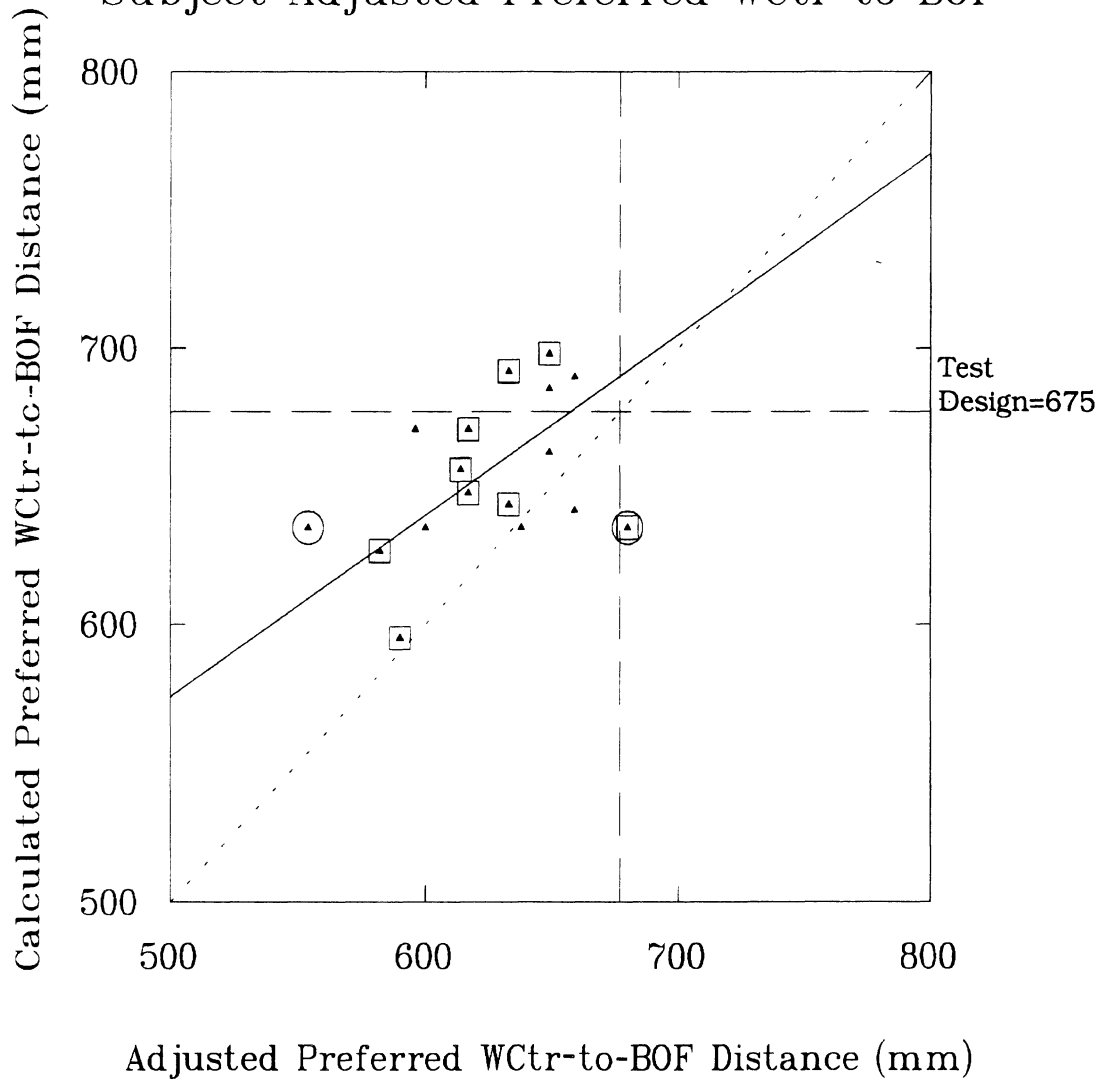


FIGURE D.12

Camaro: WCtr-to-Sternum Distance in Camaro
vs. WCtr-to-Sternum Distance in Subject's Car

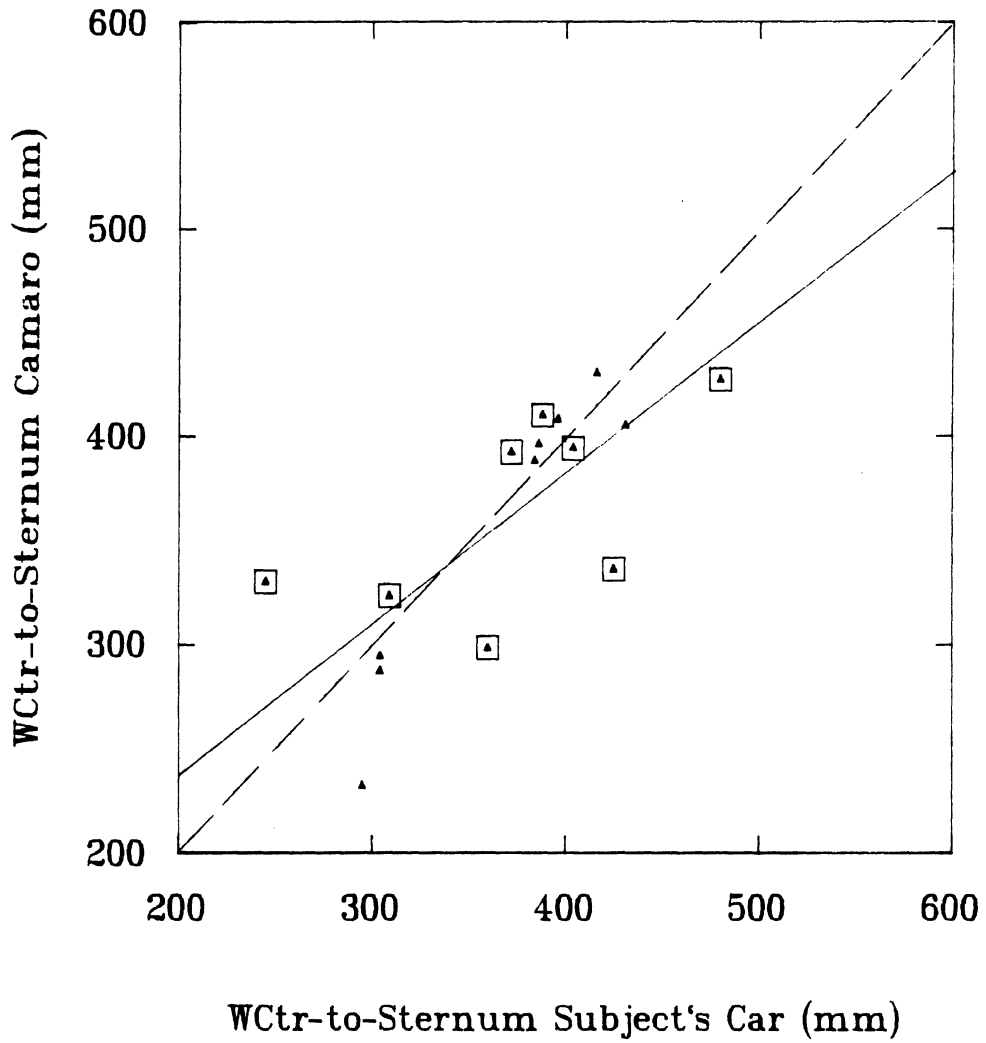


FIGURE D.13

Monte Carlo: WCtr-to-Sternum Distance in Monte Carlo
vs. WCtr-to-Sternum Distance in Subject's Car

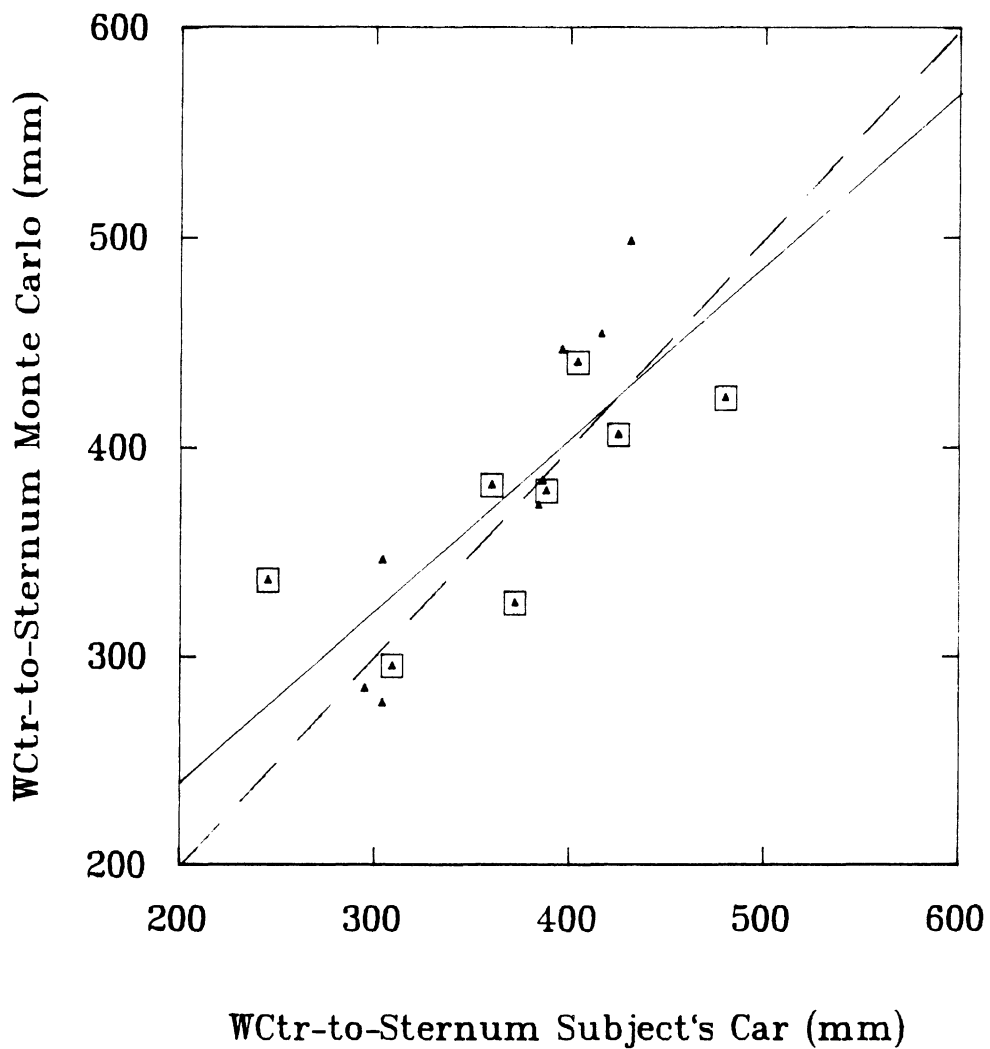


FIGURE D.14

TABLE D.1
OBSERVED UPPER AND LOWER ARM ANGLES
FOR MONTE CARLO AND CAMARO

Angle (Degrees)	Monte Carlo		Camaro	
	Mean	S.D.	Mean	S.D.
Upper Arm	43.7	9.1	42.5	10.3
Lower Arm	21.1	10.5	23.1	10.7

Upper- and Lower-Arm Angles Observed in the Monte Carlo and Camaro

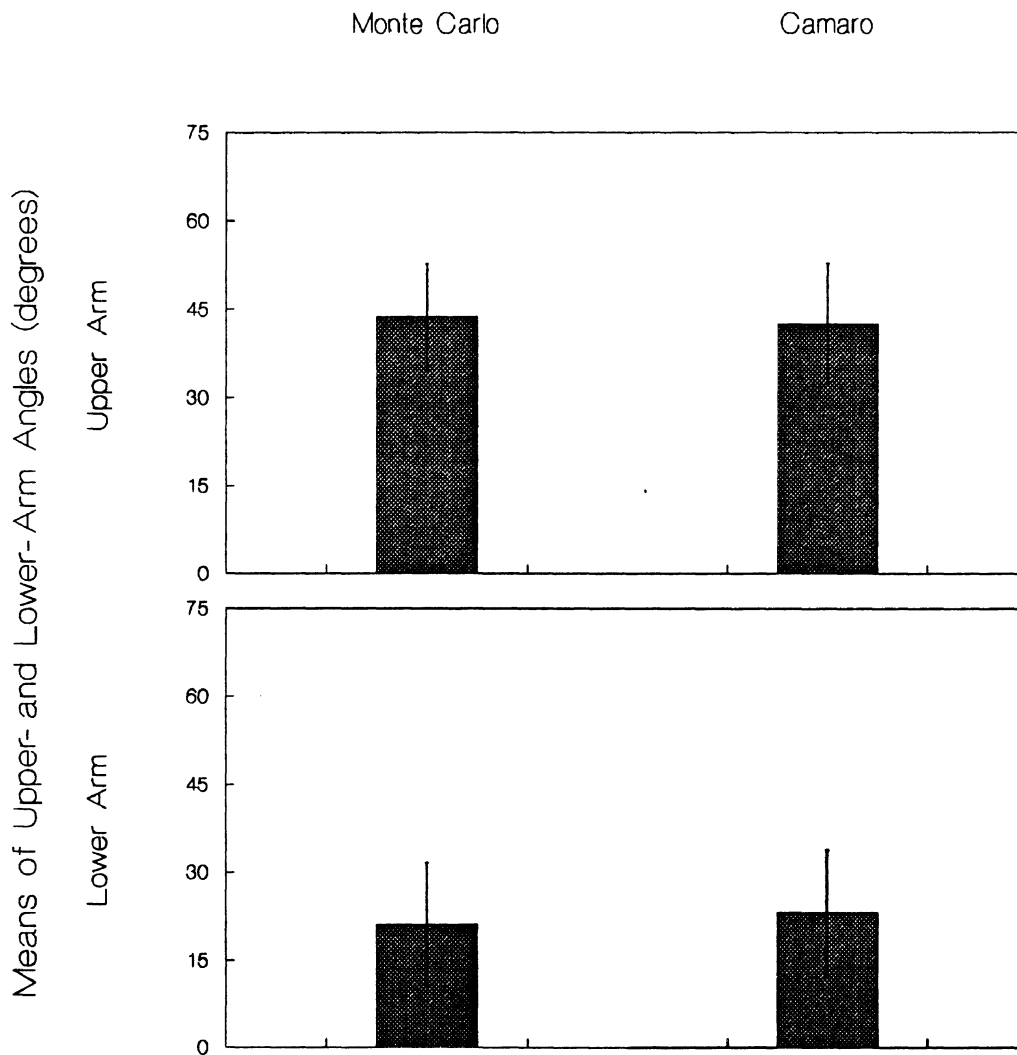


FIGURE D.15

APPENDIX E
PHASE I RESULTS—PART I
ANTHROPOMETRIC RESULTS BY SUBJECT GROUP

TABLE E.1
PHASE I: ANTHROPOMETRIC DATA SUMMARY
(in metric units)

Group	n	Age (yrs)		Weight (kgs)		Stature (mm)		Sitting Height (mm)		Eye Height (mm)		Shoulder Height (mm)		Knee Height (mm)	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	33	7	50.6	4.1	1517	22	819	16	719	13	549	17	478	12
2	6	41	16	70.4	15.0	1575	18	821	18	736	60	541	37	503	23
3	5	30	8	69.9	12.7	1615	17	844	37	746	33	572	30	506	16
4	5	37	13	63.8	11.9	1660	12	860	23	756	23	575	30	509	7
5	6	34	9	63.0	5.4	1703	25	882	19	778	14	593	16	542	17
All Females	27	35	11	63.8	12.2	1616	69	846	33	748	38	566	32	509	26
6	5	42	14	70.1	5.6	1653	13	859	21	759	30	590	40	531	10
7	6	37	15	77.7	6.0	1705	20	882	24	781	19	593	27	544	29
8	6	41	16	80.2	15.4	1741	10	901	13	800	17	610	23	559	24
9	6	31	9	91.2	6.7	1797	14	926	24	801	11	605	21	573	16
10	5	28	4	96.3	17.4	1861	28	917	39	806	51	630	35	590	16
All Males	28	36	13	83.1	14.0	1751	73	898	33	790	31	605	30	559	28
All Subjects	55	36	12	73.6	16.2	1684	98	872	42	769	40	586	37	534	37

TABLE E.1 (Continued)

Group	n	Hip Breadth (mm)		Buttock to Knee Length (mm)		Shoulder Breadth (mm)		Shoulder to Elbow Length (mm)		Forearm Length (mm)		Maximum Reach (mm)		Maximum Grasp (mm)		Interpupillary Distance (mm)	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	370	12	518	23	371	18	314	9	406	11	727	27	661	22	55	2
2	6	396	33	580	17	402	18	335	15	430	4	775	40	705	34	56	1
3	5	390	57	590	22	403	20	329	15	430	18	784	26	715	32	57	2
4	5	374	37	583	11	396	17	360	27	445	16	796	36	712	38	56	4
5	6	376	41	604	15	395	16	361	13	450	11	789	37	736	32	57	5
All Females	27	382	37	576	34	394	20	341	24	433	19	775	40	707	39	56	3
6	5	392	57	529	94	442	24	358	11	462	11	816	19	755	15	57	3
7	6	378	26	596	17	441	22	369	23	473	20	845	43	759	30	62	4
8	6	393	29	605	33	442	23	372	7	488	7	844	26	765	25	60	4
9	6	394	32	620	12	459	14	383	11	500	13	892	39	807	31	64	5
10	5	400	37	658	24	479	23	400	16	534	15	937	15	839	19	62	2
All Males	28	391	35	602	58	452	25	376	19	491	27	866	51	784	40	61	4
All Subjects	55	386	36	590	49	423	37	359	28	462	38	821	65	746	55	59	5

TABLE E.2

PHASE I: ANTHROPOMETRIC DATA SUMMARY
(in English units)

Group	n	Age (yrs)		Weight (lbs)		Stature (in)		Sitting Height (in)		Eye Height (in)		Shoulder Height (in)		Knee Height (in)	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	33	7	111.4	9.1	59.72	0.86	32.24	0.64	28.31	0.52	21.62	0.69	18.82	0.49
2	6	41	16	154.8	32.9	61.99	0.69	32.32	0.72	28.99	2.35	21.28	1.44	19.79	0.90
3	5	30	8	153.8	27.9	63.57	0.66	33.24	1.46	29.35	1.29	22.54	1.17	19.91	0.62
4	5	37	13	140.4	26.3	65.35	0.47	33.85	0.90	29.76	0.89	22.65	1.18	20.06	0.29
5	6	34	9	138.5	11.9	67.03	0.98	34.72	0.75	30.64	0.57	23.34	0.63	21.35	0.66
All Females	27	35	11	140.3	26.8	63.61	2.70	33.29	1.30	29.44	1.48	22.29	1.26	20.03	1.02
6	5	42	14	154.2	12.2	65.06	0.52	33.83	0.84	29.90	1.17	23.24	1.58	20.89	0.41
7	6	37	15	170.8	13.3	67.11	0.79	34.73	0.94	30.74	0.75	23.33	1.06	21.43	1.13
8	6	41	16	176.3	33.9	68.56	0.38	35.46	0.53	31.50	0.66	24.00	0.89	21.99	0.96
9	6	31	9	200.7	14.8	70.75	0.57	36.44	0.93	31.55	0.42	23.82	0.83	22.57	0.62
10	5	28	4	211.8	38.2	73.26	1.12	36.11	1.53	31.74	1.99	24.79	1.37	23.21	0.61
All Males	28	36	13	182.8	30.7	68.93	2.86	35.34	1.31	31.11	1.21	23.82	1.19	22.02	1.10
All Subjects	55	36	12	161.9	35.7	66.32	3.85	34.34	1.65	30.29	1.58	23.07	1.44	21.04	1.45

TABLE E.2 (Continued)

Group	n	Hip Breadth (in)		Buttock to Knee Length (in)		Shoulder Breadth (in)		Shoulder to Elbow Length (in)		Forearm Length (in)		Maximum Reach (in)		Maximum Grasp (in)		Interpillary Distance (in)	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	14.58	0.47	20.41	0.92	14.60	0.69	12.38	0.34	15.98	0.42	28.64	1.07	26.02	0.87	2.17	0.07
2	6	15.58	1.31	22.81	0.68	15.81	0.69	13.20	0.59	16.94	0.17	30.51	1.57	27.77	1.32	2.19	0.05
3	5	15.34	2.26	23.24	0.87	15.87	0.77	12.97	0.59	16.94	0.71	30.88	1.04	28.17	1.26	2.26	0.06
4	5	14.73	1.46	22.97	0.42	15.58	0.67	14.18	1.05	17.51	0.63	31.35	1.43	28.03	1.51	2.22	0.14
5	6	14.81	1.62	23.79	0.60	15.56	0.65	14.20	0.53	17.70	0.45	31.06	1.46	28.99	1.25	2.22	0.18
All Females	27	15.02	1.46	22.69	1.34	15.50	0.78	13.41	0.93	17.03	0.76	30.51	1.57	27.84	1.52	2.21	0.11
6	5	14.86	1.02	23.48	0.65	17.35	0.88	14.51	0.92	18.61	0.77	33.25	1.70	29.86	1.18	2.44	0.17
7	6	15.47	1.16	23.81	1.31	17.40	0.89	14.65	0.29	19.23	0.28	33.23	1.02	30.12	0.99	2.37	0.17
8	6	15.51	1.26	24.40	0.45	18.06	0.56	15.07	0.42	19.67	0.49	35.12	1.55	31.77	1.21	2.53	0.20
9	6	15.74	1.45	25.92	0.96	18.87	0.90	15.74	0.63	21.02	0.61	36.90	0.59	33.02	0.75	2.46	0.07
10	5																
All Males	28	15.39	1.37	23.71	2.27	17.79	0.97	14.81	0.76	19.33	1.08	34.10	2.01	30.86	1.57	2.41	0.18
All Subjects	55	15.21	1.41	23.21	1.92	16.67	1.45	14.12	1.10	18.20	1.48	32.34	2.55	29.38	2.16	2.31	0.18

Mean Stature by Group

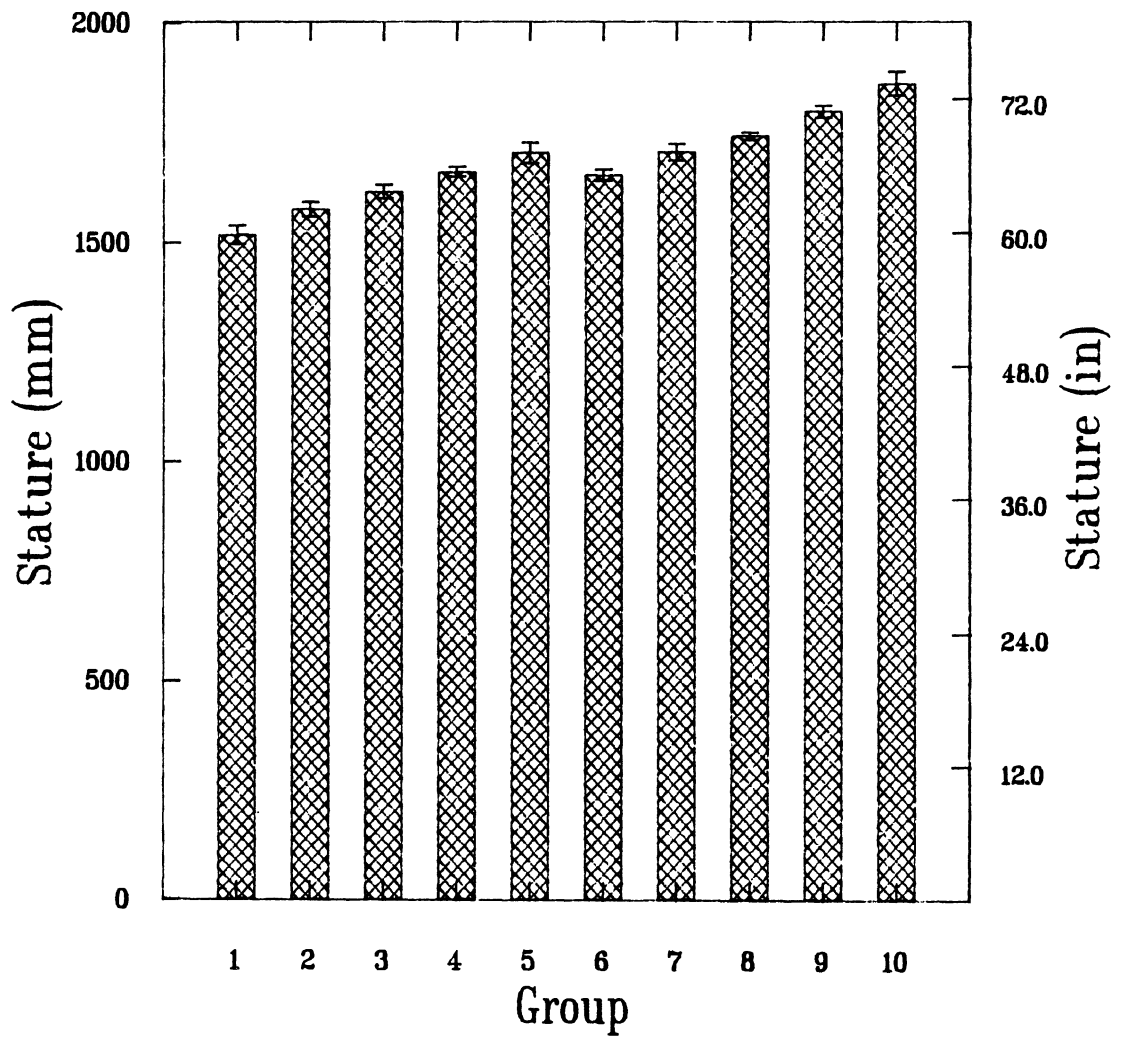


FIGURE E.1

Mean Age by Group

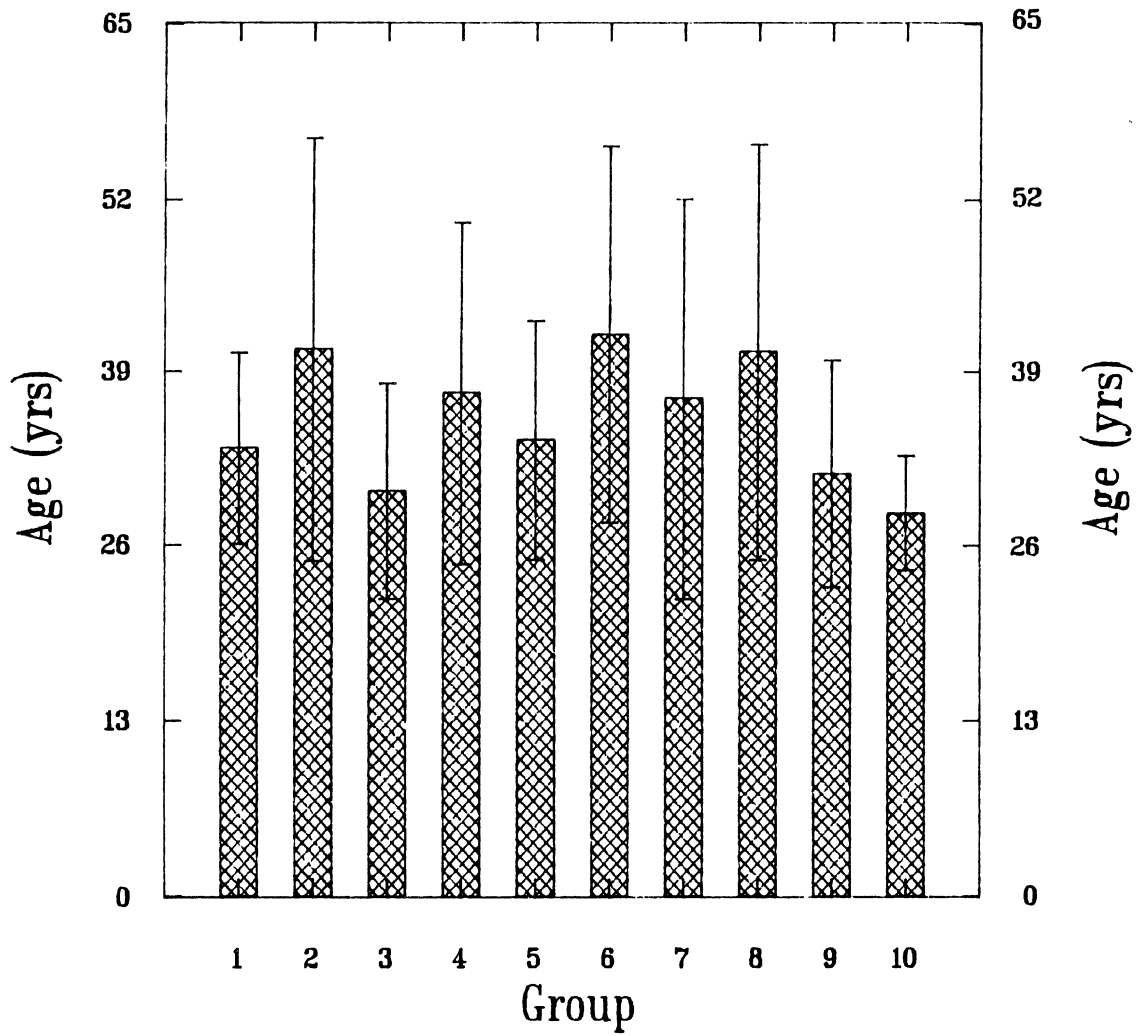


FIGURE E.2

Mean Weight by Group

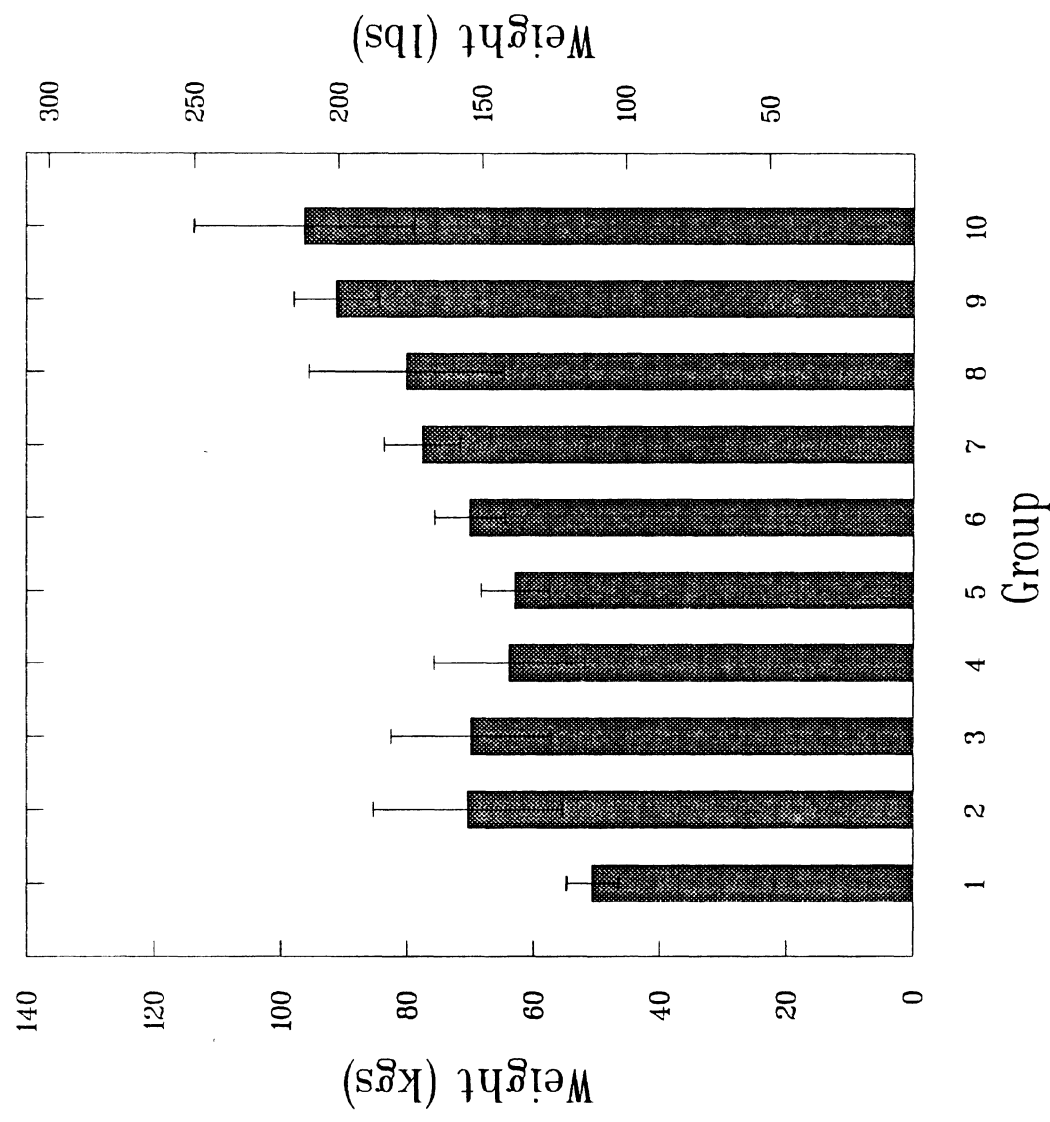


FIGURE E.3

Mean Sitting Height by Group

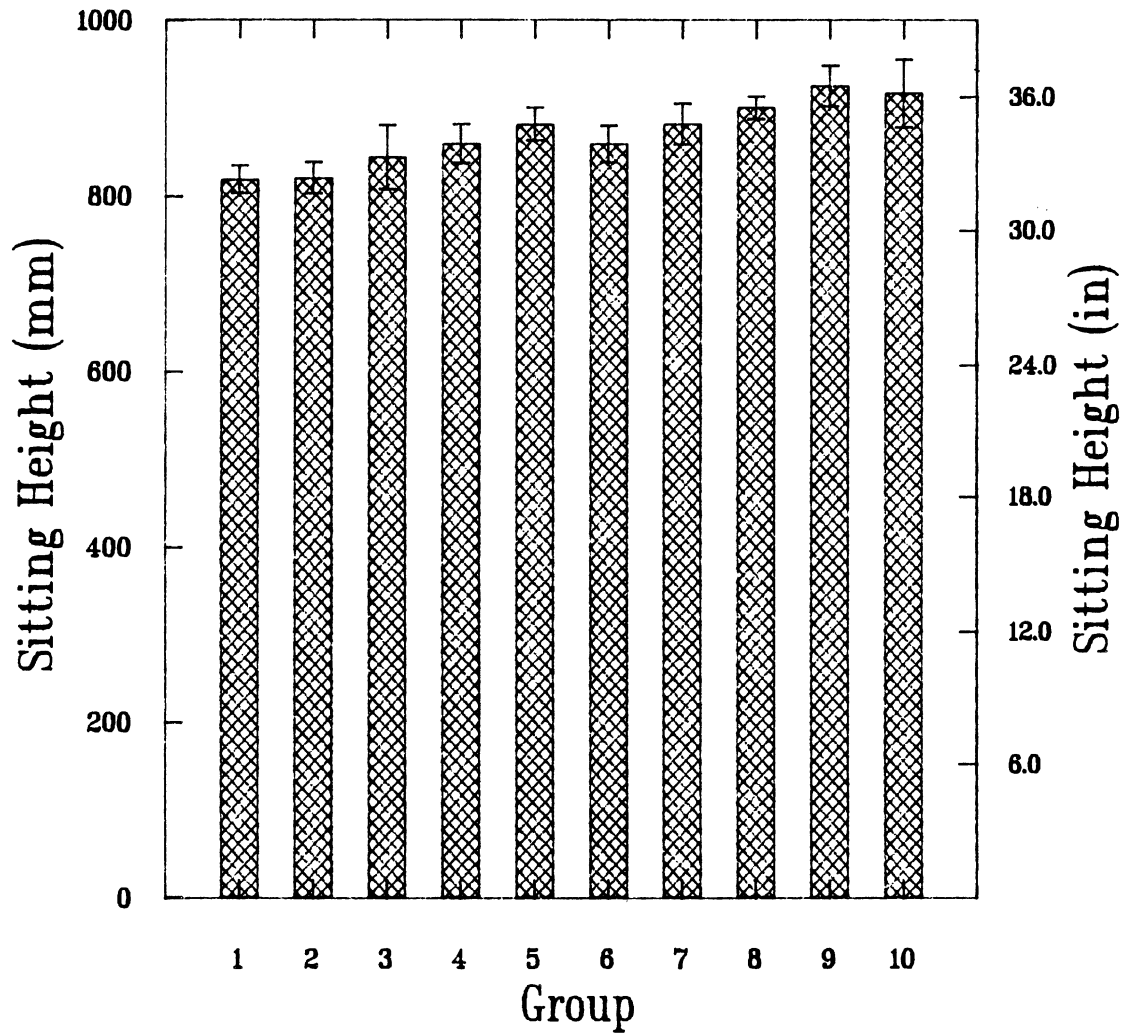


FIGURE E.4

Mean Eye Height by Group

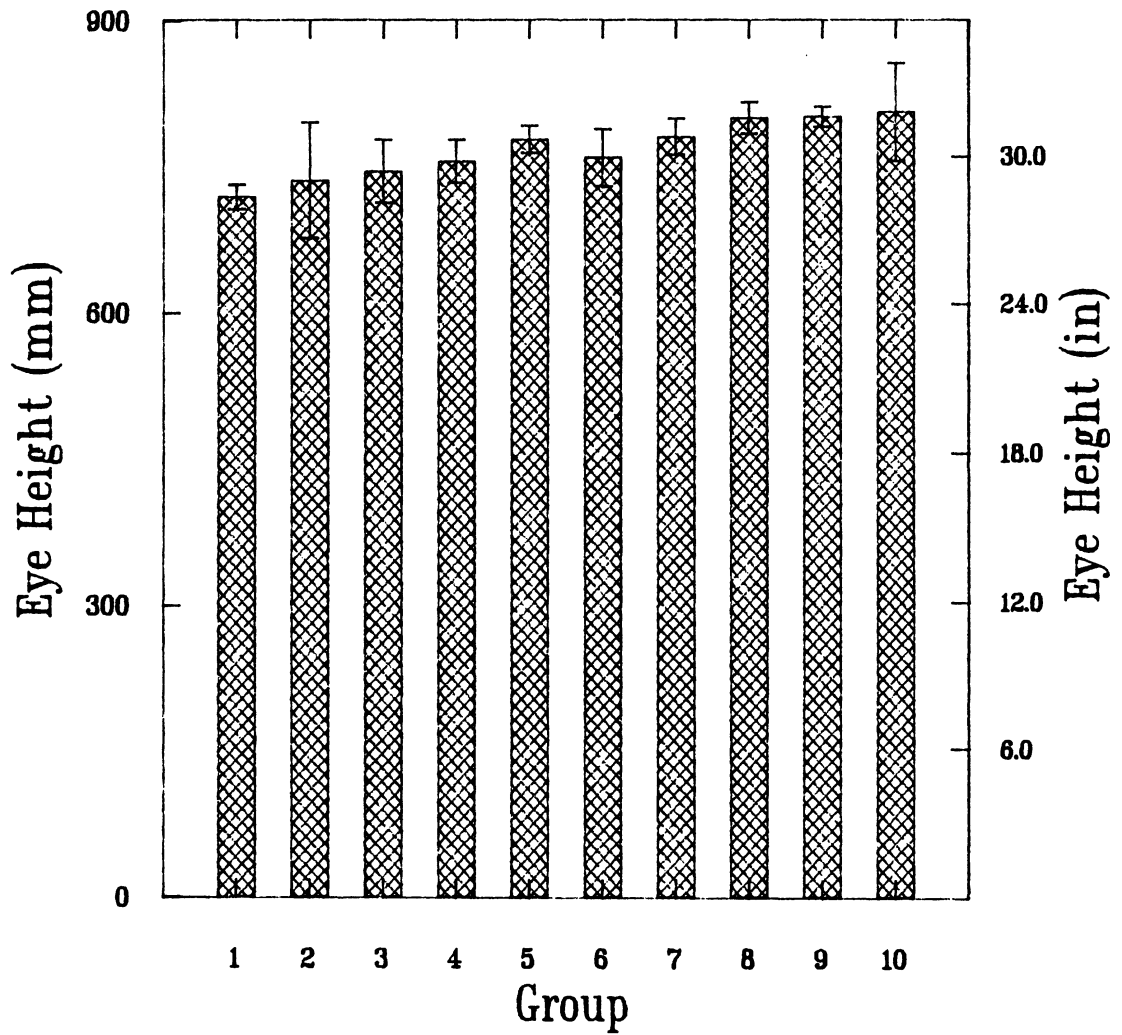


FIGURE E.5

Mean Shoulder Height by Group

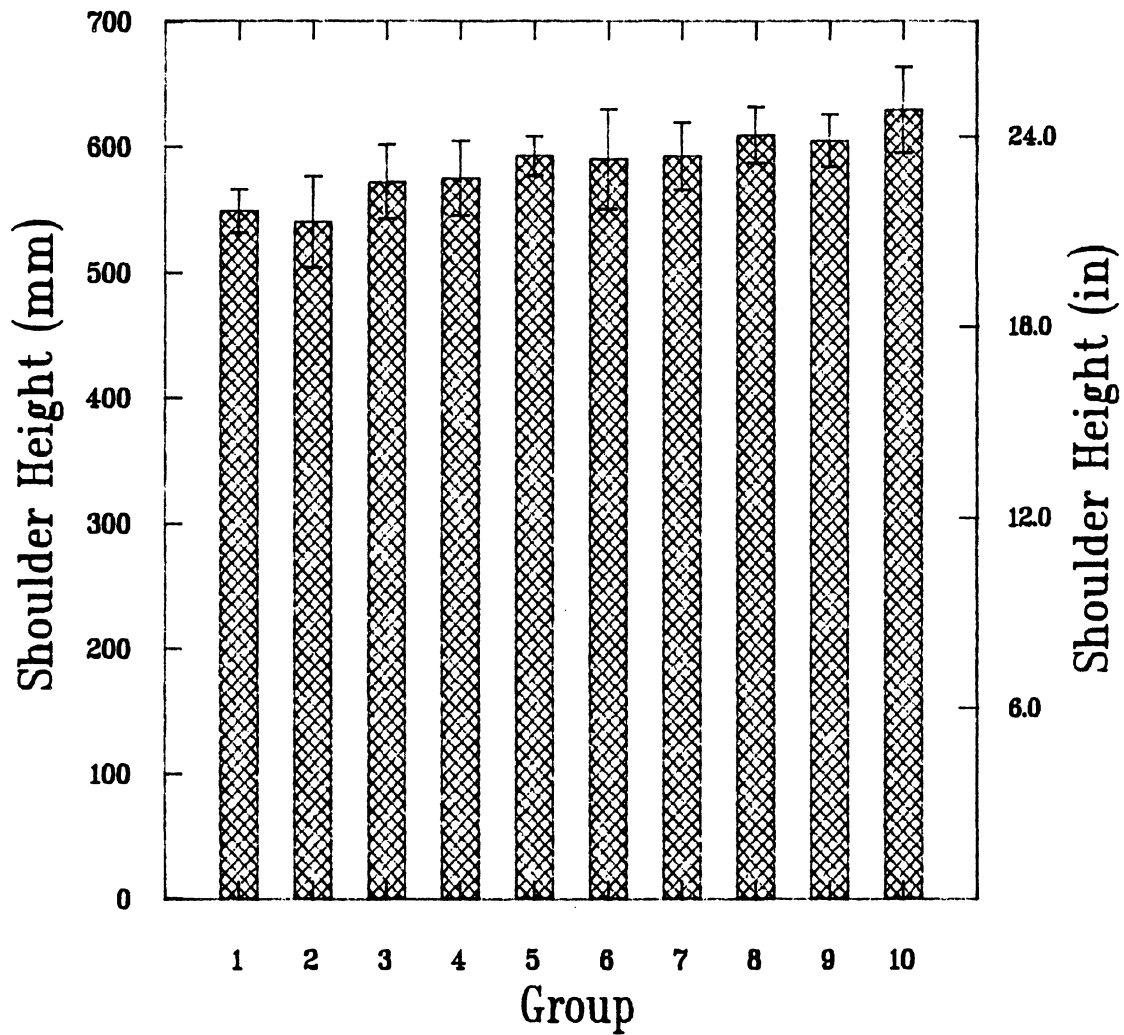


FIGURE E.6

Mean Knee Height by Group

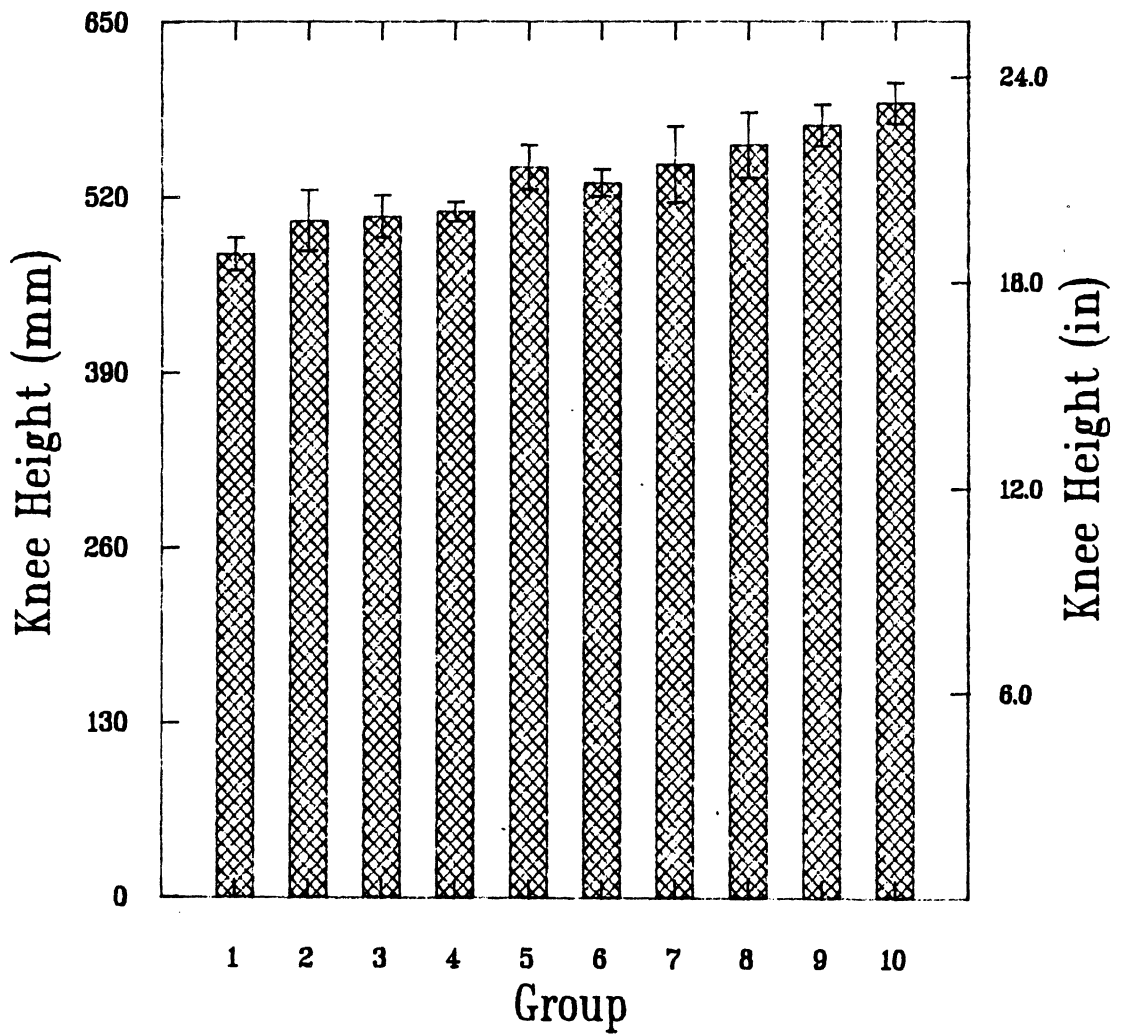


FIGURE E.7

Mean Hip Breadth by Group

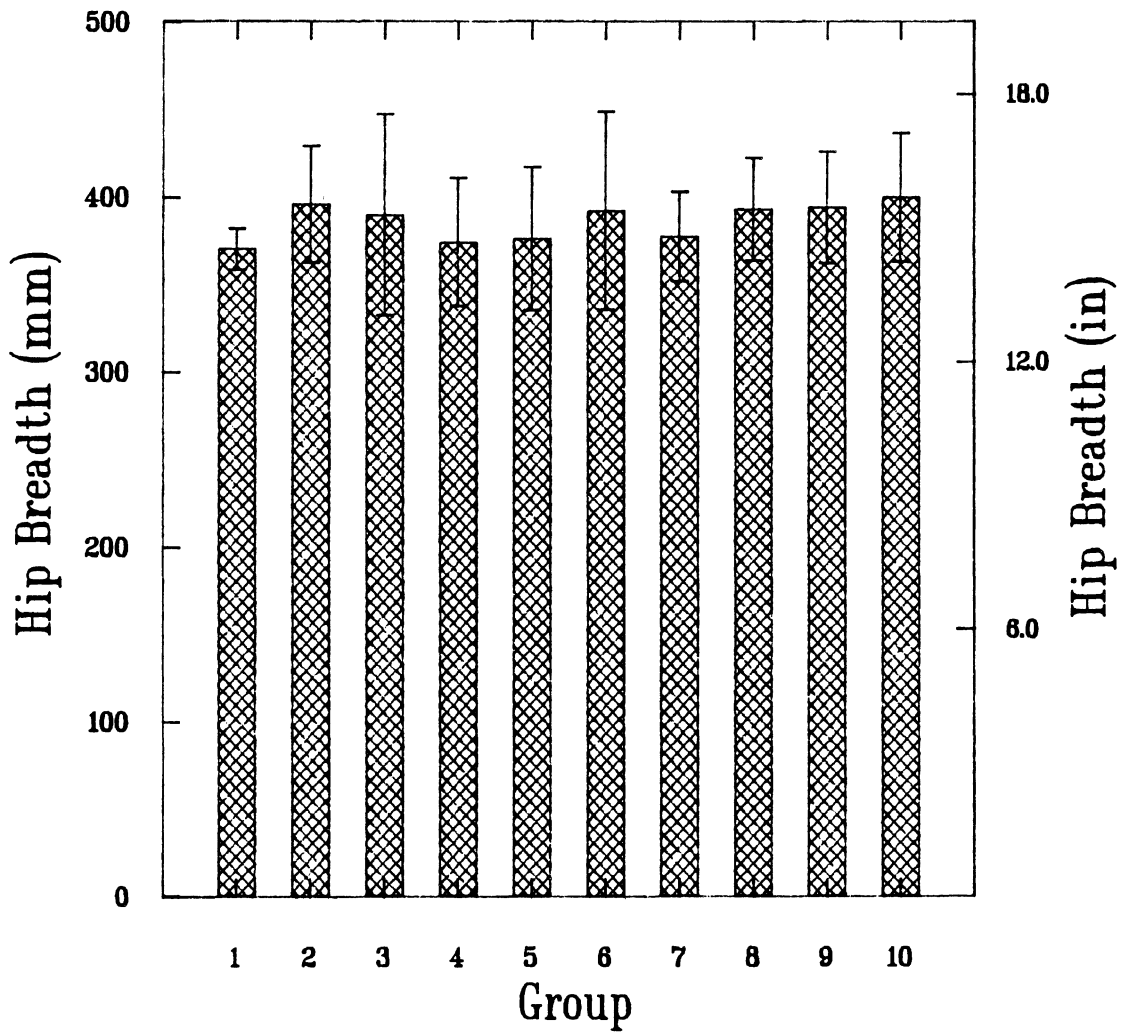


FIGURE E.8

Mean Buttock-to-Knee Length by Group

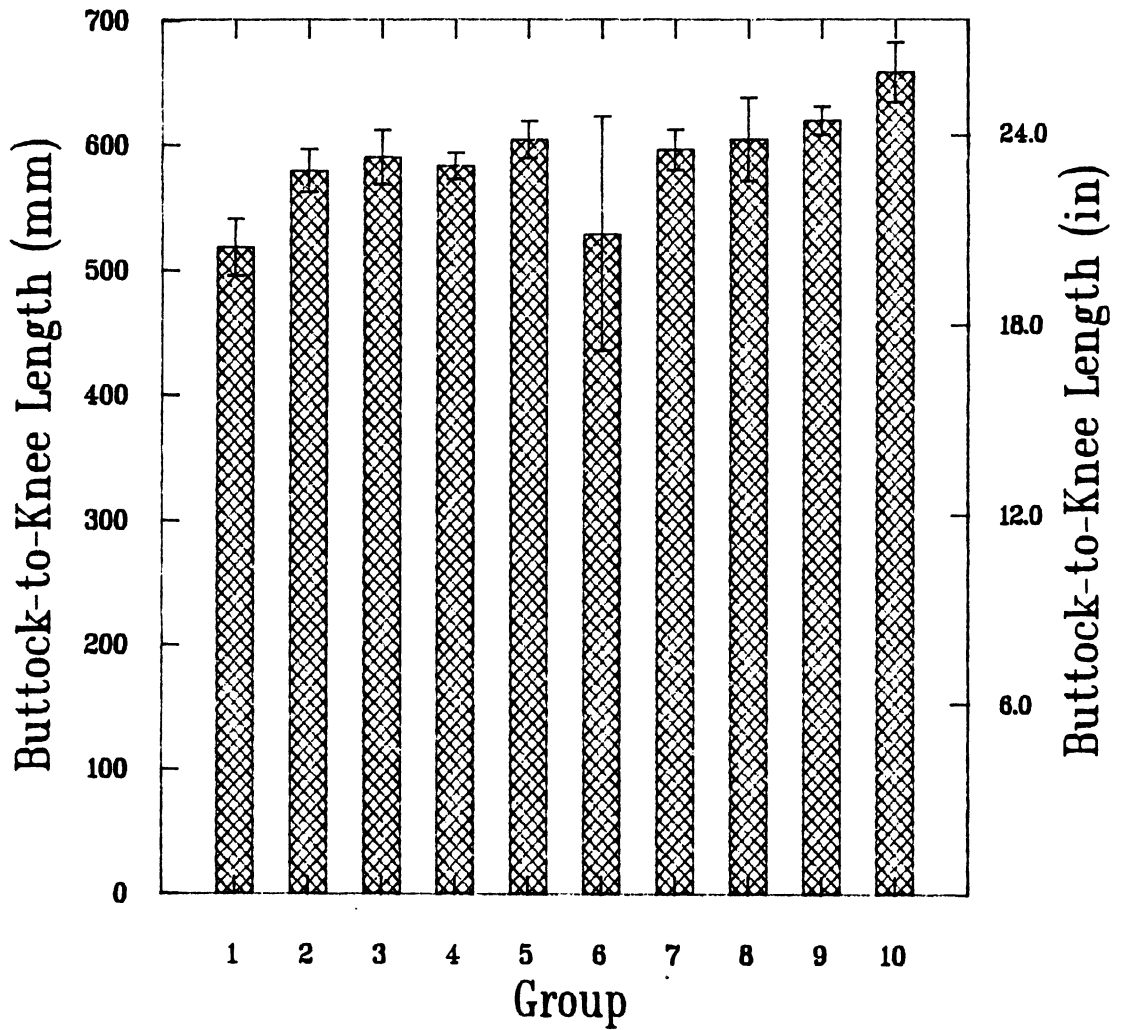


FIGURE E.9

Mean Shoulder Breadth by Group

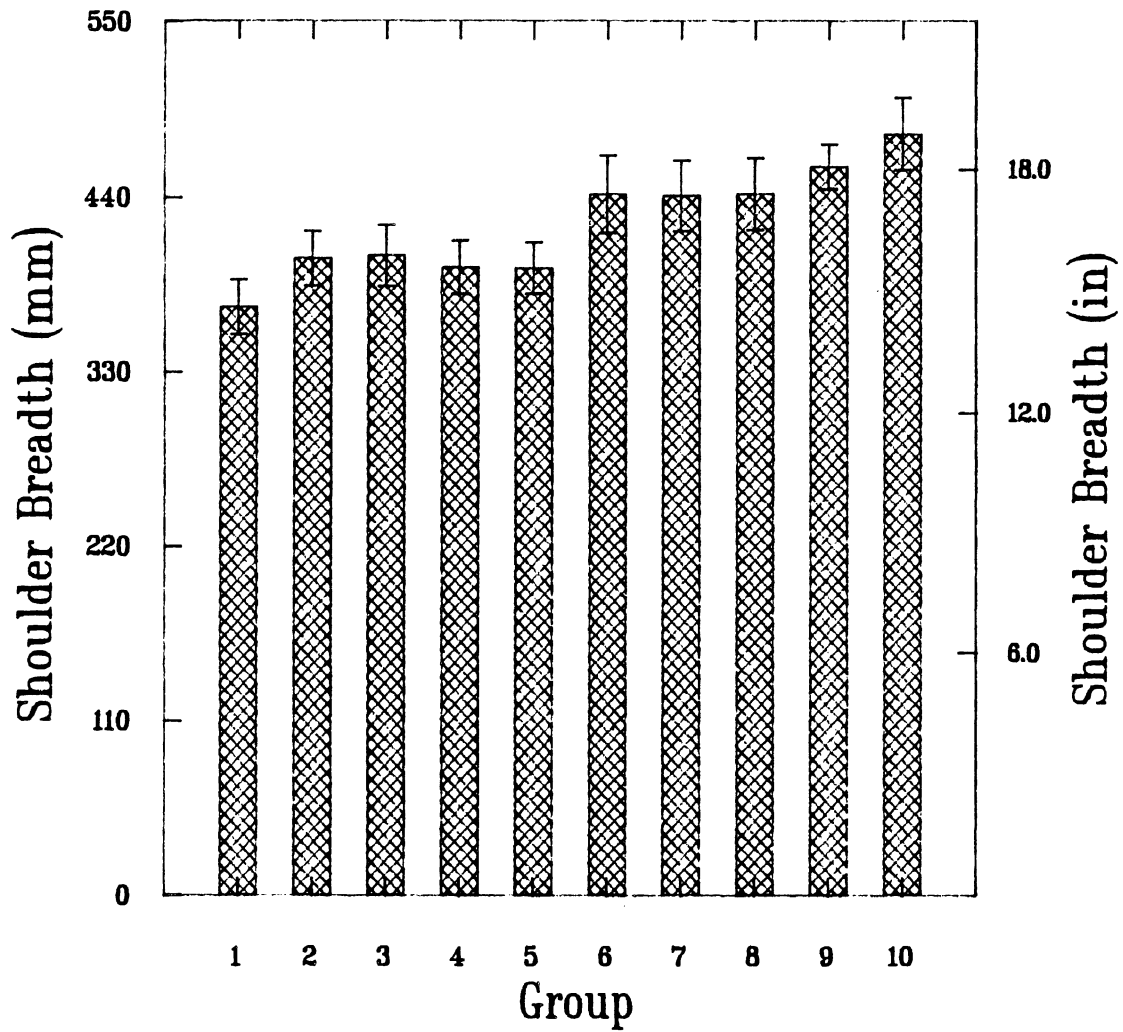


FIGURE E.10

Mean Shoulder-to-Elbow Length by Group

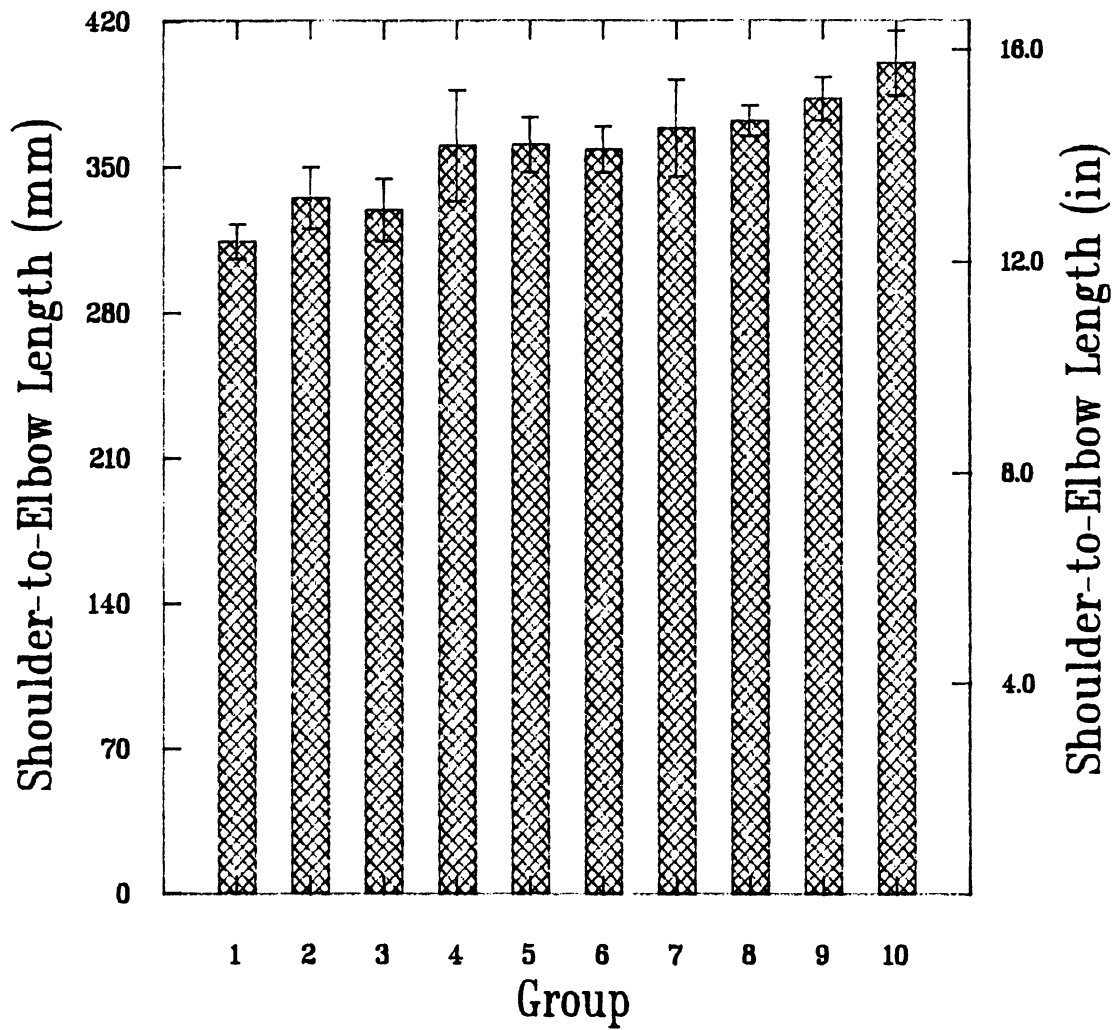


FIGURE E.11

Mean Forearm Length by Group

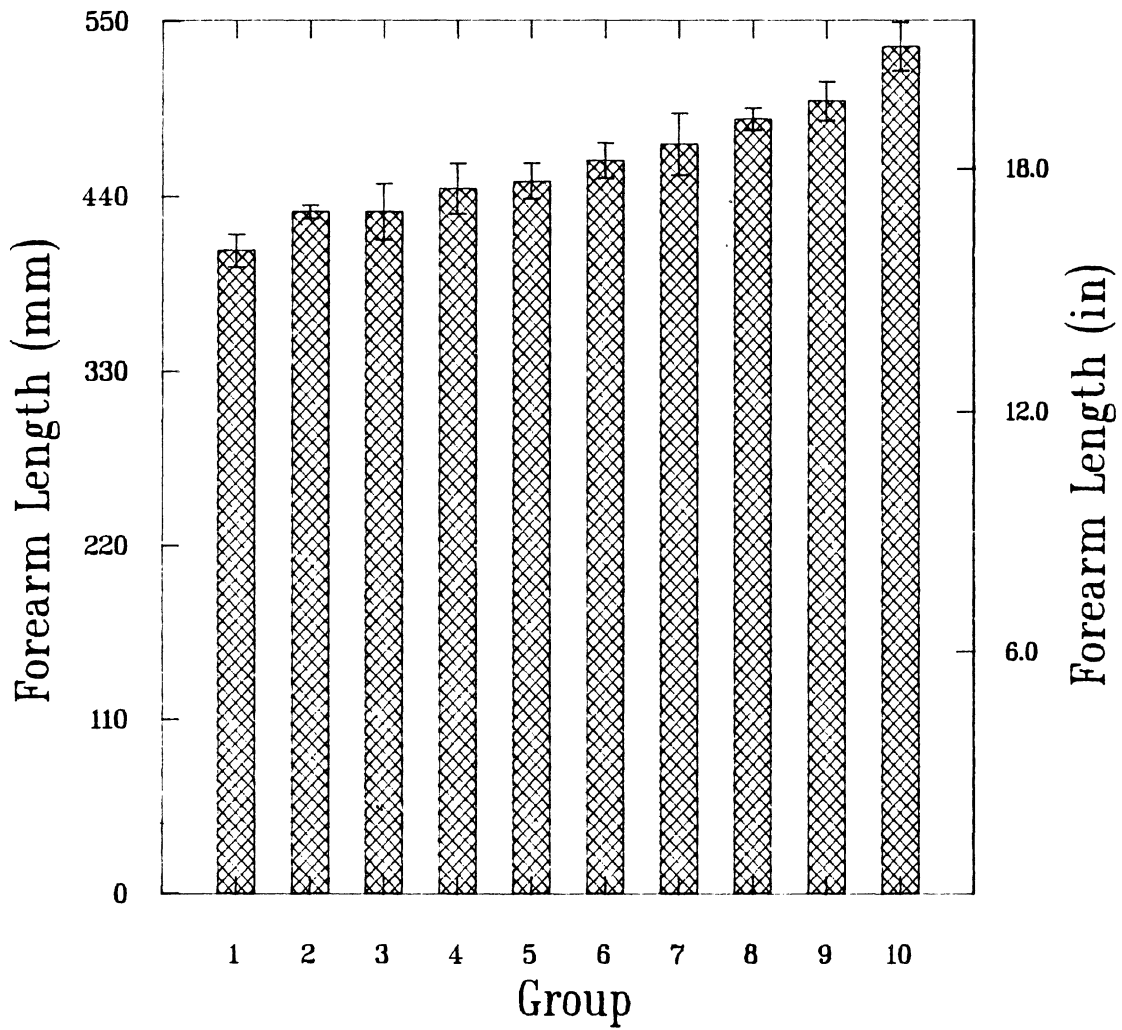


FIGURE E.12

Mean Maximum Reach by Group

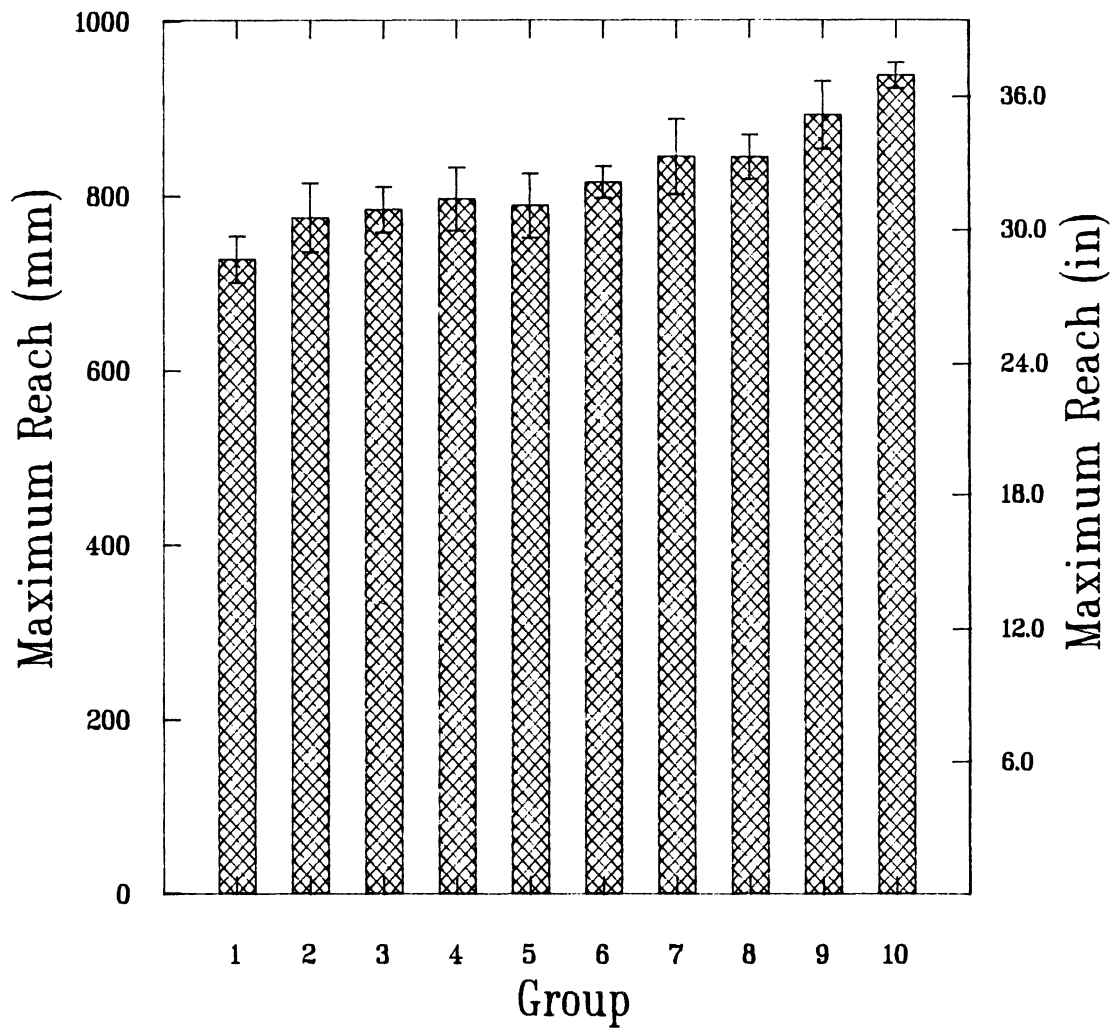


FIGURE E.13

Mean Maximum Grasp by Group

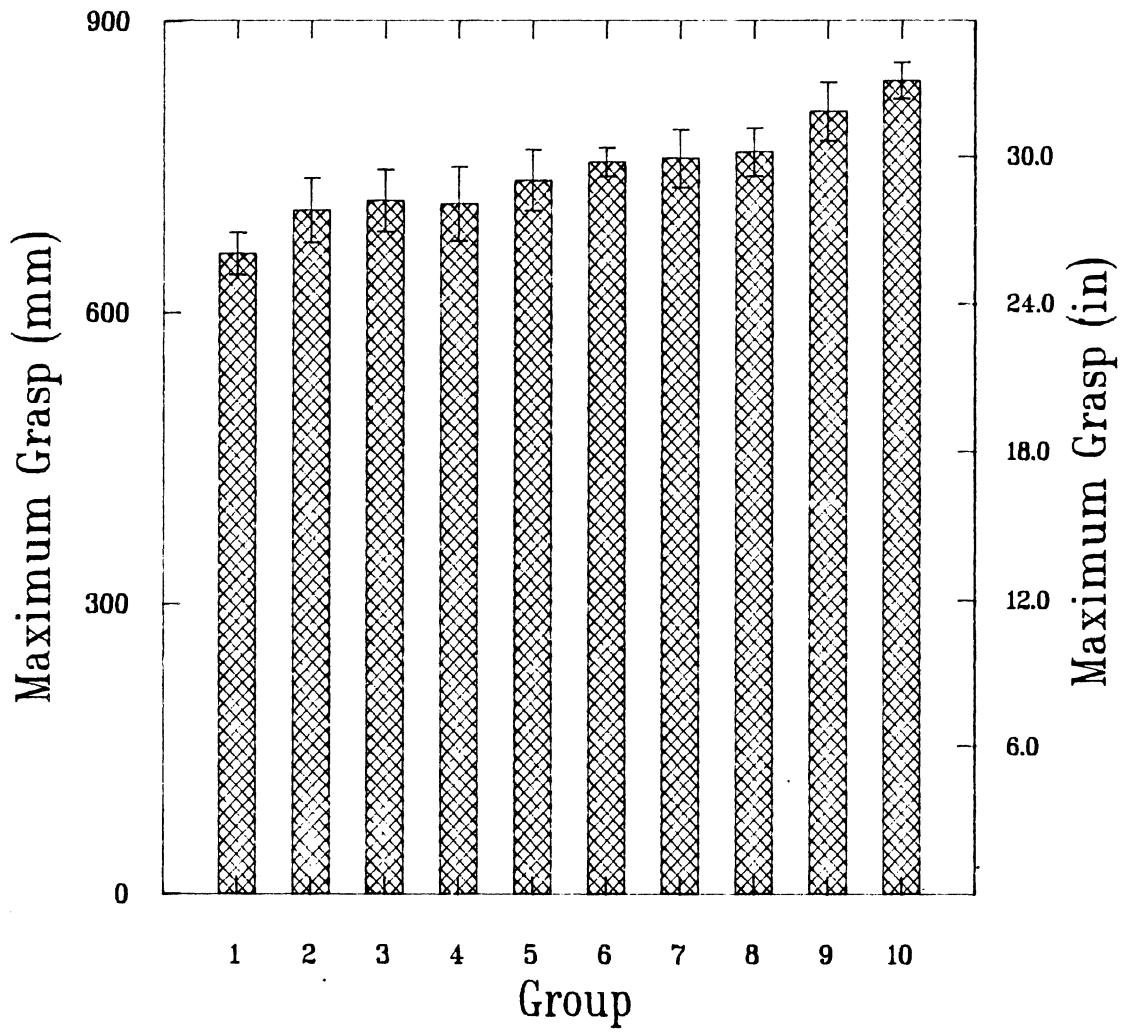


FIGURE E.14

Mean Interpupillary Distance by Group

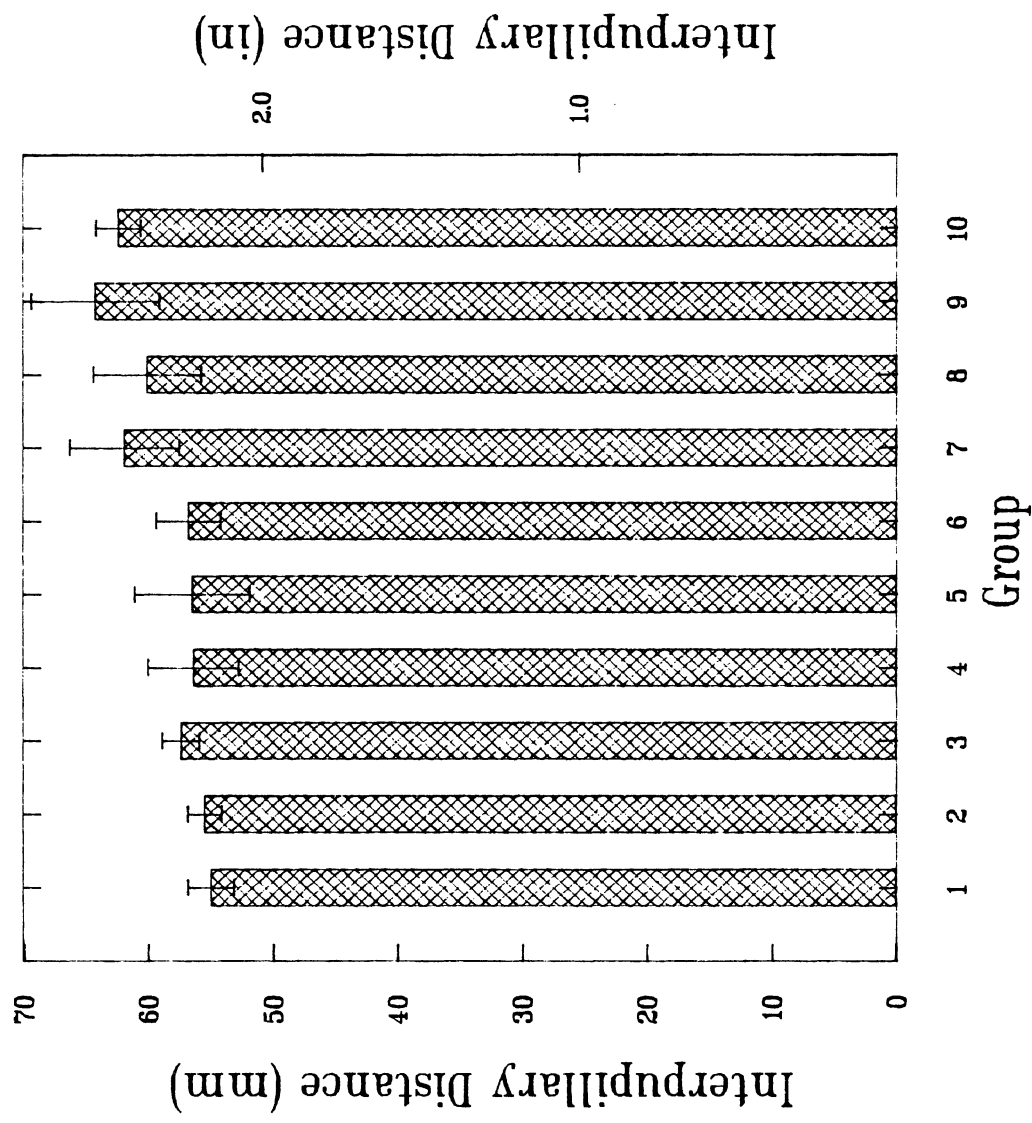


FIGURE E.15

APPENDIX F

PHASE I RESULTS—PART II: PREFERRED SEAT POSITIONS, SEATBACK ANGLES, AND STEERING WHEEL ANGLES

TABLE F.1

PHASE I: SEAT POSITION DATA SUMMARY*

Group	Blazer (X in mm)		Cadillac (X in mm)		Camaro Ph. 1 (X in mm)		Monte Carlo (X in mm)		
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	2258	55	3043	9	2941	5	2993	25
2	6	2303	26	3082	10	3020	9	3064	30
3	5	2321	12	3101	19	3040	18	3070	18
4	5	2334	42	3113	39	3038	27	3072	36
5	6	2369	37	3139	17	3069	15	3101	27
All Females	27	2318	50	3097	41	3023	49	3062	44
6	5	2309	18	3086	29	3031	24	3062	9
7	6	2348	22	3116	26	3051	22	3087	19
8	6	2366	39	3136	19	3076	35	3112	36
9	6	2404	11	3160	29	3114	17	3147	16
10	5	2443	9	3189	21	3118	58	3167	35
All Males	28	2374	50	3137	42	3078	46	3115	44
All Subjects	55	2347	57	3117	46	3051	55	3089	51
All Subjects Weighted	55	2346		3117		3052		3090	

*data given in vehicle coordinates with respect to X-coordinates of SAE J826 H-point calibration

TABLE F.2

PHASE I: SEAT BACK RECLINER DATA SUMMARY*

Group		Blazer (degrees)		Cadillac ** (degrees)		Camaro Ph. 1 (degrees)		Monte Carlo (degrees)	
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	26.6	3.0	14.4	2.7	28.1	3.3	22.6	1.3
2	6	24.0	5.2	21.3	3.5	29.0	4.9	25.8	3.6
3	5	20.2	1.8	17.4	1.5	27.5	5.6	22.0	1.8
4	5	21.4	3.3	16.6	3.4	27.5	5.1	22.3	3.3
5	6	21.0	4.0	18.0	0.6	25.5	2.8	26.0	5.7
All Females	27	22.6	4.2	17.4	3.2	27.5	4.3	23.9	3.8
6	5	23.8	5.0	20.9	3.8	28.1	2.3	24.1	3.8
7	6	22.3	4.5	19.7	4.8	29.8	4.9	24.8	5.1
8	6	21.0	2.2	19.8	3.0	25.0	3.2	21.3	1.3
9	6	25.0	5.1	22.2	2.4	28.8	4.5	25.0	2.5
10	5	23.8	3.9	23.0	3.0	29.3	3.4	27.4	6.1
All Males	28	23.1	4.2	21.1	3.5	28.1	4.0	24.4	4.2
All Subjects	55	22.9	4.1	19.0	4.6	27.8	4.1	24.2	4.0
All Subjects Weighted	55	22.9		19.4		27.9		24.1	
Design Recliner Angle		23		26		26		26.5	

*angles given with respect to SAE J826 H-point calibration at or near design back angle

**back angles include adjustment for tilt of power seat from design pan angle

TABLE F.3

PHASE I: TILT WHEEL ANGLE DATA SUMMARY*

Group	Blazer (degrees)		Cadillac (degrees)		Camaro Ph. 1 (degrees)		Monte Carlo (degrees)		
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	25.5	5.5	21.0	3.5	21.5	5.0	26.0	5.7
2	6	24.8	2.6	19.3	5.2	21.5	3.2	24.0	4.5
3	5	18.5	5.7	14.0	4.5	16.5	5.0	18.0	6.5
4	5	21.5	5.0	19.0	4.5	18.5	4.5	21.0	5.7
5	6	19.0	4.2	14.3	2.6	15.7	3.8	17.3	2.6
All Females	27	21.9	5.2	17.5	4.8	18.7	4.7	21.2	5.8
6	5	15.5	5.5	16.0	7.9	19.5	8.4	18.0	8.9
7	6	23.2	4.1	17.7	2.6	19.8	2.6	20.7	2.6
8	6	20.7	4.9	14.3	4.1	18.2	2.6	19.8	4.9
9	6	25.7	6.6	22.7	5.2	24.0	6.1	22.3	4.1
10	5	24.5	2.7	19.0	2.7	21.5	5.0	31.0	8.4
All Males	28	22.0	5.8	18.0	5.3	20.6	5.3	22.2	7.1
All Subjects	55	22.0	5.5	17.7	5.0	19.7	5.0	21.7	6.4
All Subjects Weighted	55	22.2		17.9		19.8		21.7	

*angle of steering wheel plane with respect to vertical

Blazer Preferred Seat Position

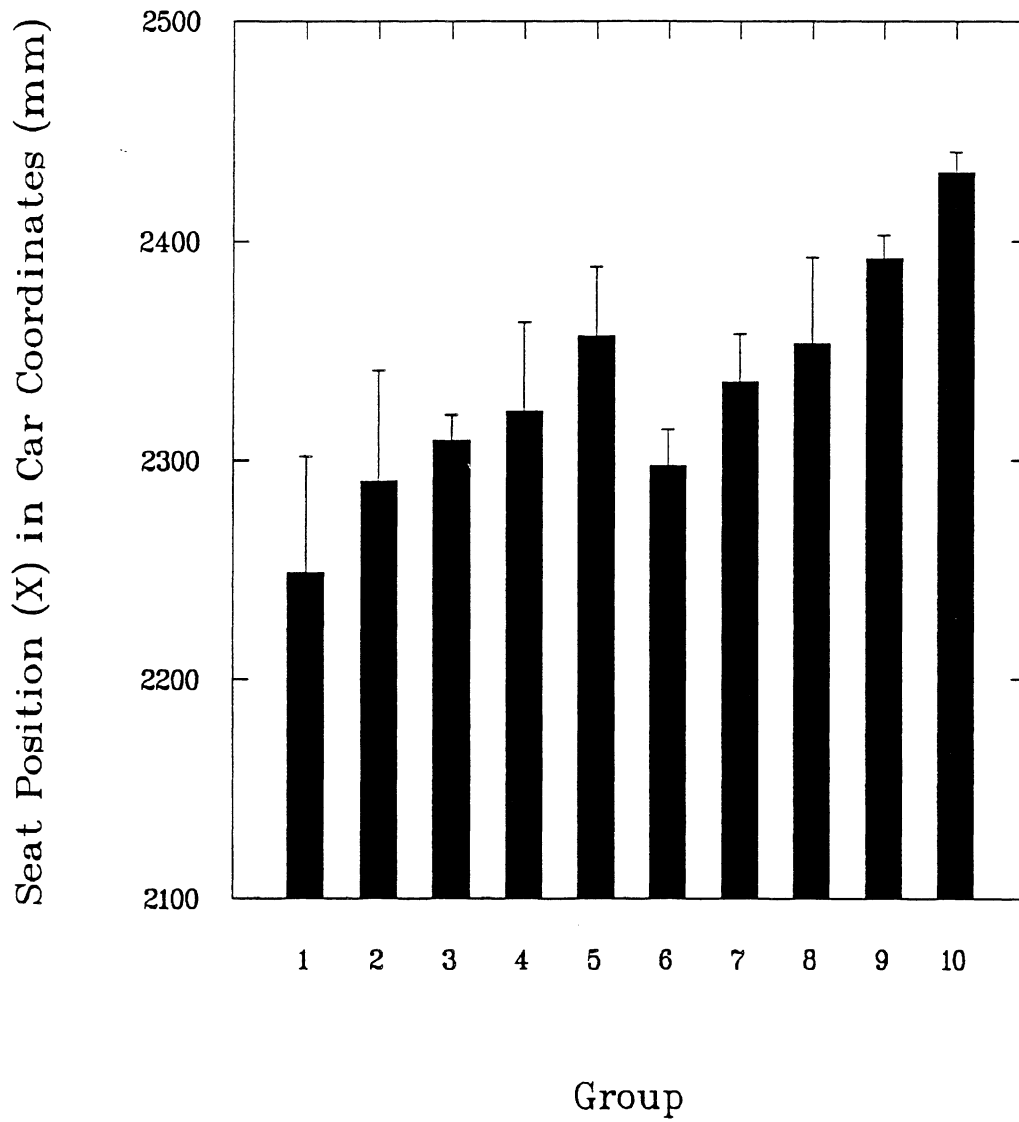


FIGURE F.1

Cadillac Preferred Seat Position

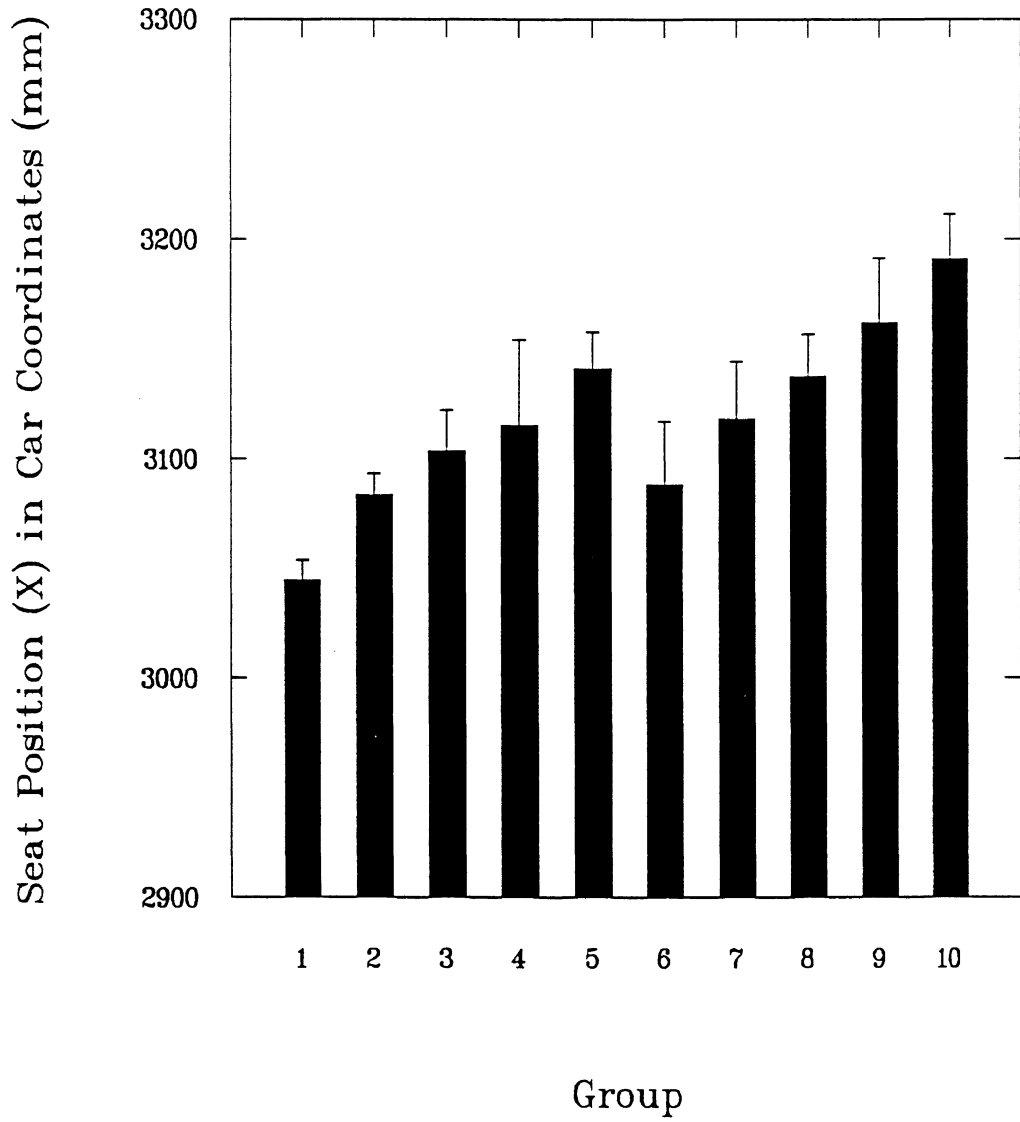


FIGURE F.2

Camaro Preferred Seat Position

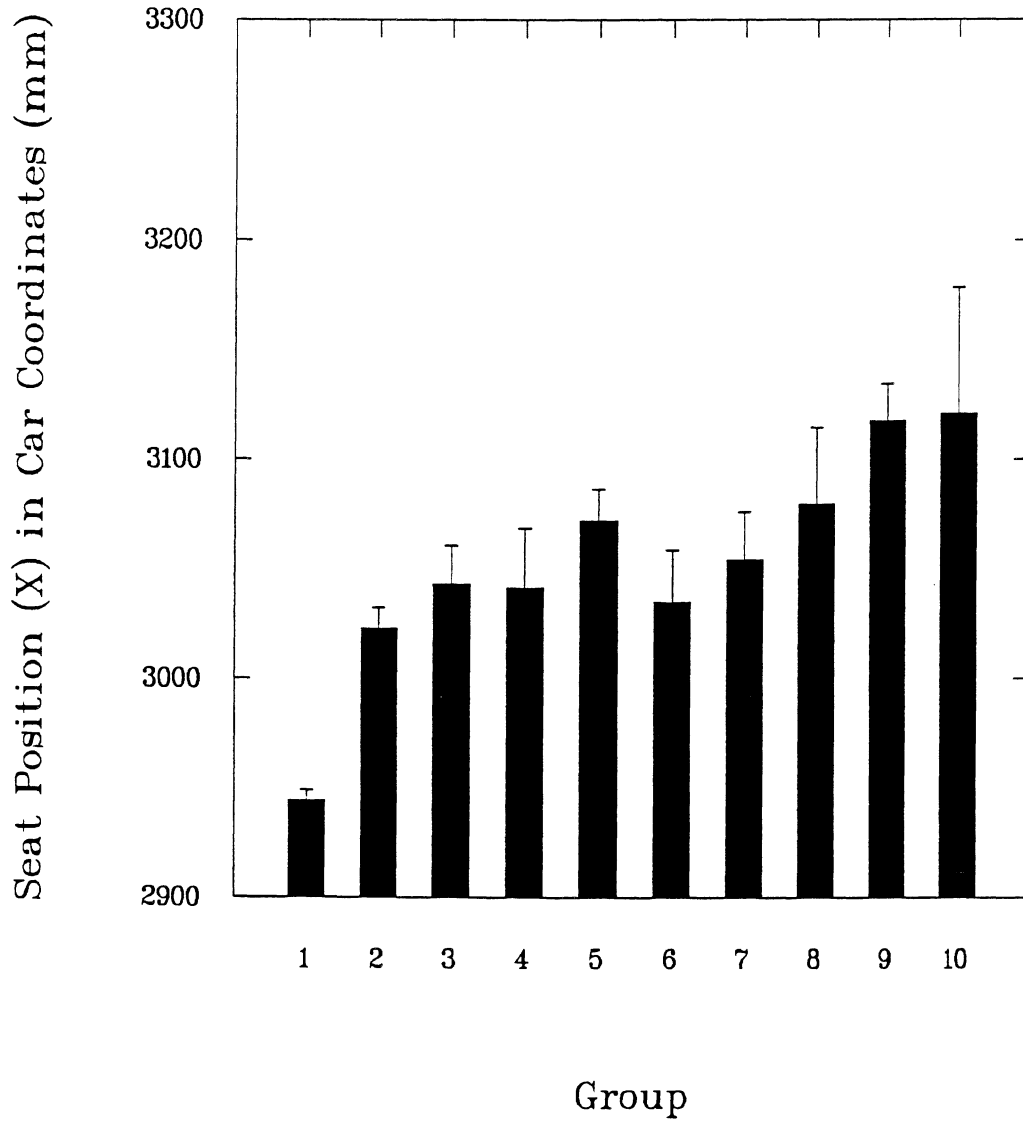


FIGURE F.3

Monte Carlo Preferred Seat Position

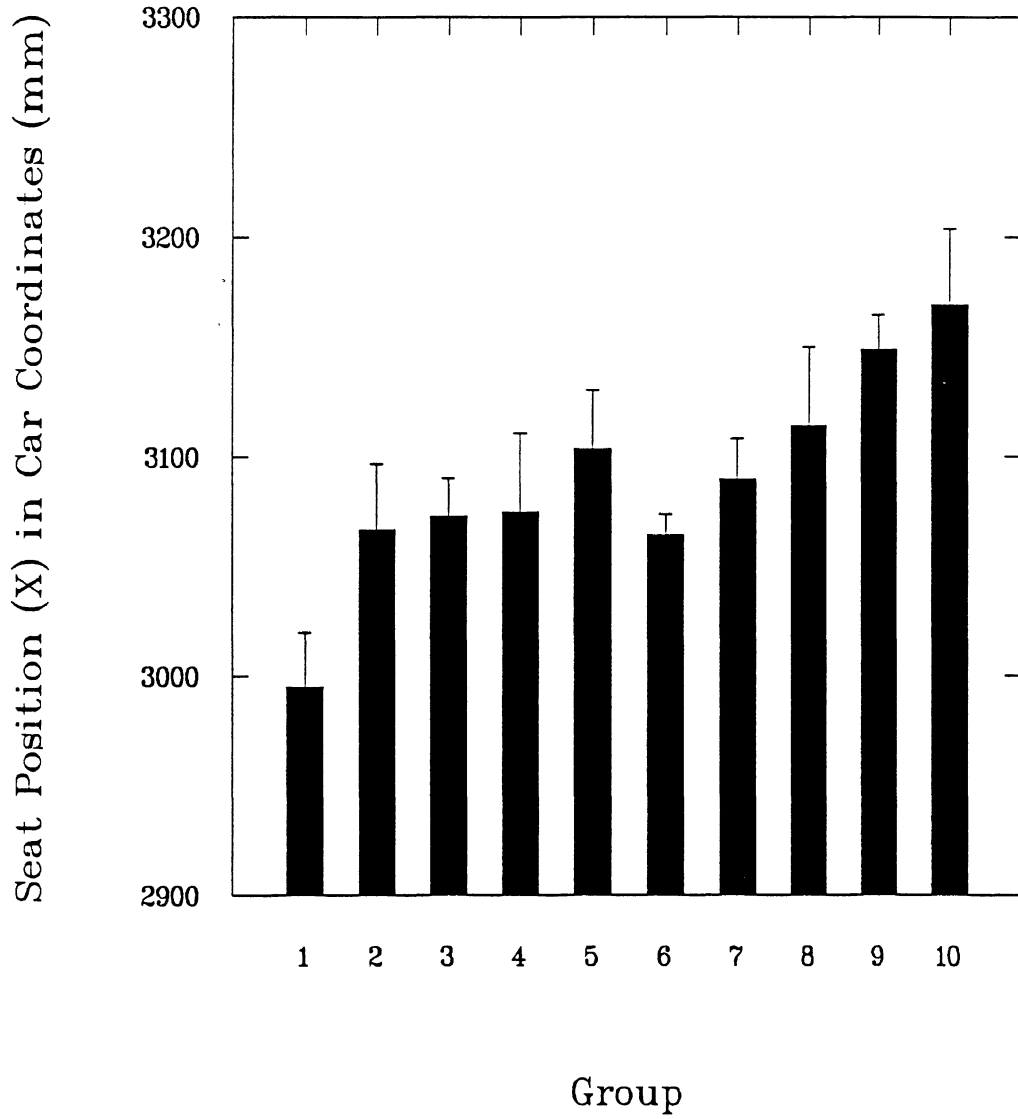


FIGURE F.4

Blazer Preferred Seat Back Angle

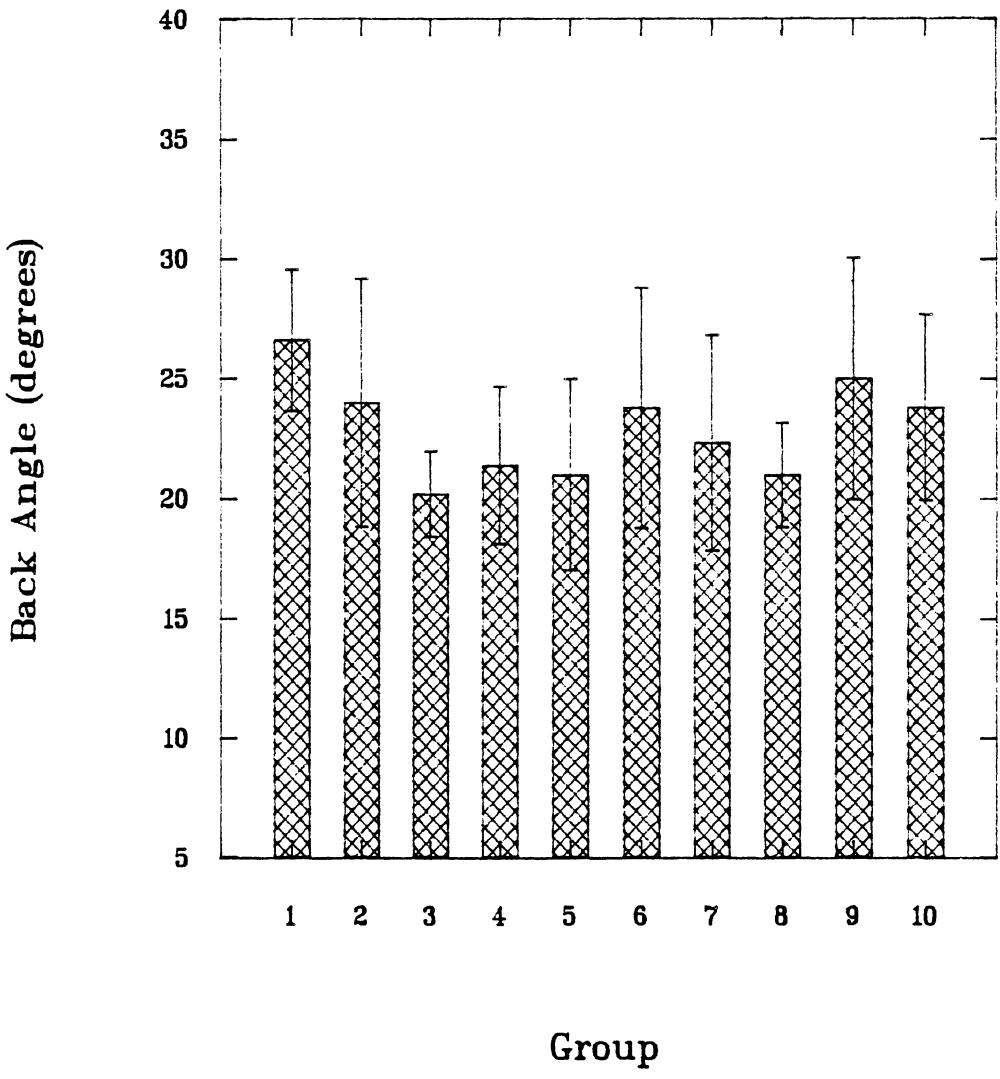


FIGURE F.5

Cadillac Preferred Seat Back Angle

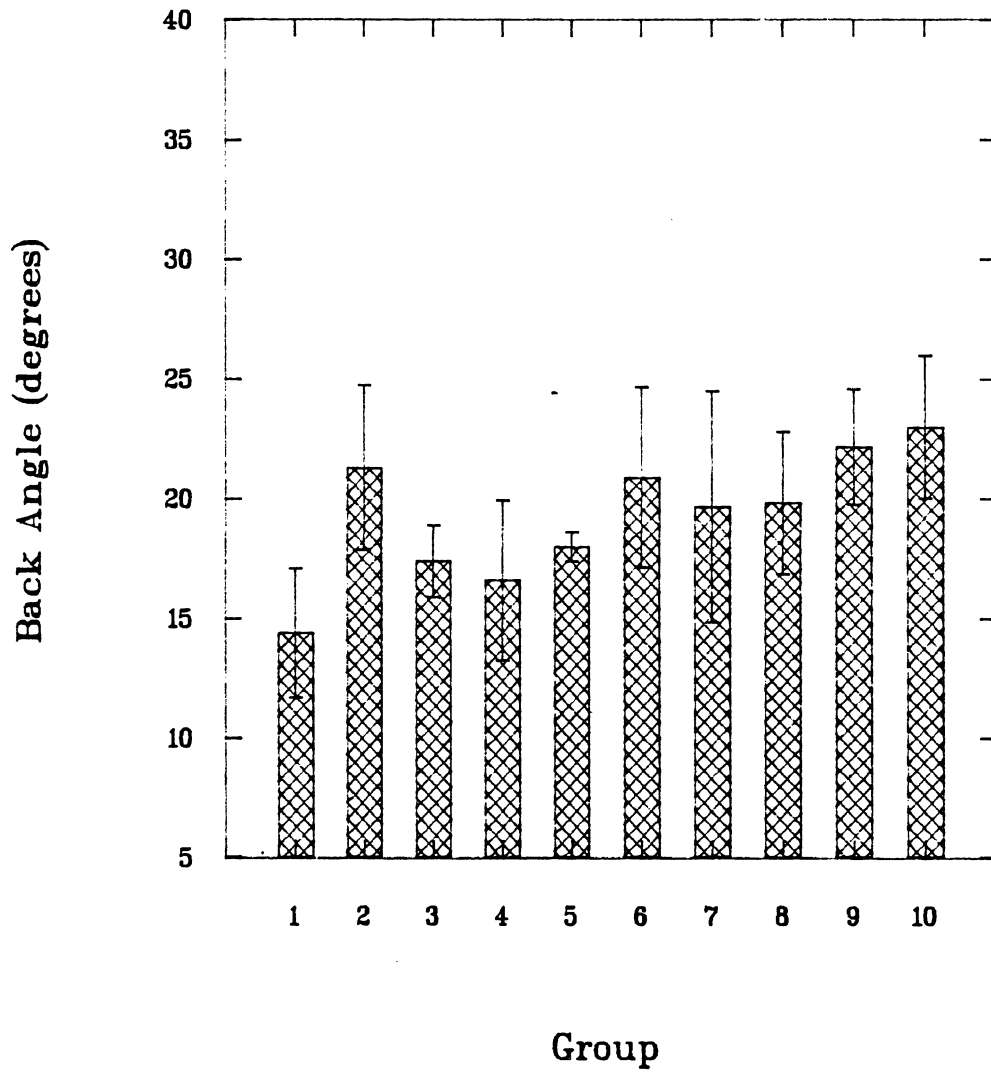


FIGURE F.6

Camaro Preferred Seat Back Angle

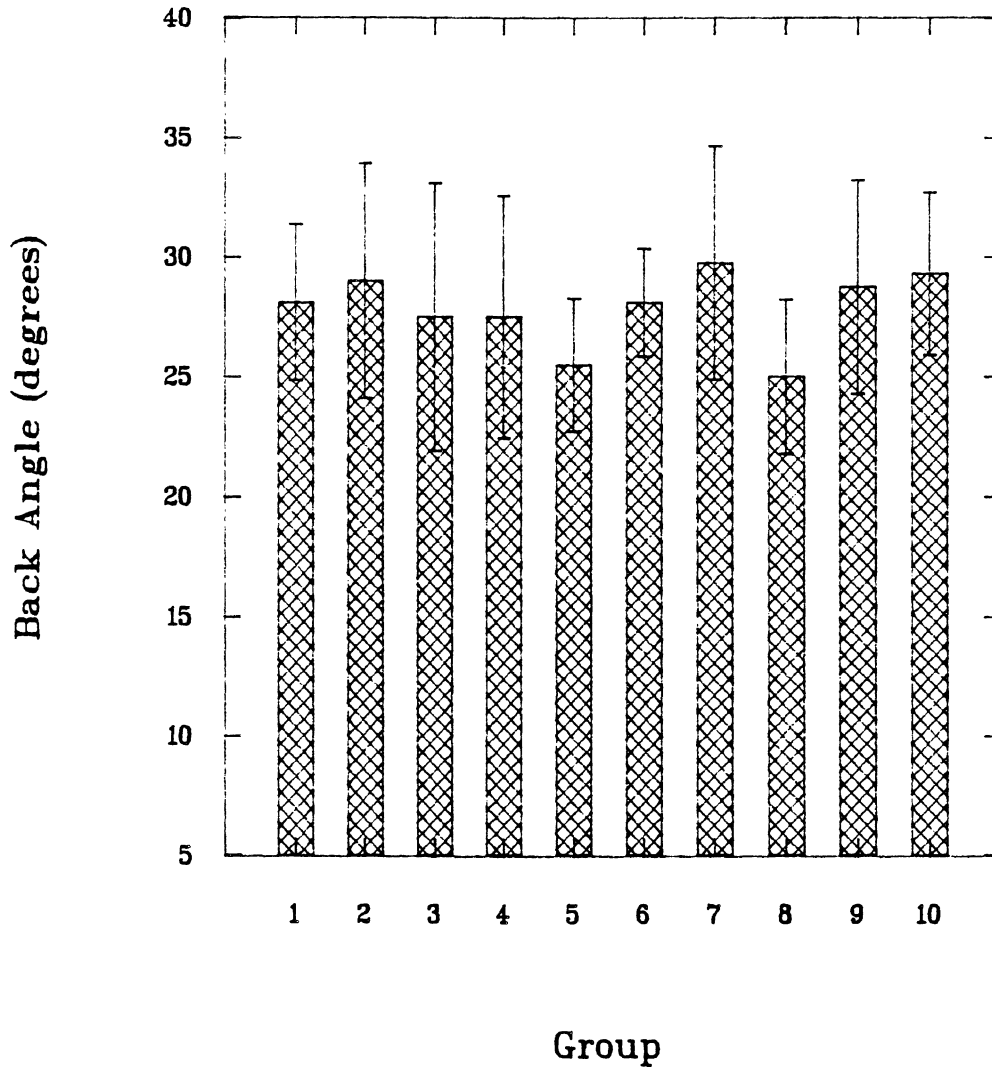


FIGURE F.7

Monte Carlo Preferred Seat Back Angle

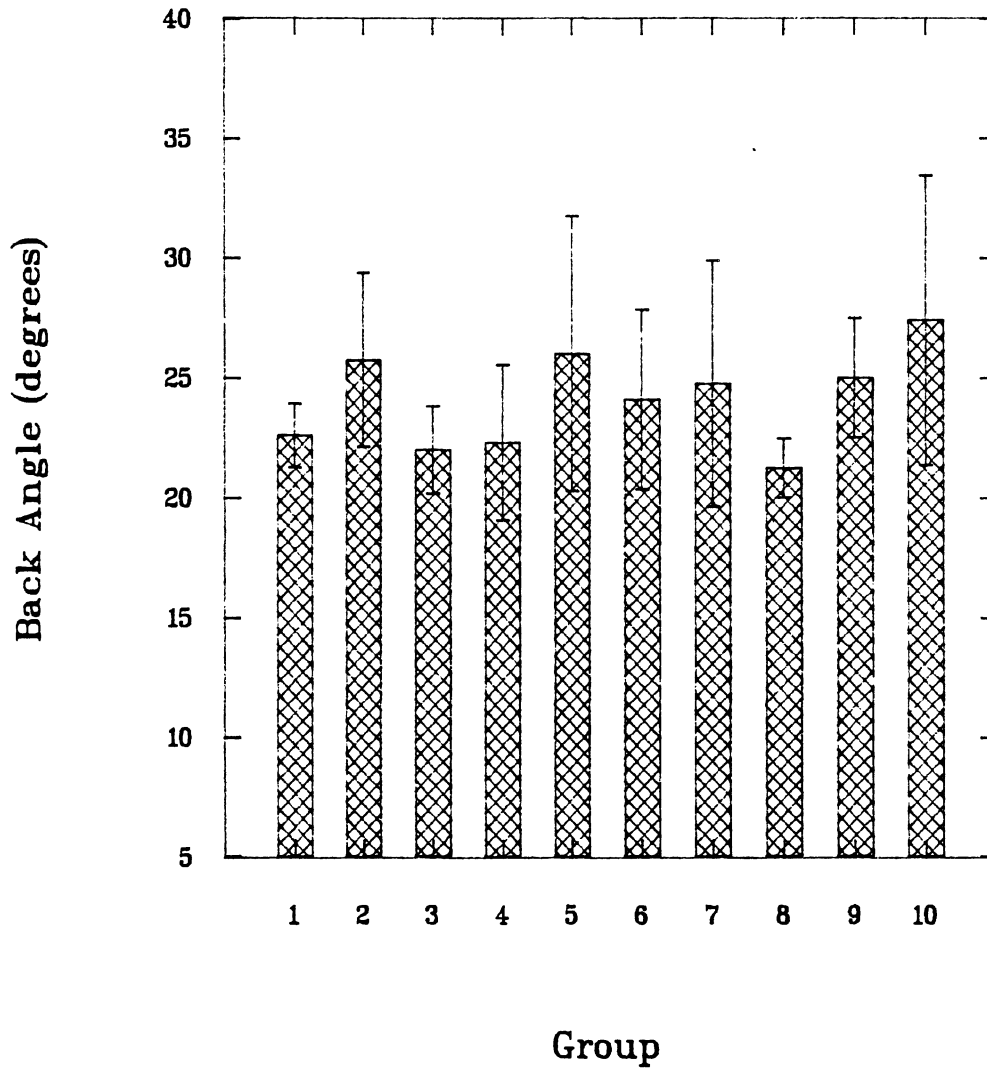


FIGURE F.8

Blazer Preferred Tilt-Wheel Angle

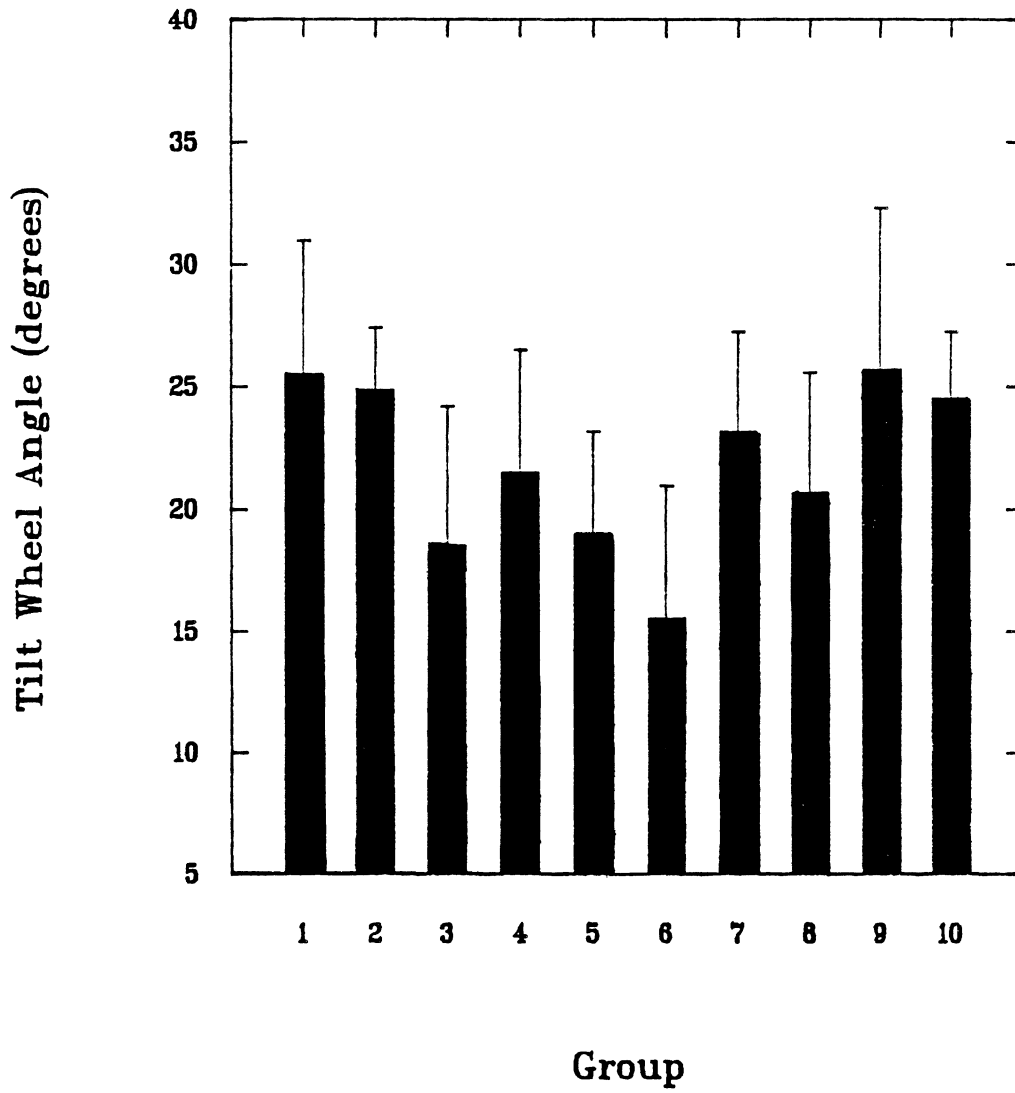


FIGURE F.9

Cadillac Preferred Tilt-Wheel Angle

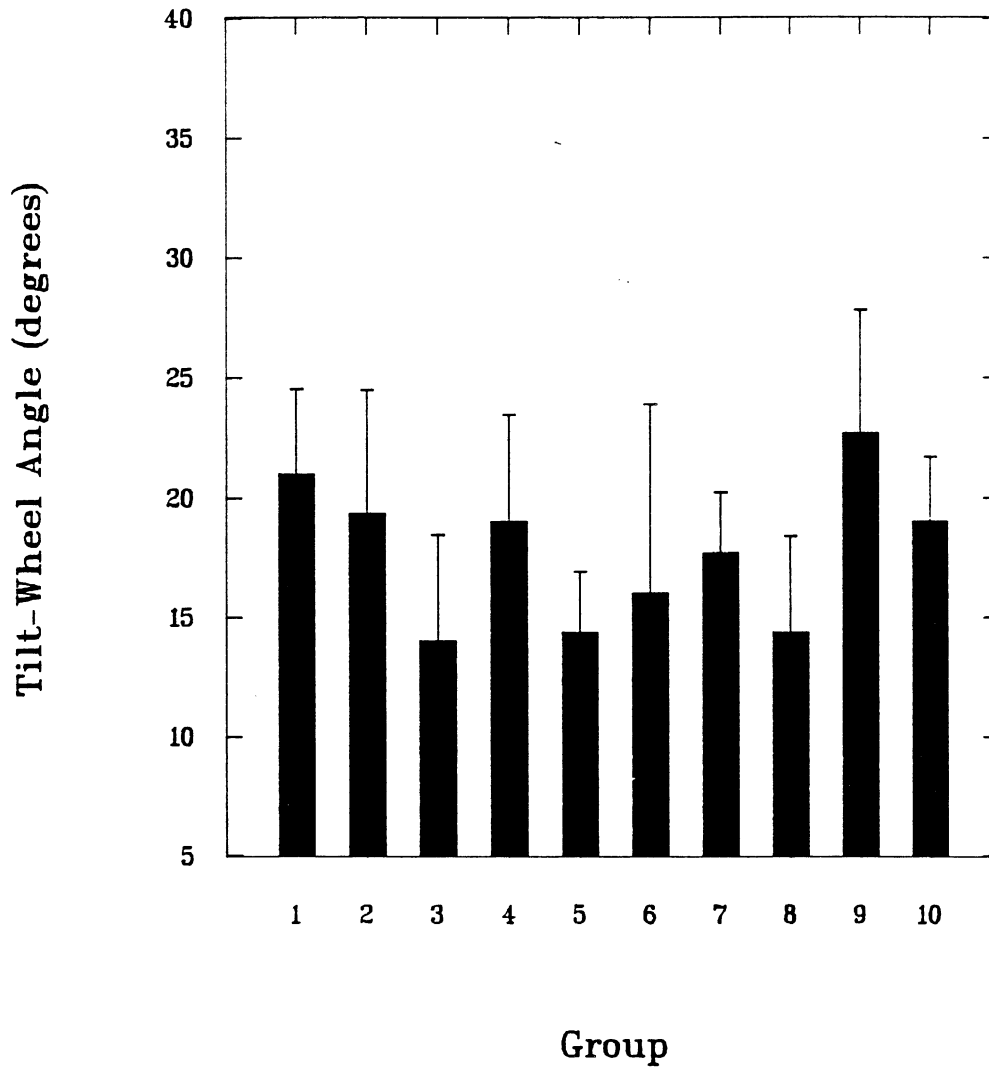


FIGURE F.10

Camaro Preferred Tilt-Wheel Angle

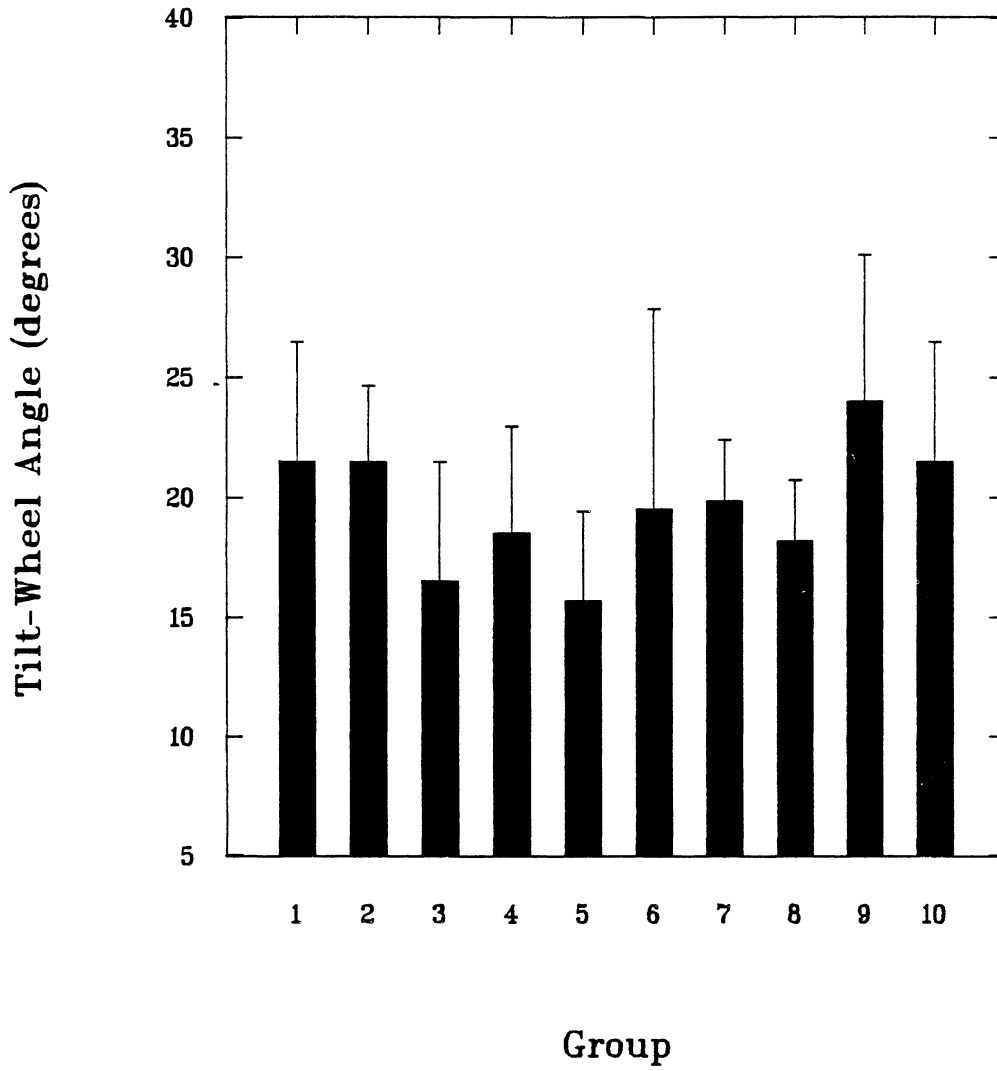


FIGURE F.11

Monte Carlo Preferred Tilt-Wheel Angle

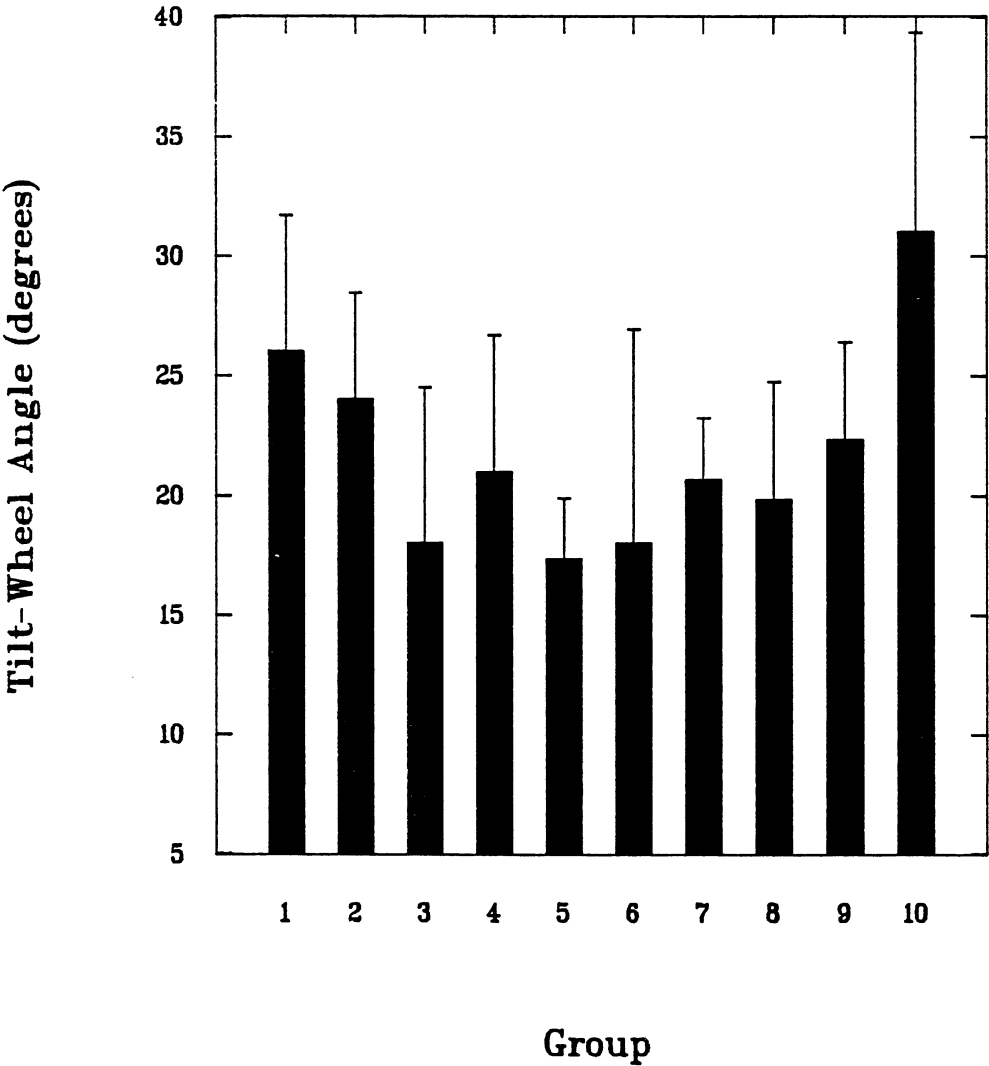


FIGURE F.12

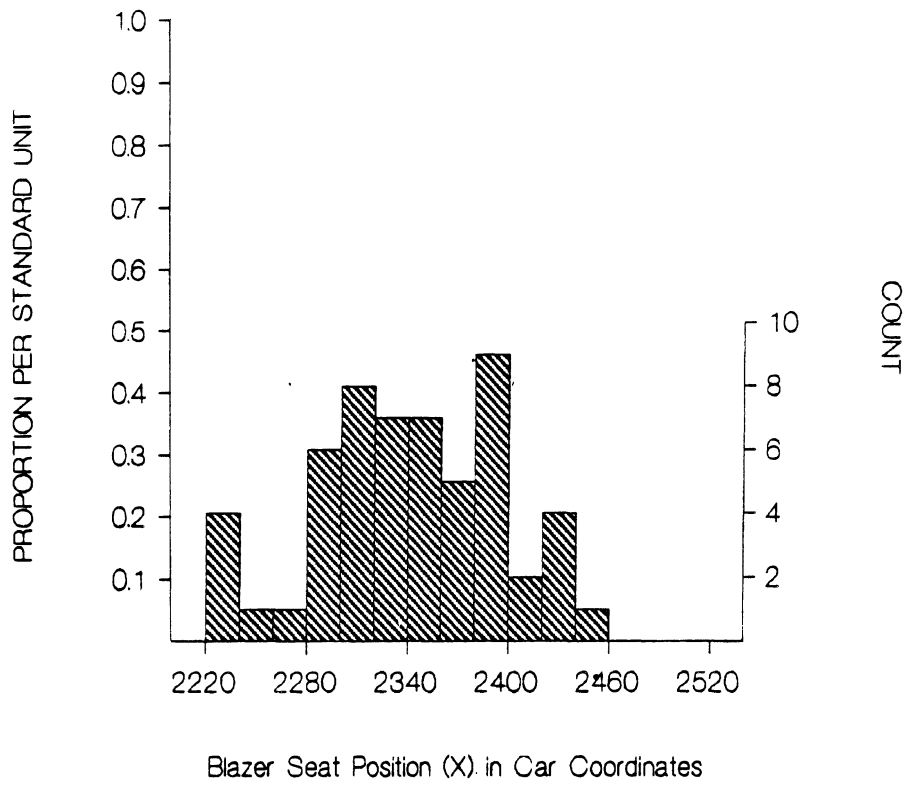


FIGURE F.13

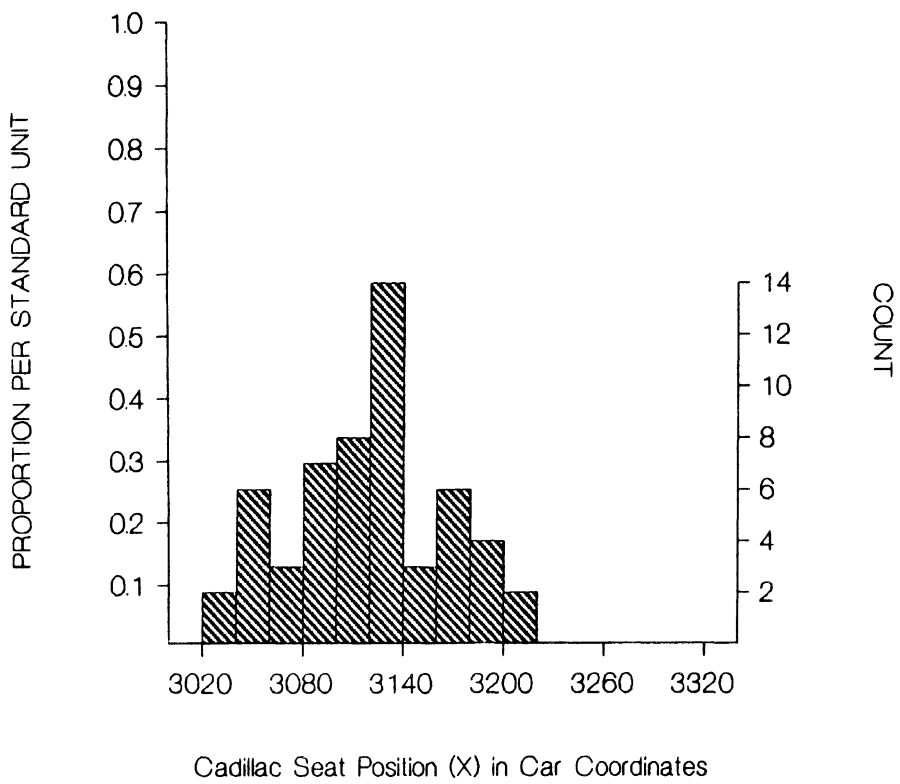
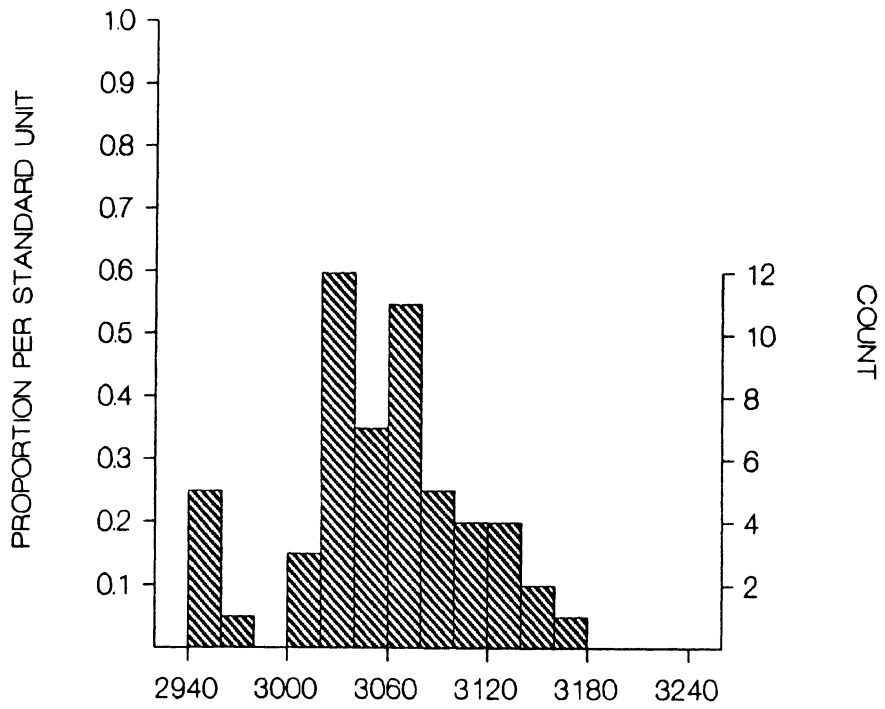
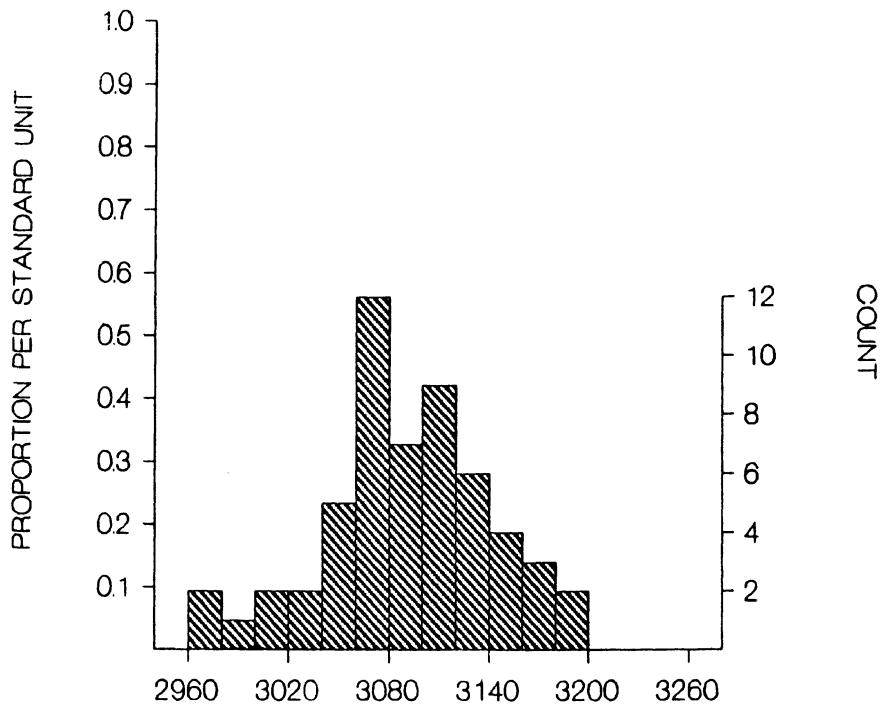


FIGURE F.14



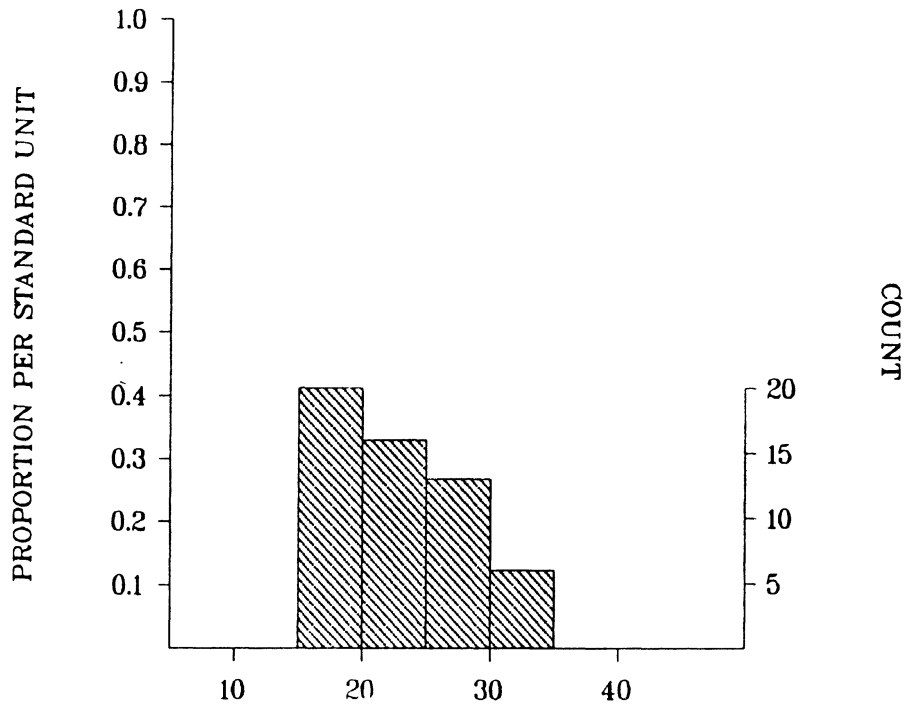
Camaro Phase 1 Seat Position (X) in Car Coordinates

FIGURE F.15



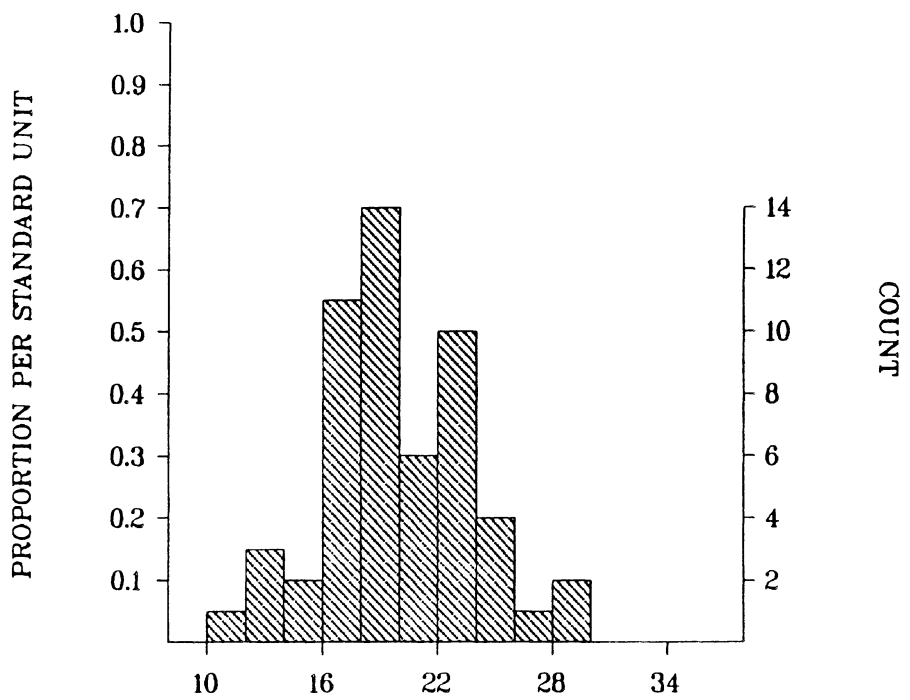
Monte Carlo Seat Position (X) in Car Coordinates

FIGURE F.16



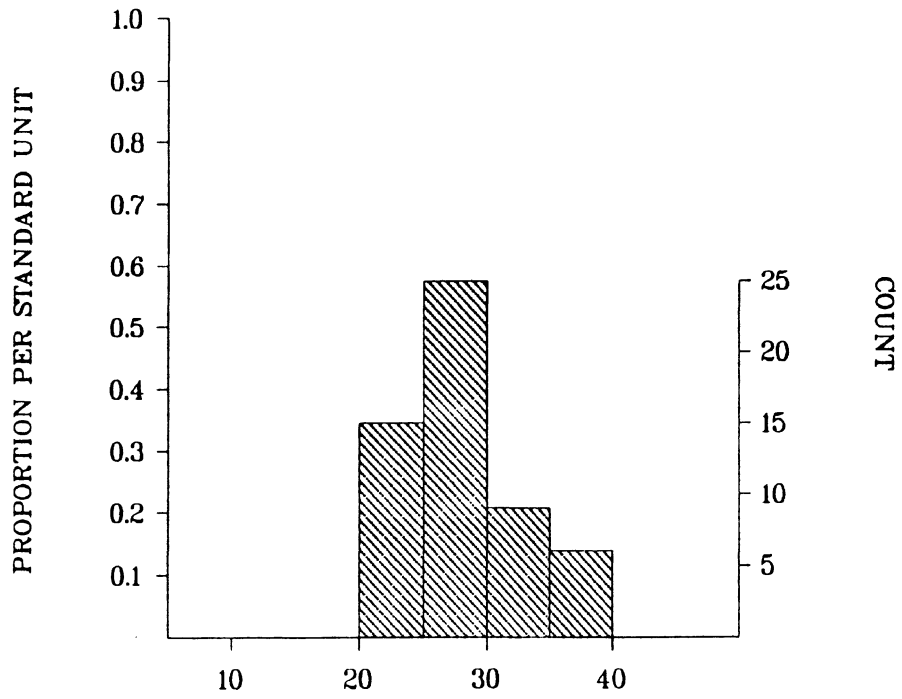
Blazer Seat Back Angle (degrees) Relative to Vertical

FIGURE F.17



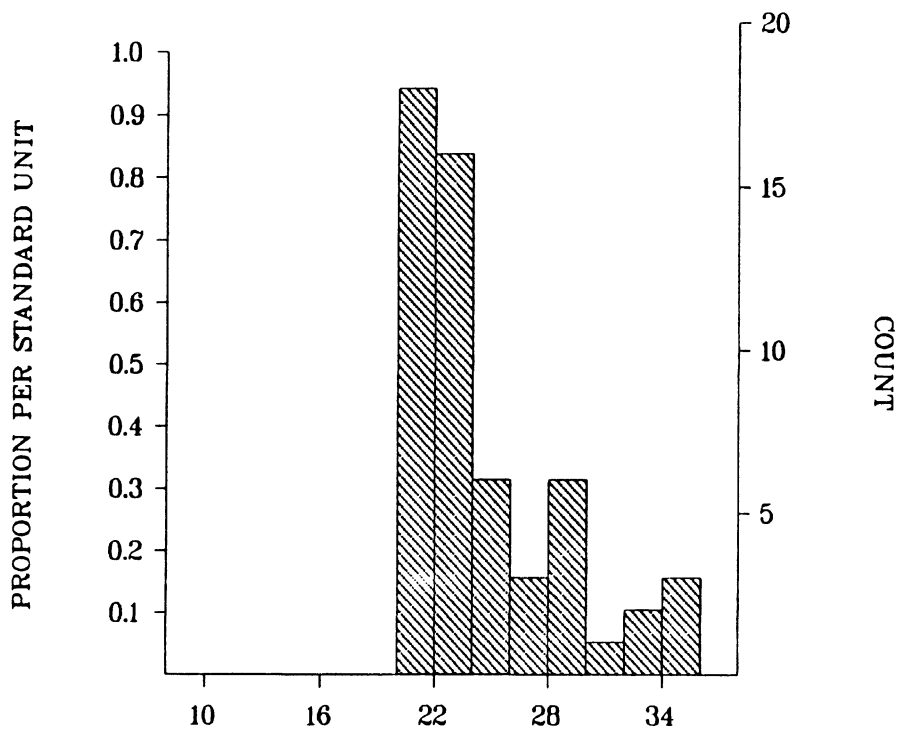
Cadillac Seat Back Angle (degrees) Relative to Vertical

FIGURE F.18



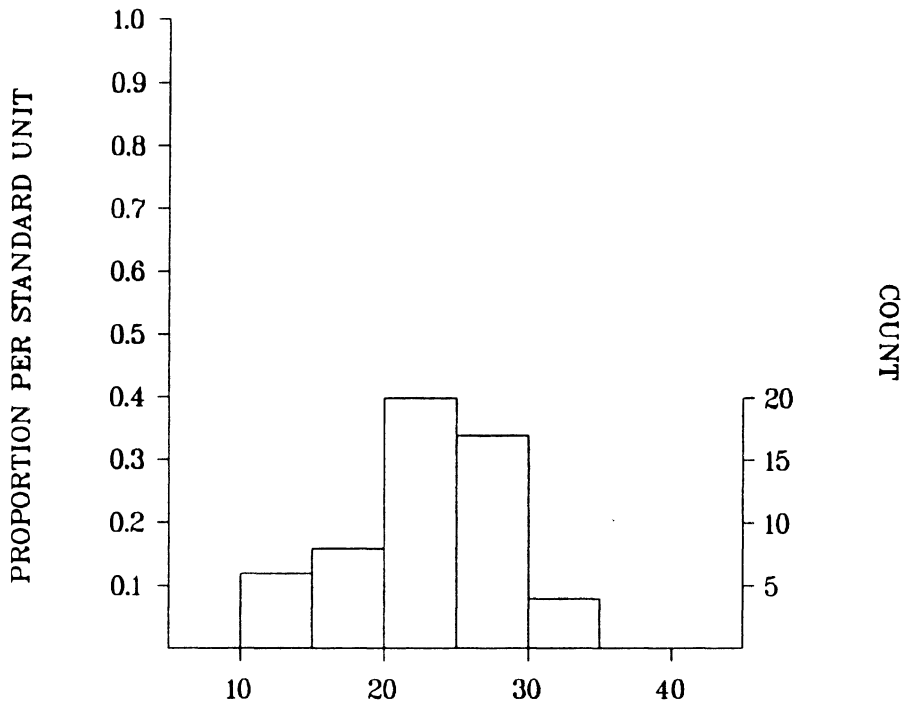
Camaro Phase 1 Seat Back Angle (degrees) Relative to Vertical

FIGURE F.19



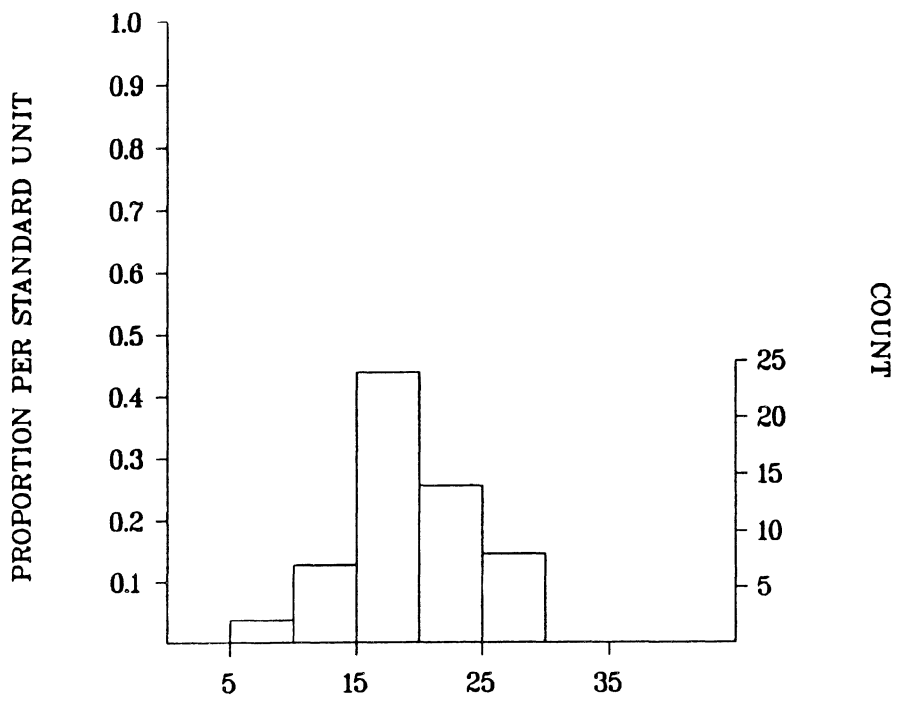
Monte Carlo Seat Back Angle (degrees) Relative to Vertical

FIGURE F.20



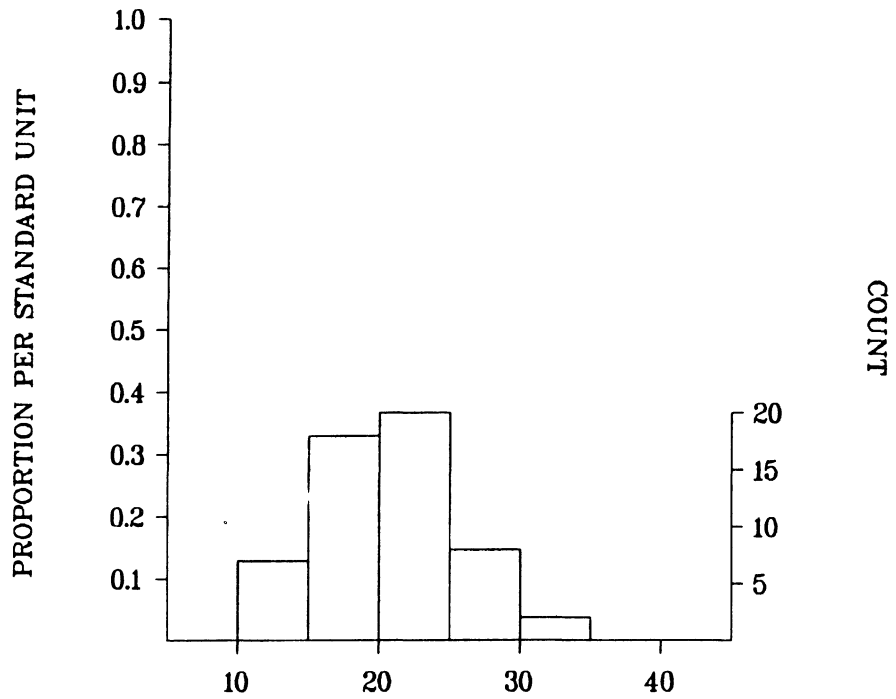
Blazer Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE F.21



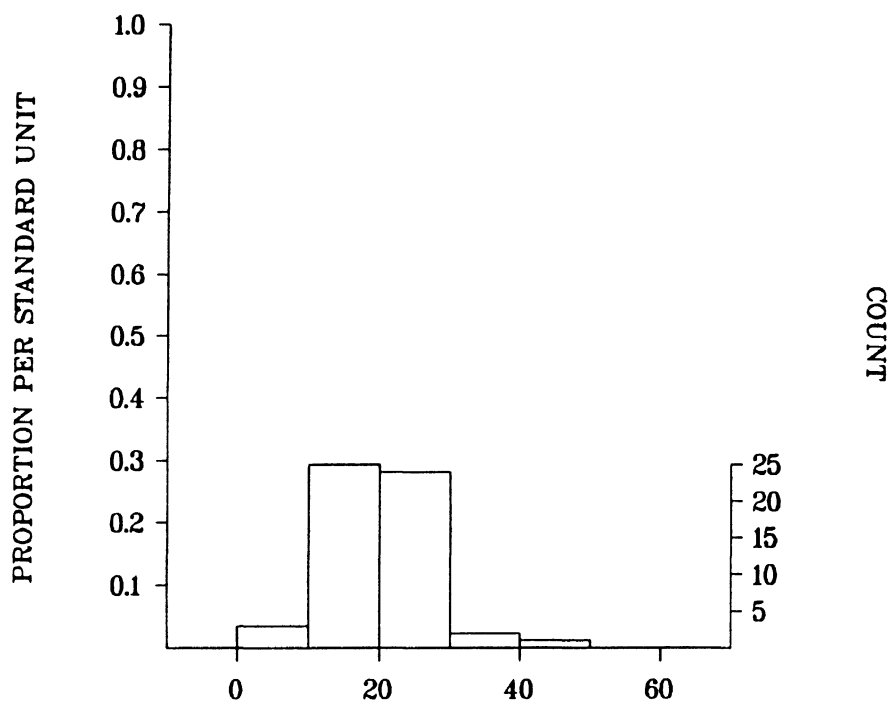
Cadillac Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE F.22



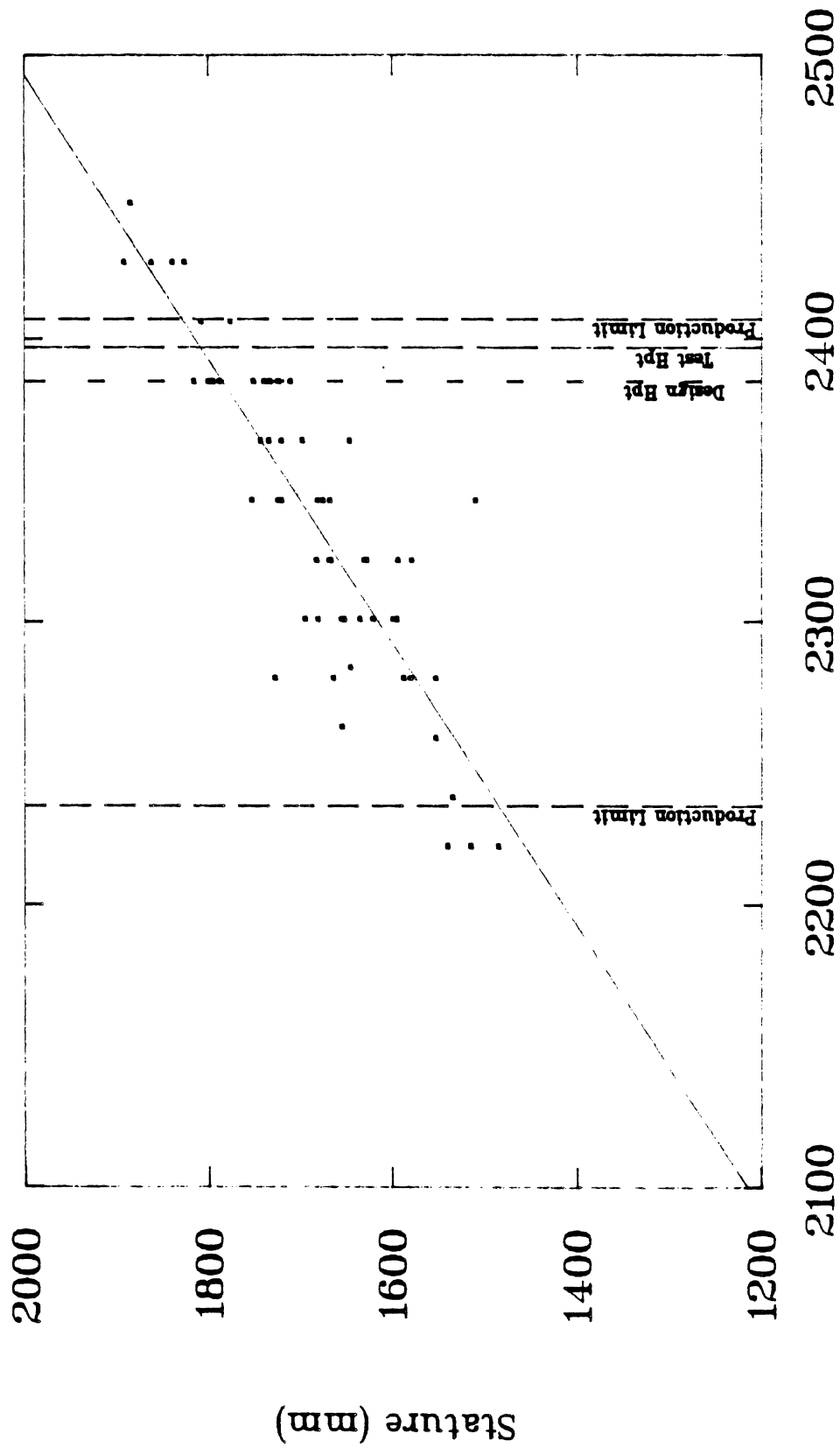
Camaro Phase 1 Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE F.23



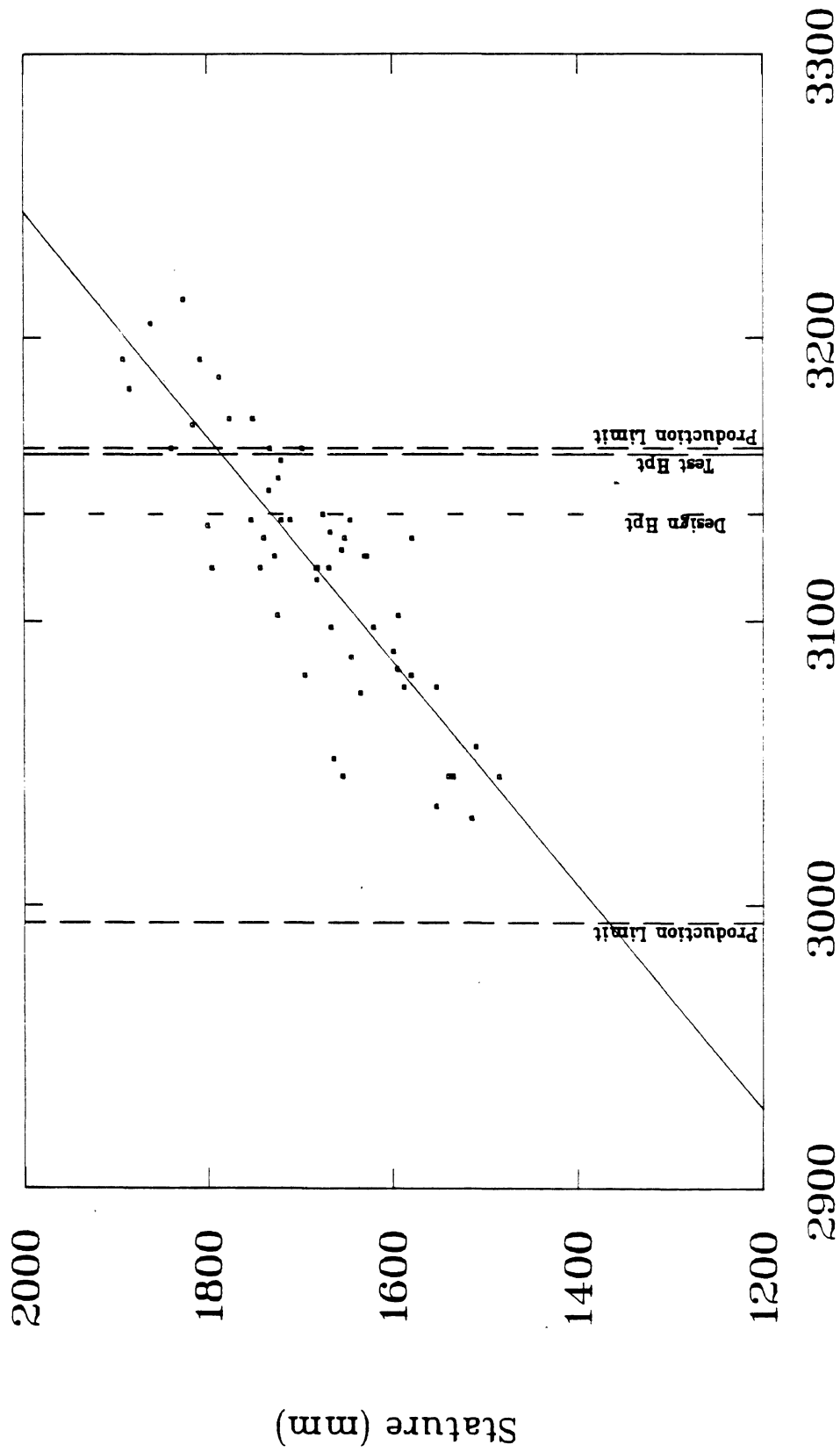
Monte Carlo Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE F.24



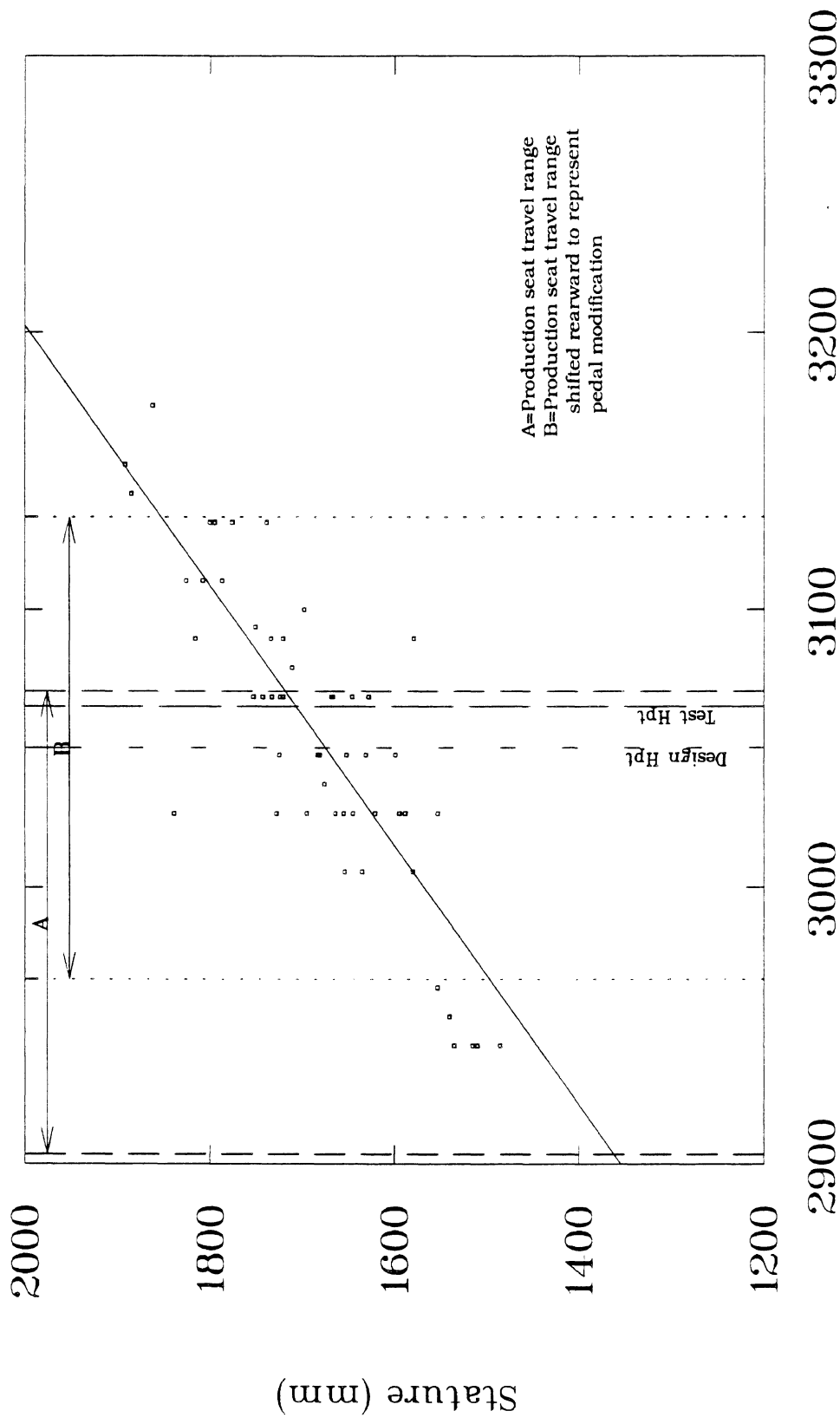
Blazer Seat Position in Car Coordinates (mm)

FIGURE F.25



Cadillac Seat Position in Car Coordinates (mm)

FIGURE F.26



Camaro Phase 1 Seat Position in Car Coordinates (mm)

FIGURE F.27

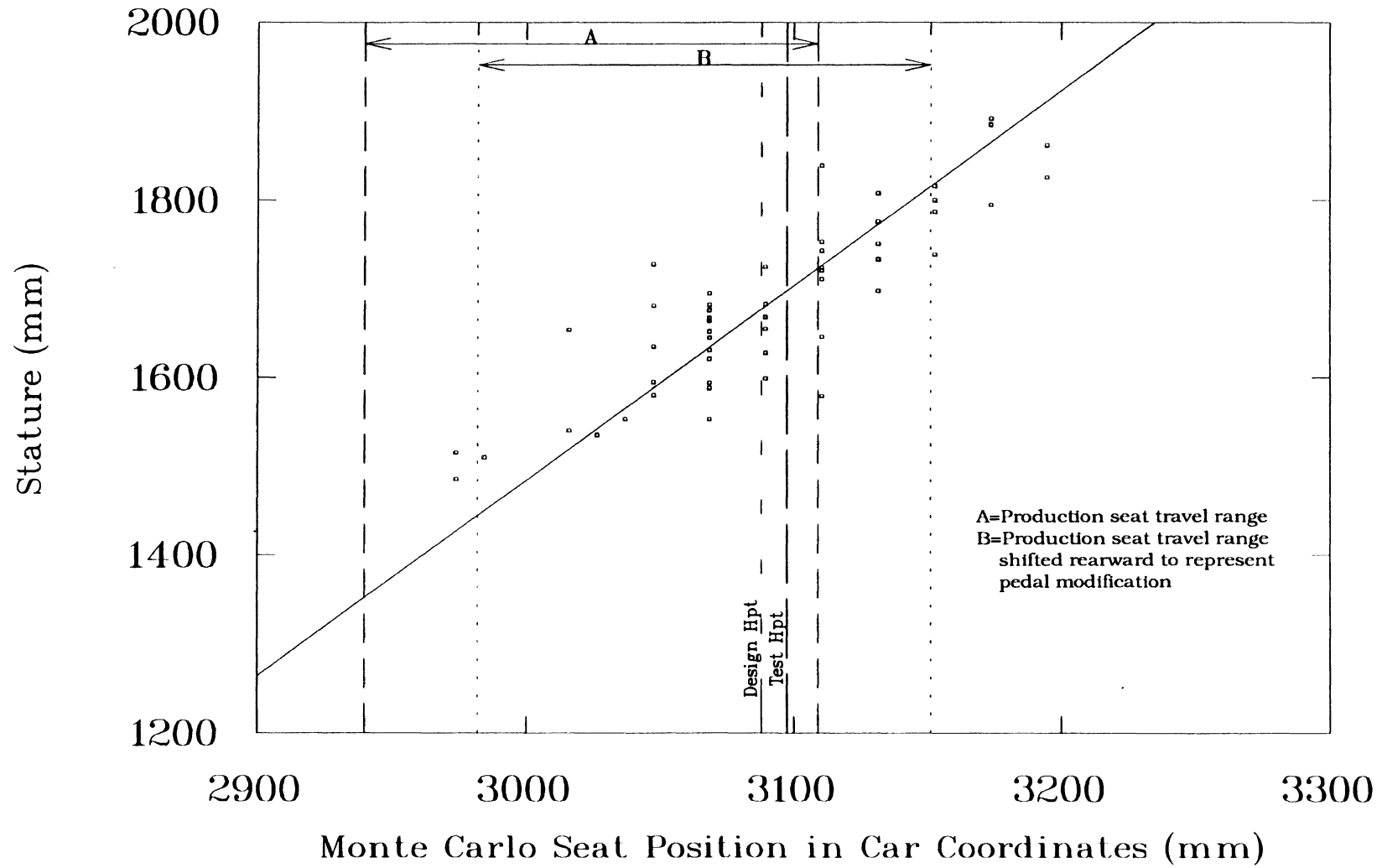
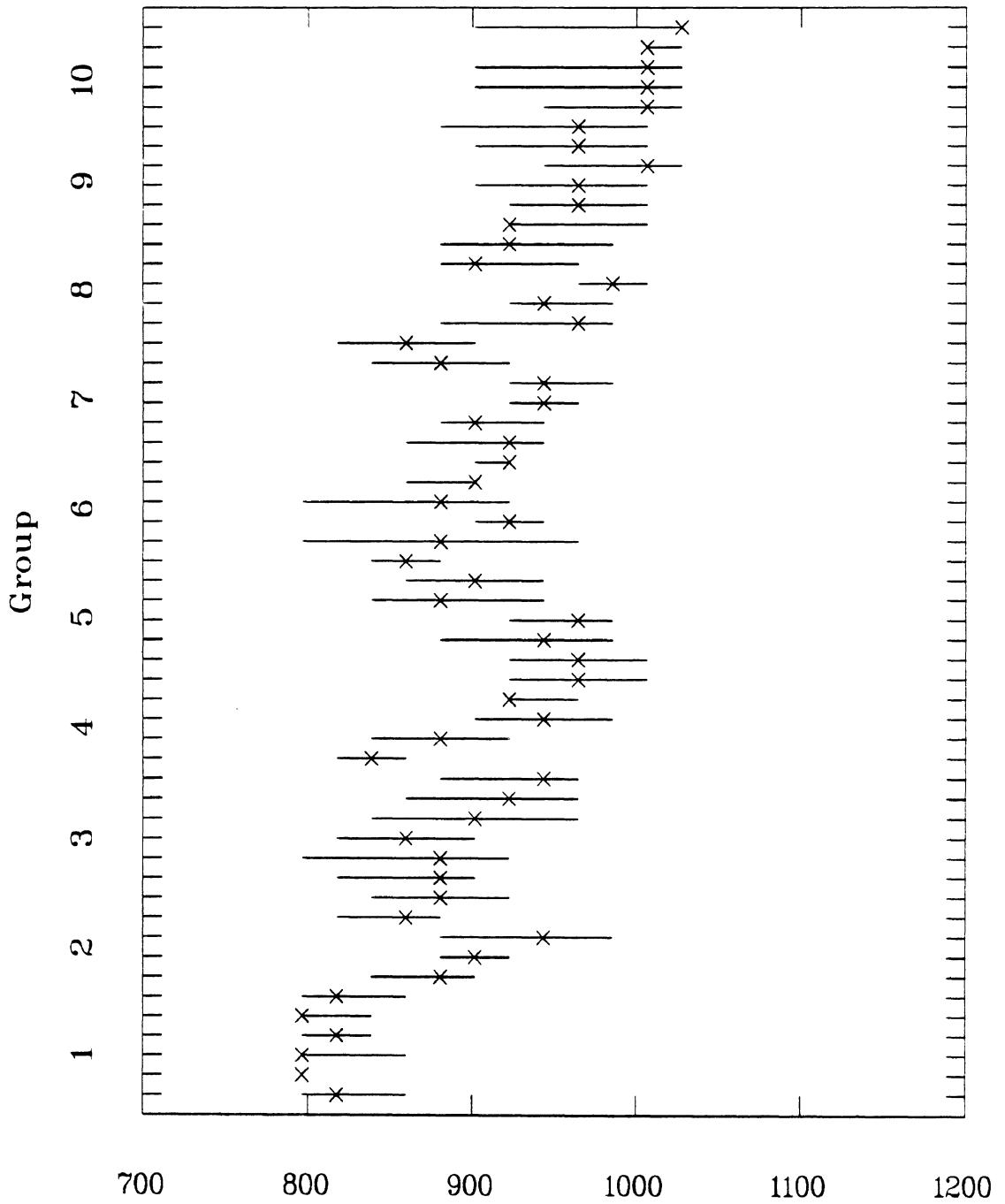


FIGURE F.28

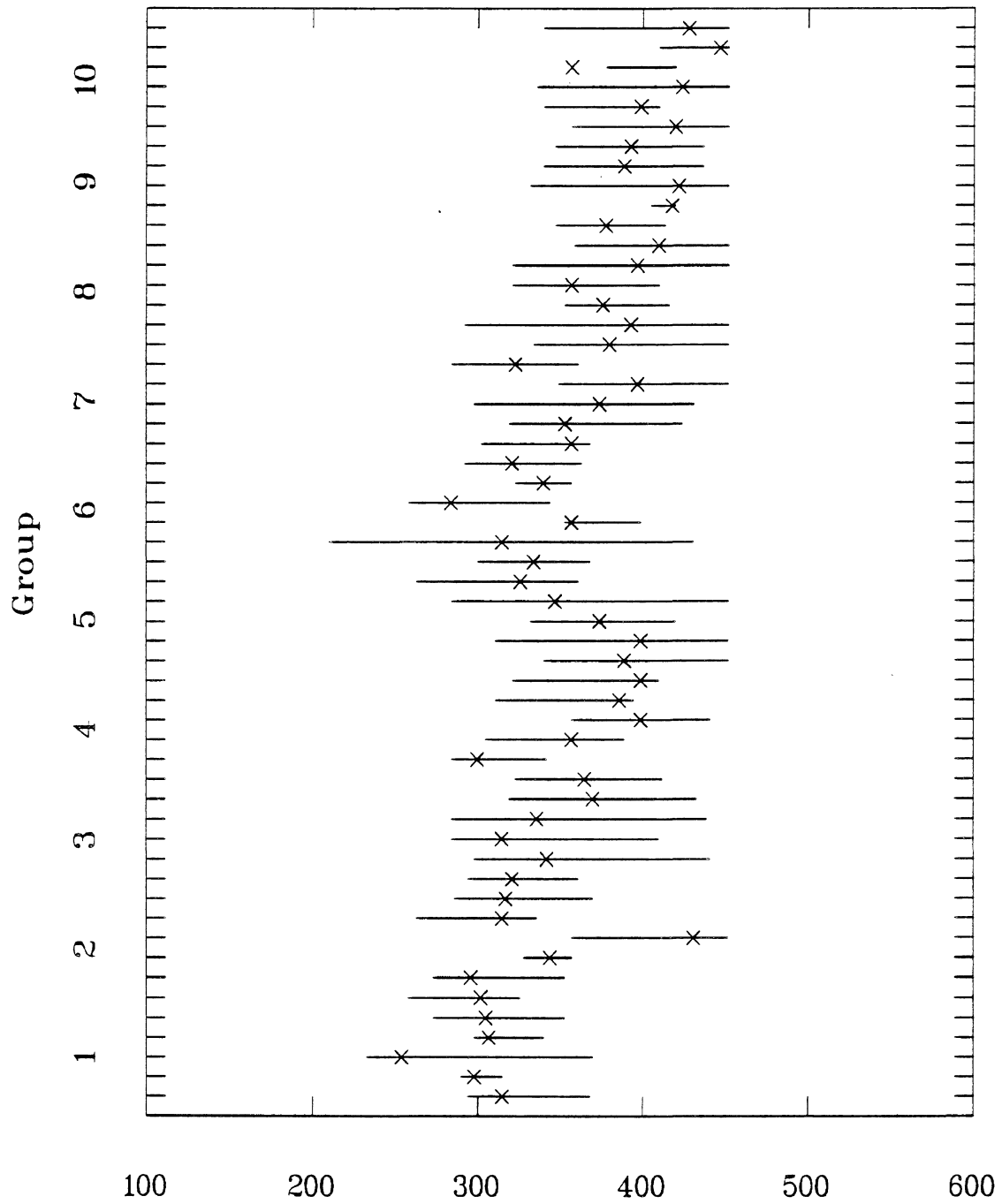
APPENDIX G

PHASE I: PREFERRED WHEEL POSITION RESULTS



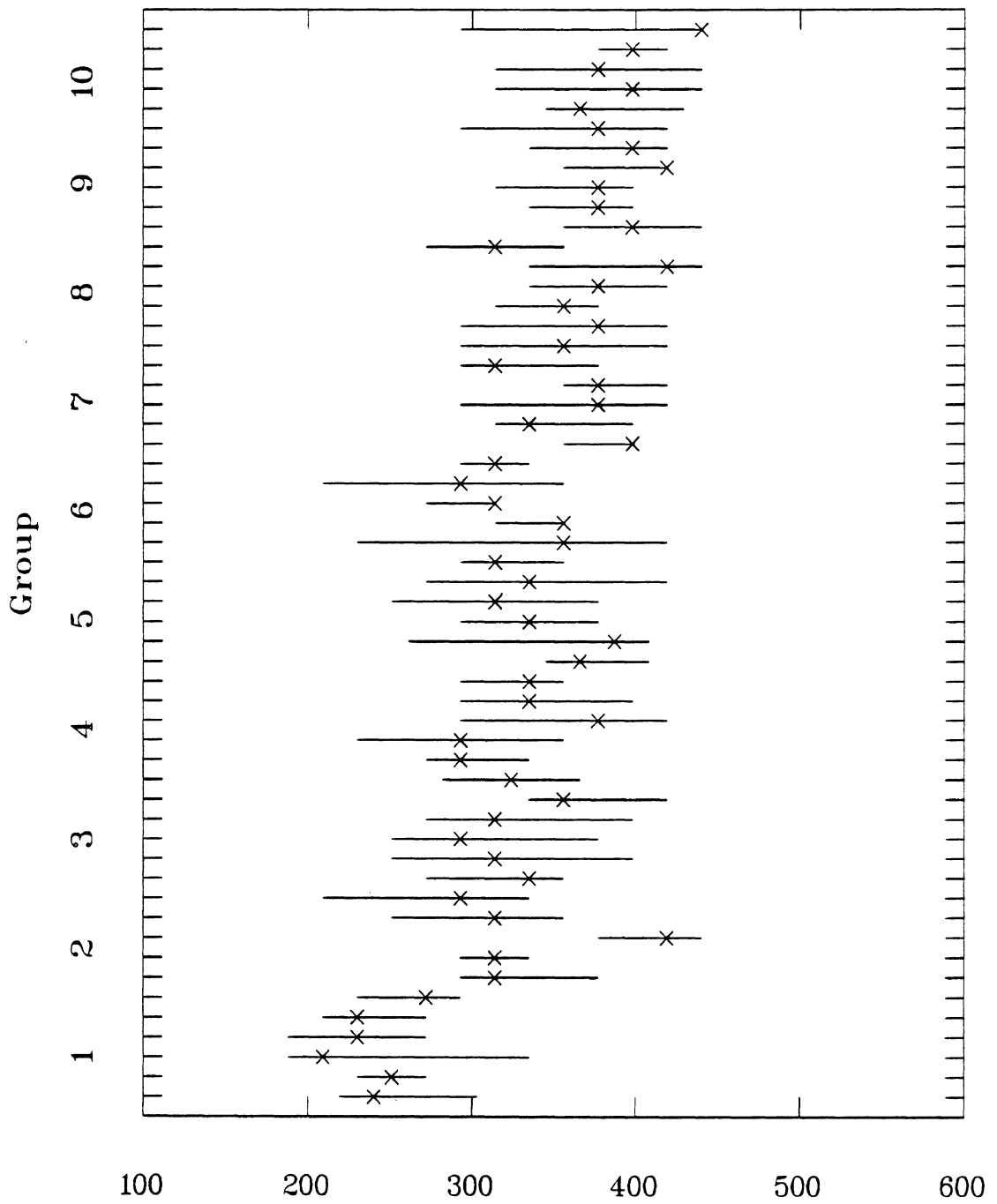
Blazer Hpt to BOF (mm),
 Preferred +/- Acceptable Limits

FIGURE G.1



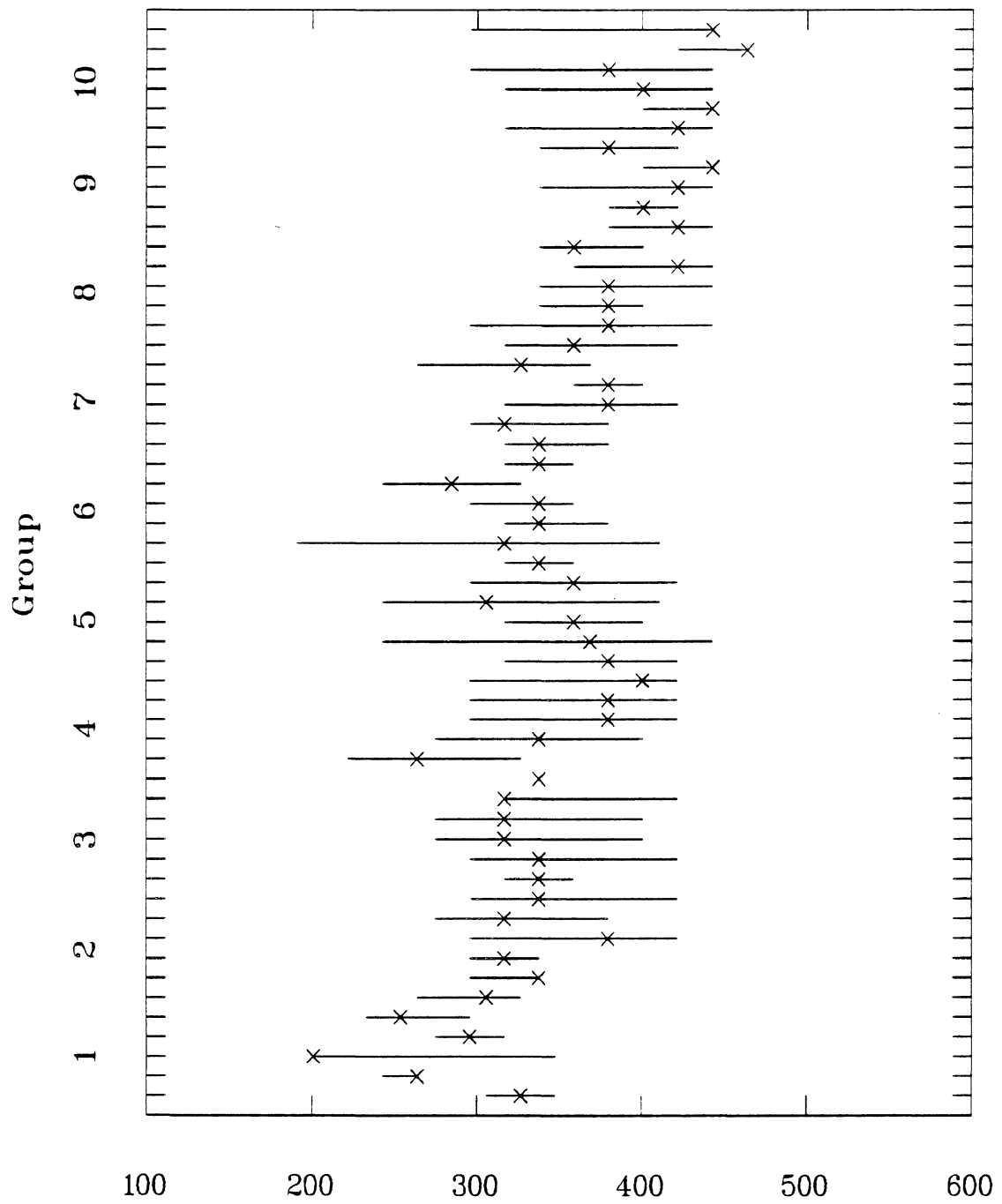
Cadillac Hpt to WCtr (mm),
Preferred +/- Acceptable Limits

FIGURE G.2



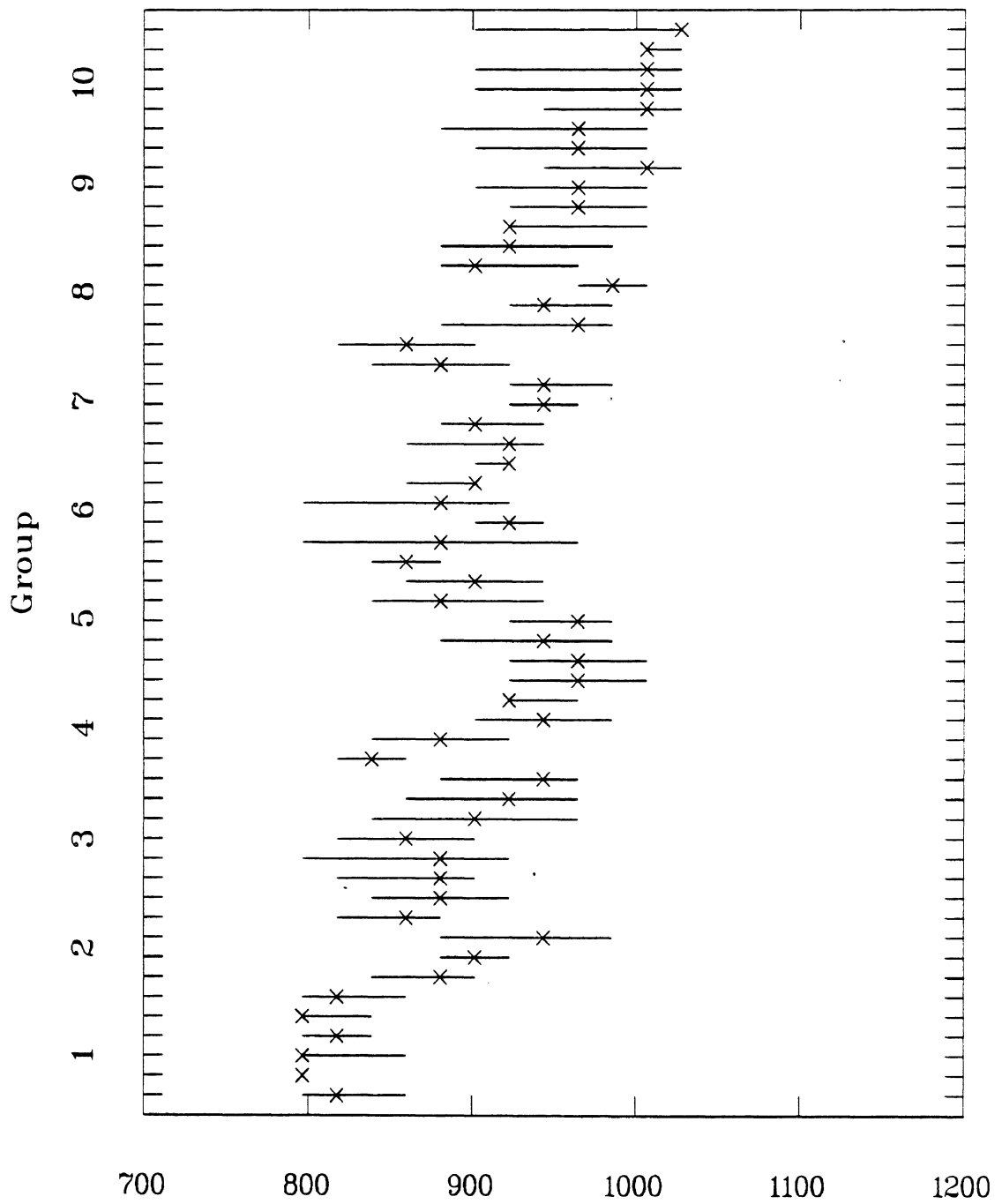
Camaro Hpt to WCtr (mm),
 Preferred +/- Acceptable Limits

FIGURE G.3



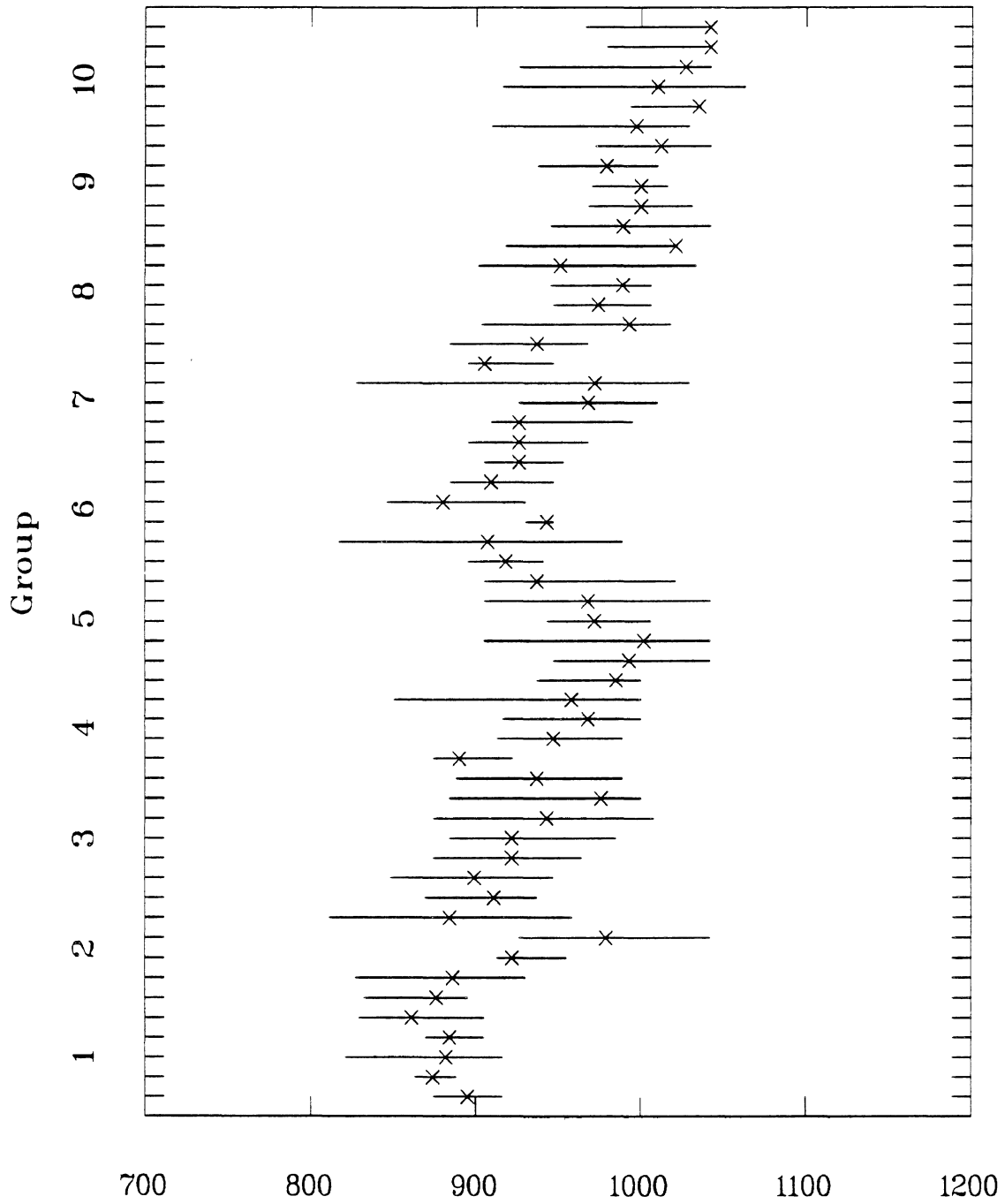
Monte Carlo Hpt to Wctr (mm),
Preferred +/- Acceptable Limits

FIGURE G.4



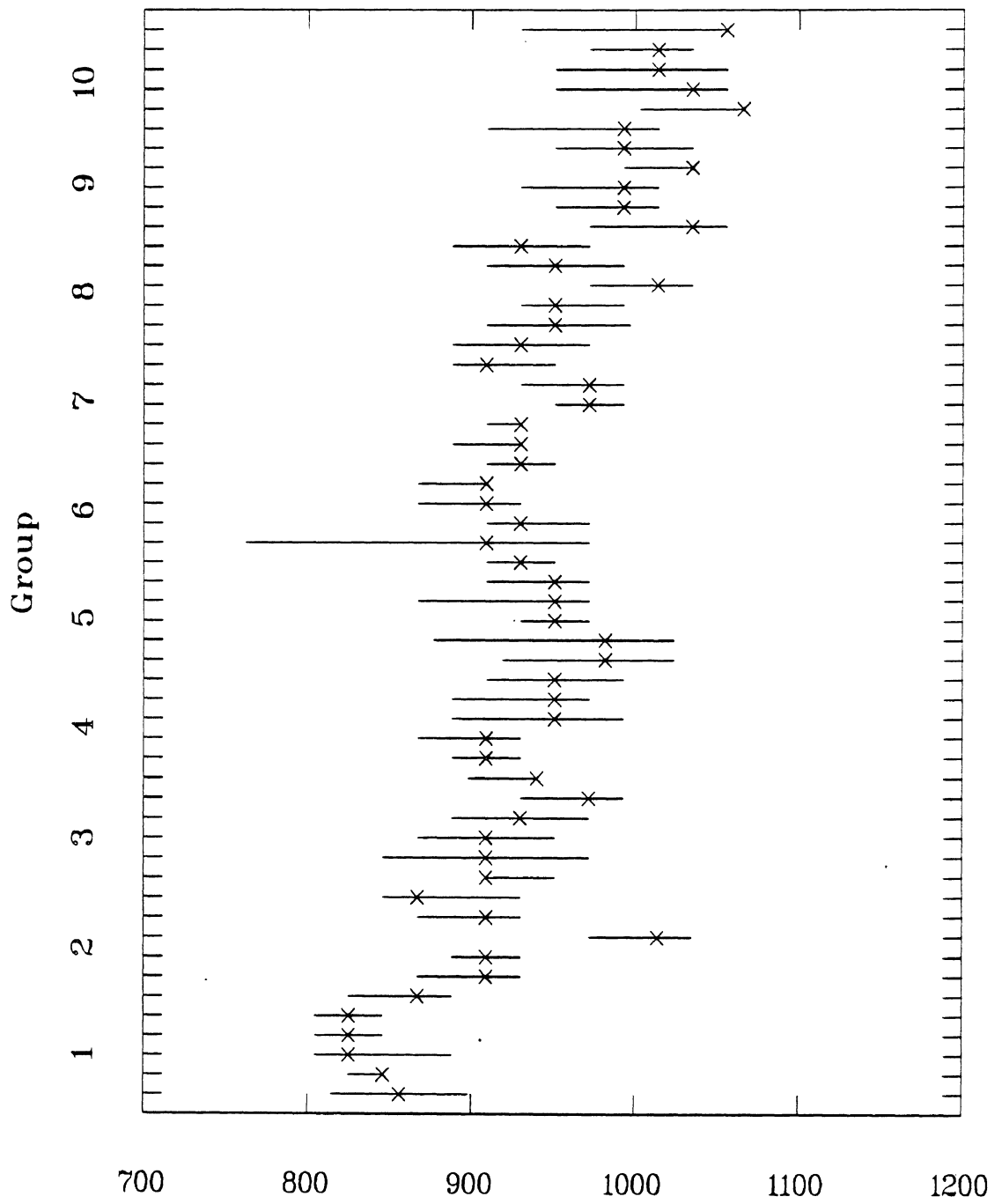
Blazer Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE G.5



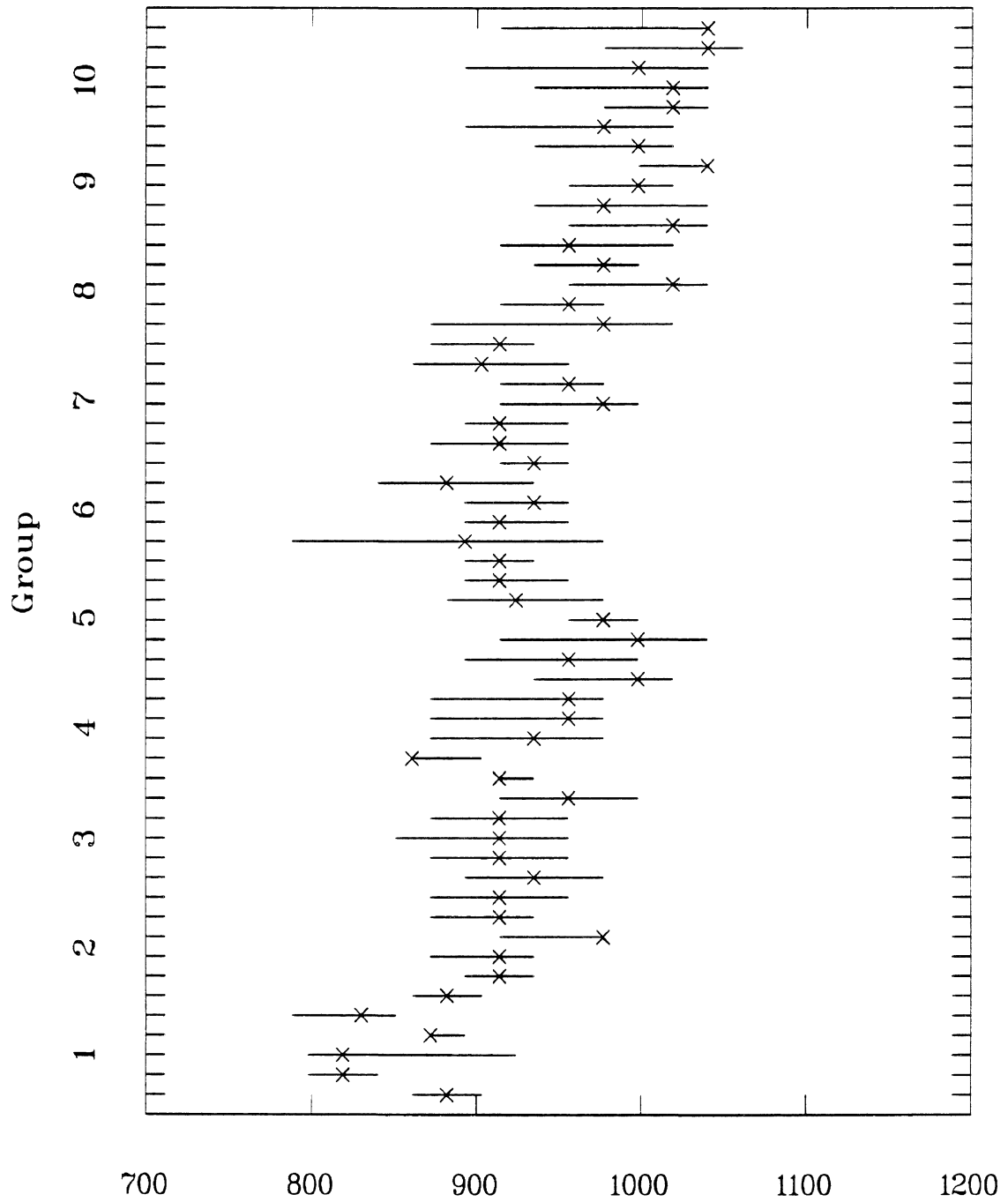
Cadillac Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE G.6



Camaro Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE G.7



Monte Carlo Hpt to BOF (mm),
Preferred +/- Acceptable Limits

FIGURE G.8

Blazer-Number of Subjects
Accommodated vs. Hpt-to-BOF Distance

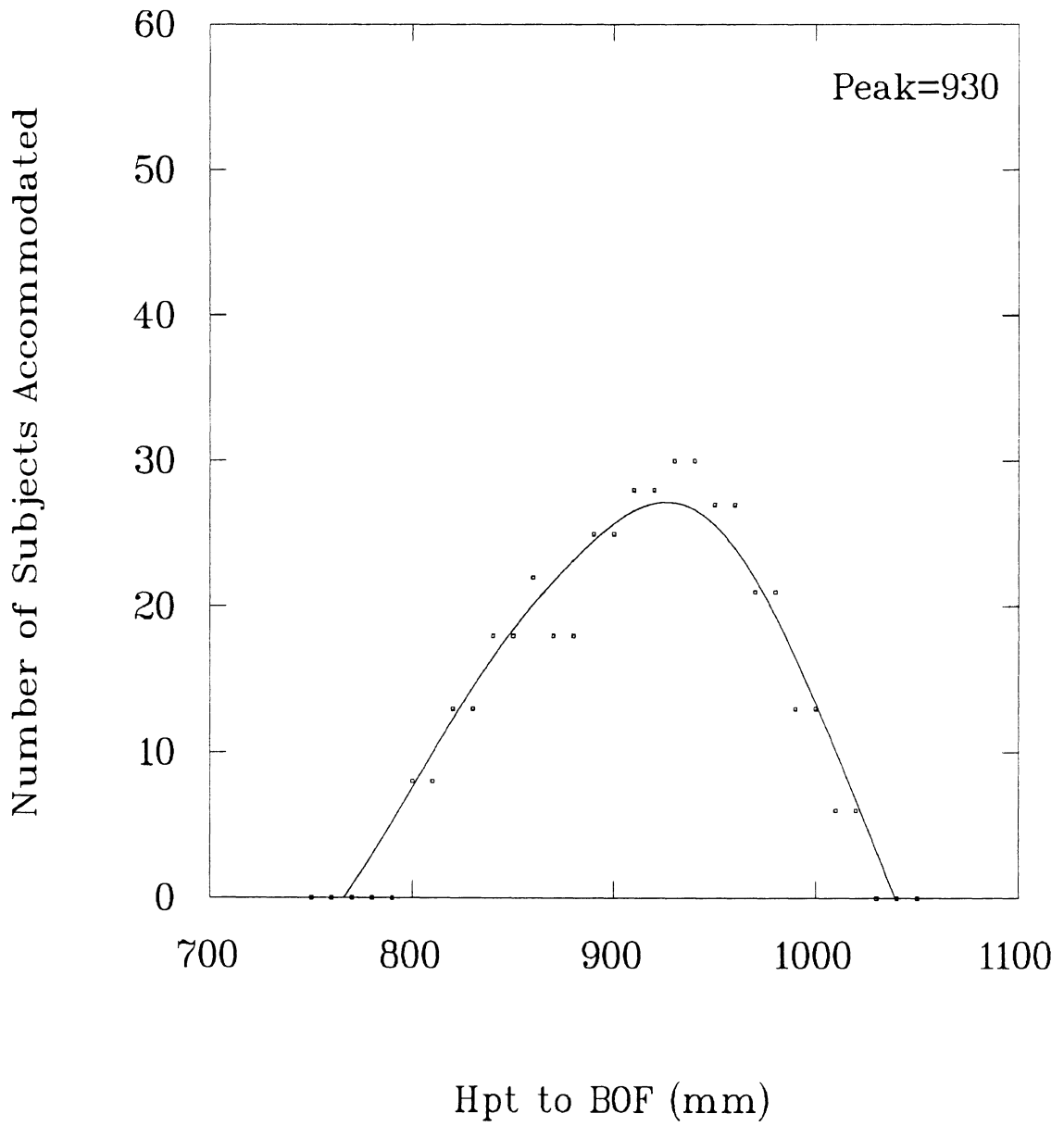


FIGURE G.9

Cadillac—Number of Subjects
Accommodated vs. Hpt-to-BOF Distance

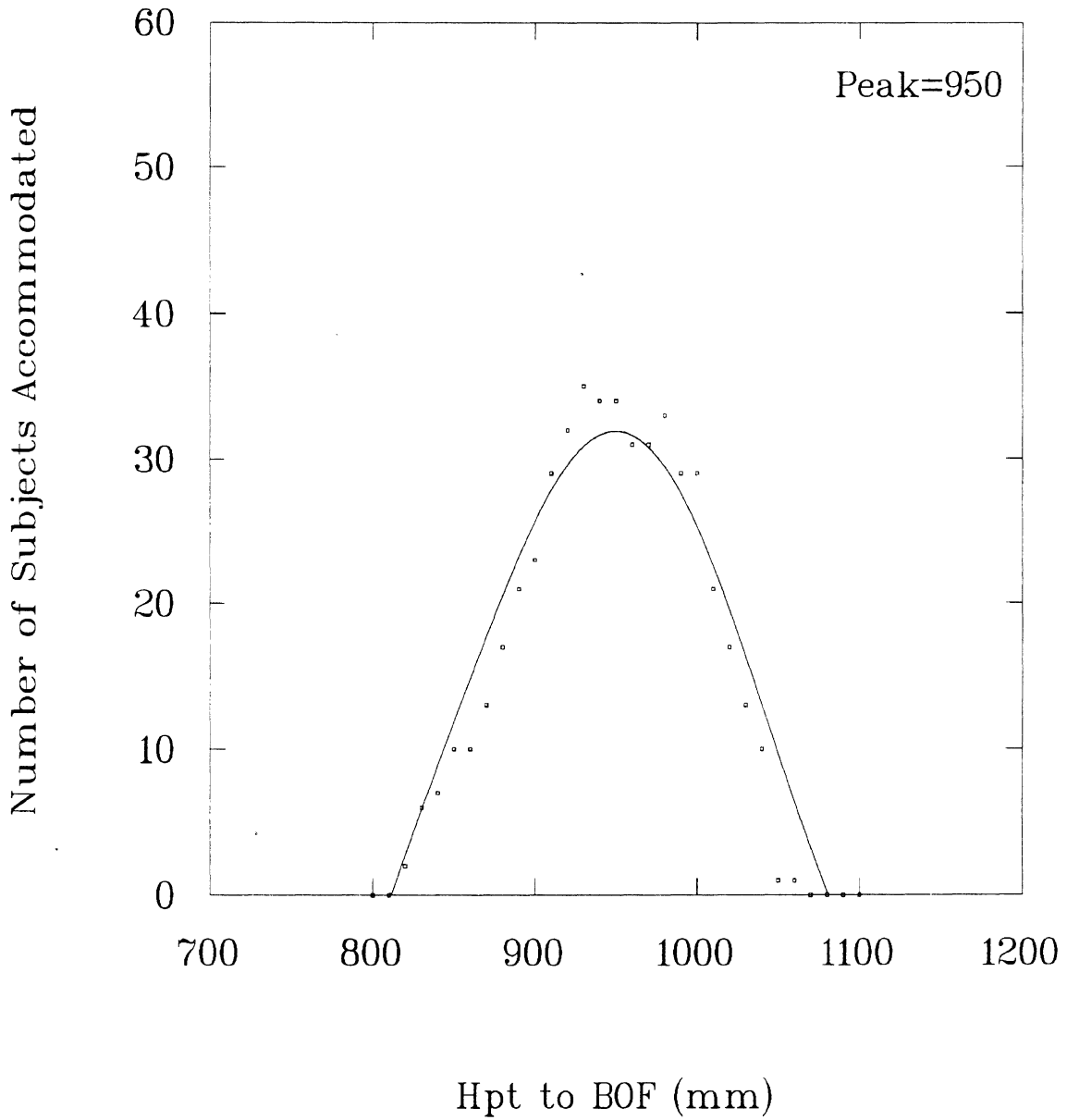


FIGURE G.10

Camaro-Number of Subjects
Accommodated vs. Hpt-to-BOF Distance

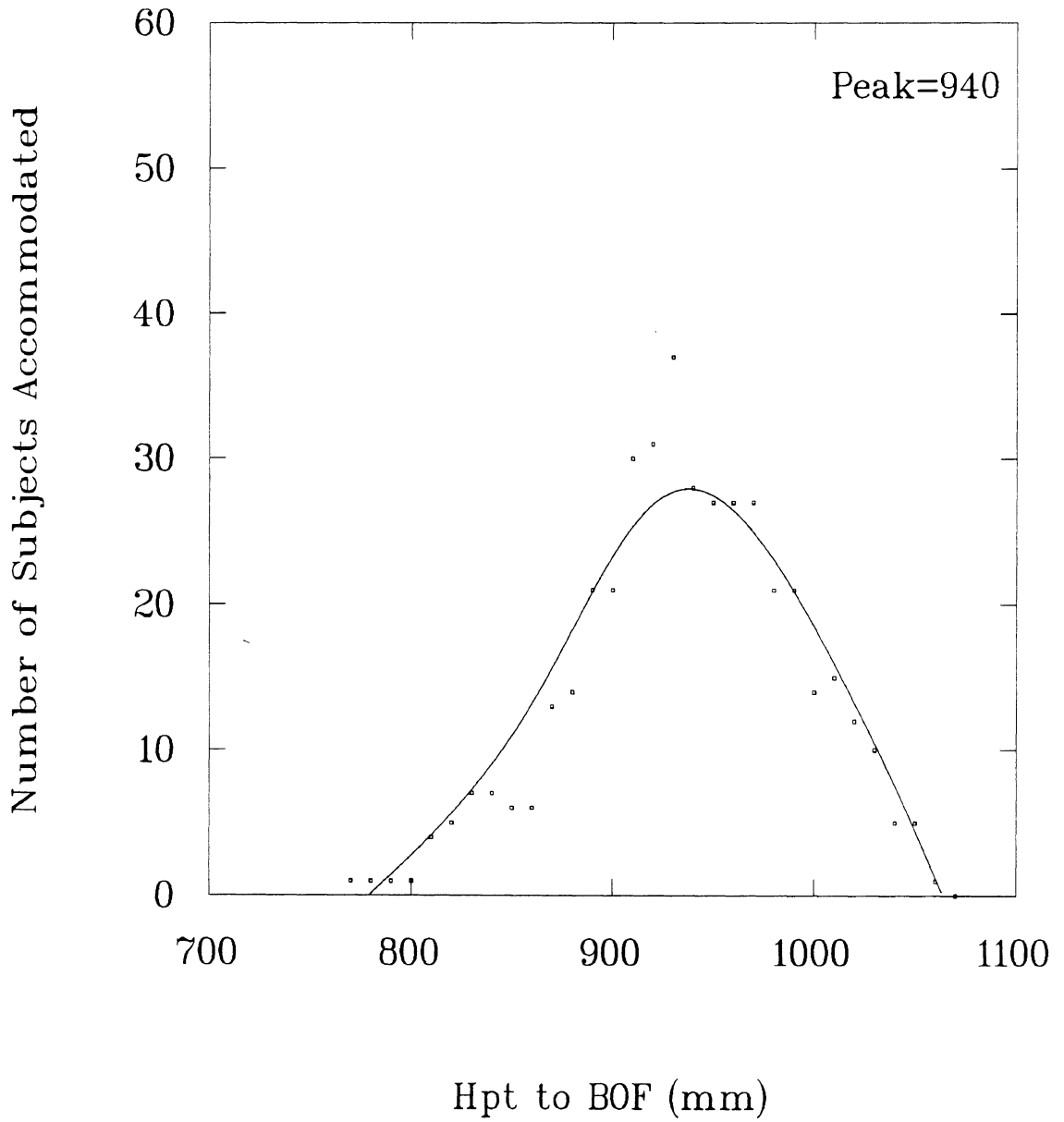


FIGURE G.11

Monte Carlo-Number of Subjects
Accommodated vs. Hpt-to-BOF Distance

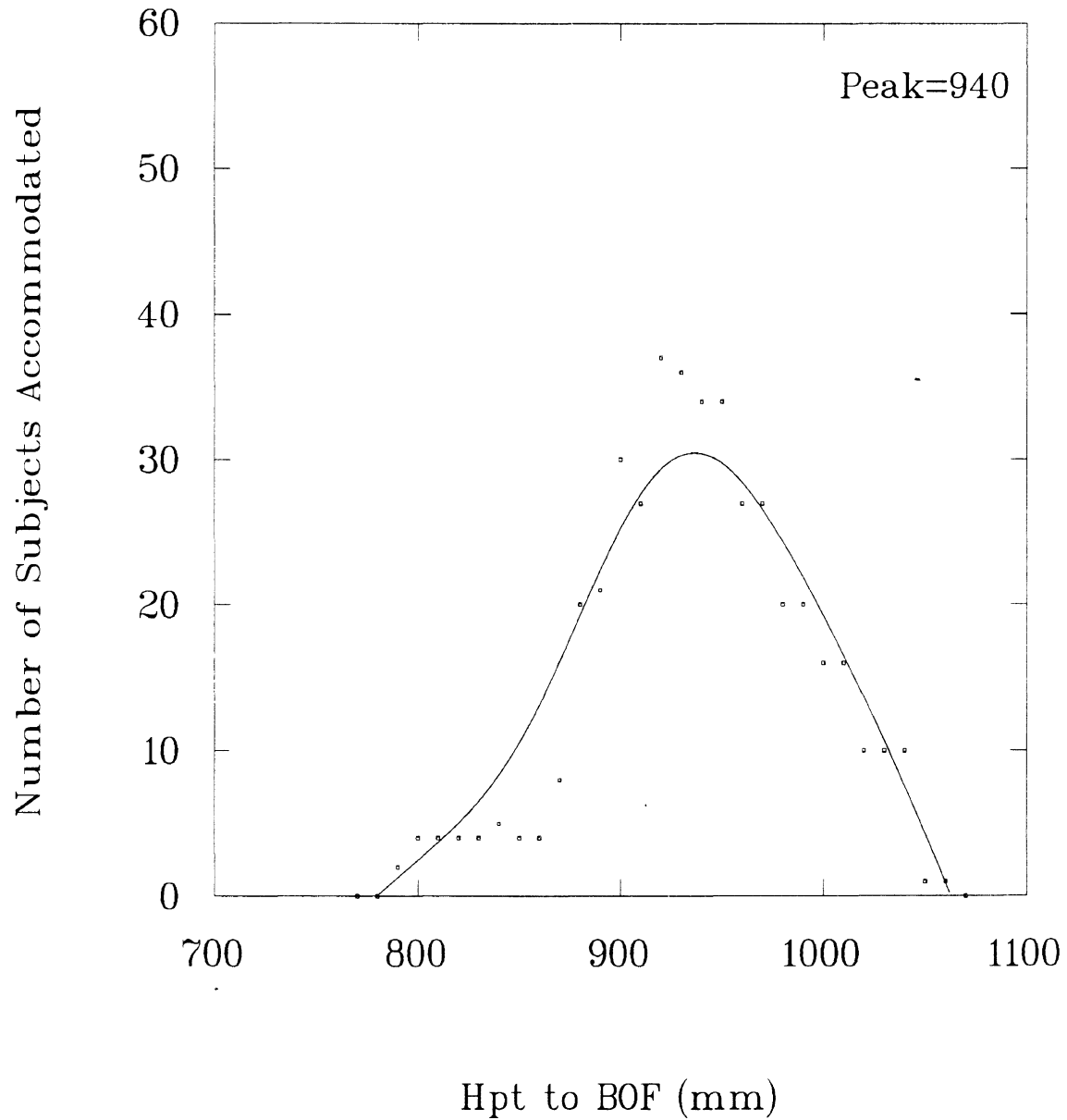


FIGURE G.12

Blazer-Number of Subjects
Accommodated vs. Hpt-to-WCtr Distance

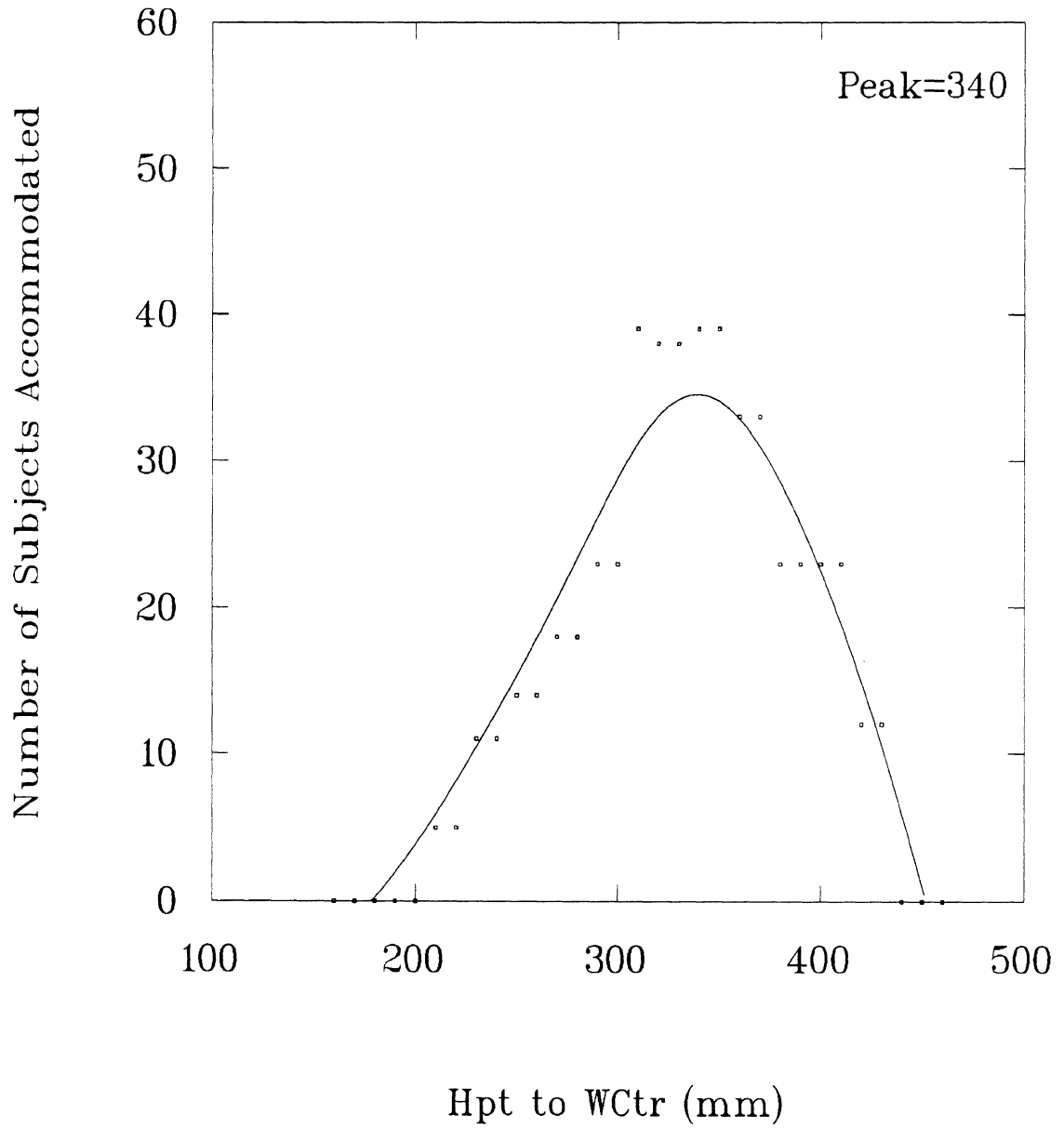


FIGURE G.13

Cadillac-Number of Subjects
Accommodated vs. Hpt-to-WCtr Distance

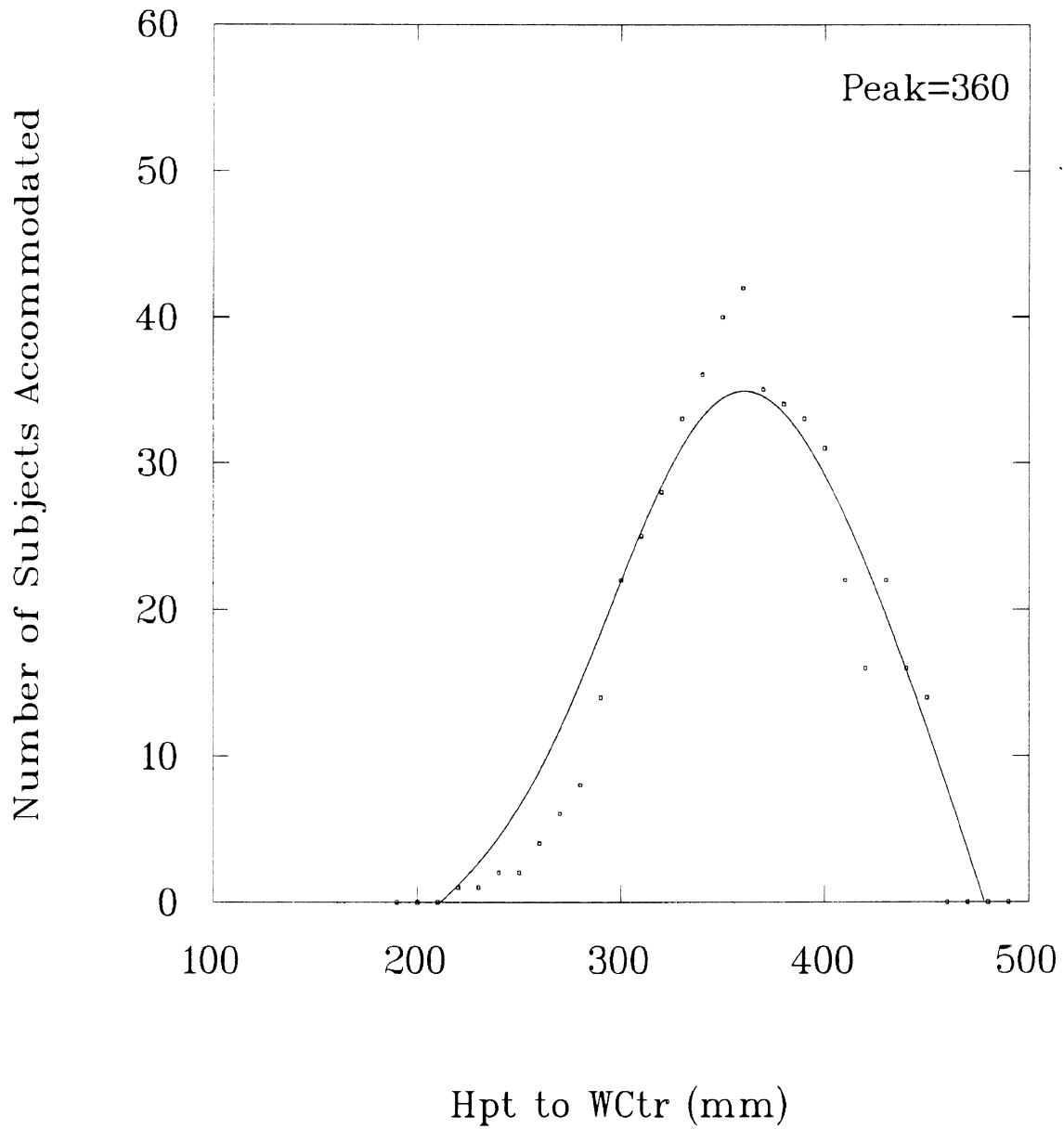


FIGURE G.14

Camaro-Number of Subjects
Accommodated vs. Hpt-to-WCtr Distance

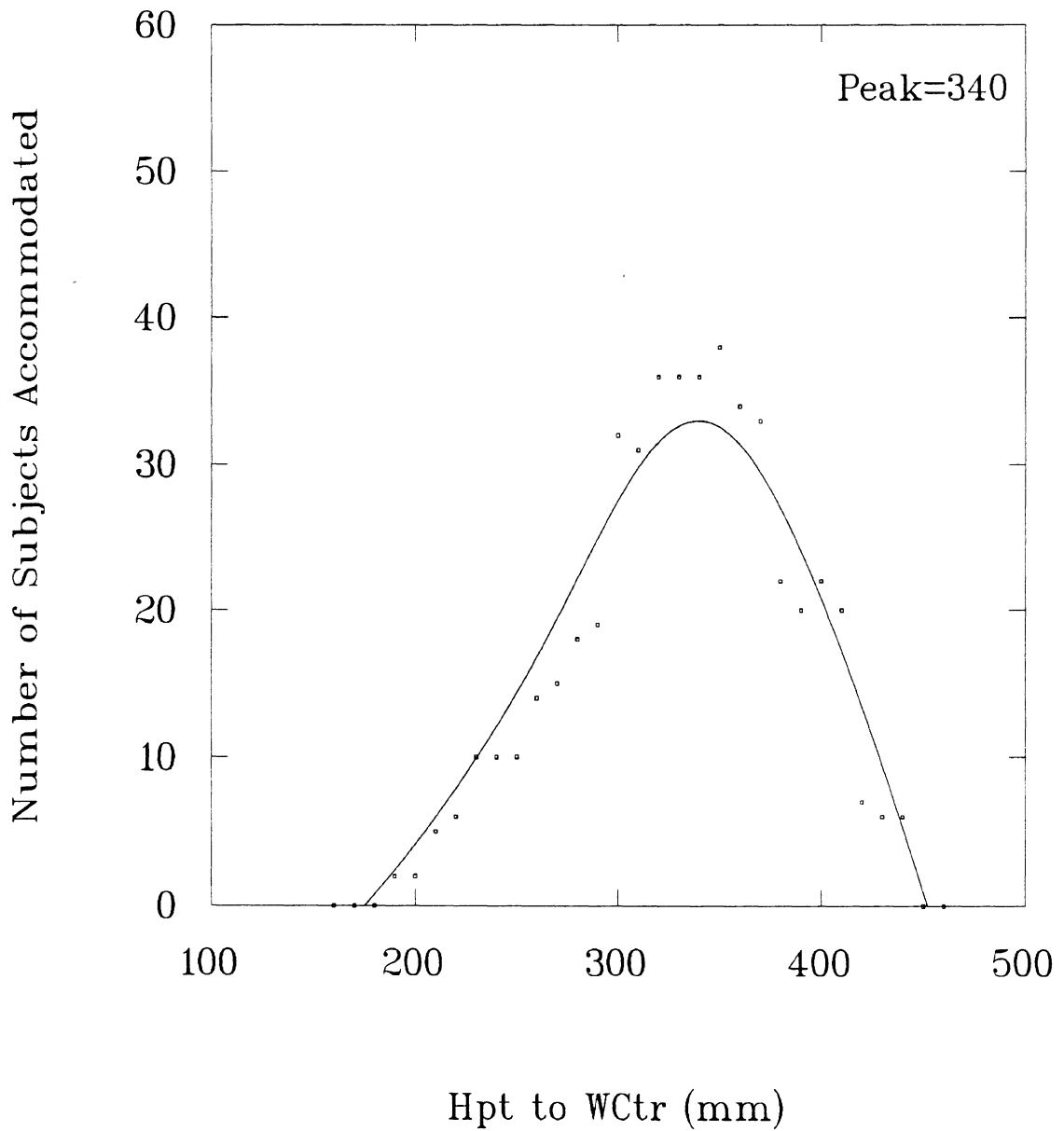


FIGURE G.15

Monte Carlo-Number of Subjects
Accommodated vs. Hpt-to-WCtr Distance

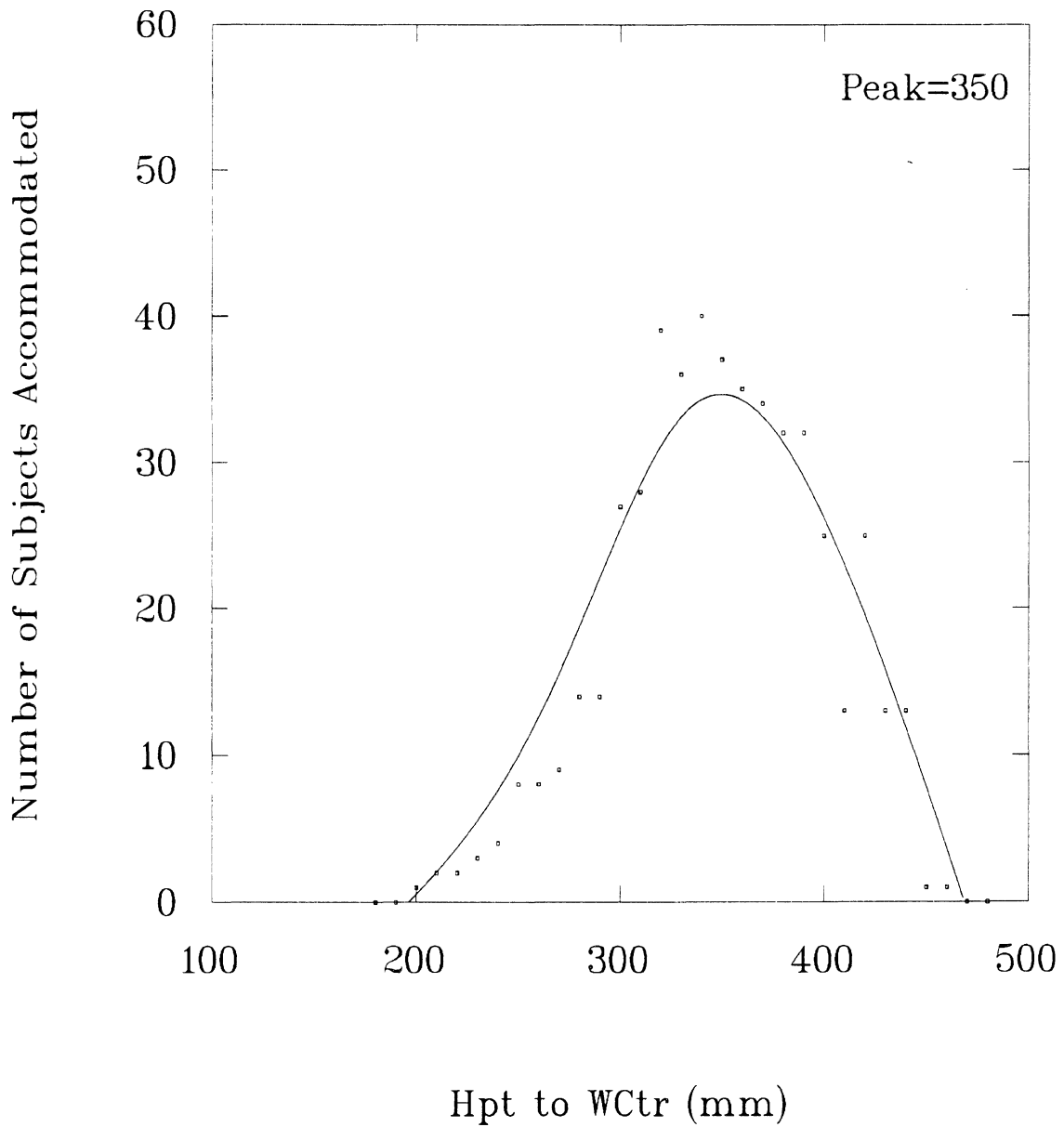


FIGURE G.16

Blazer-Calculated Preferred
WCtr-to-BOF Distance vs. Stature

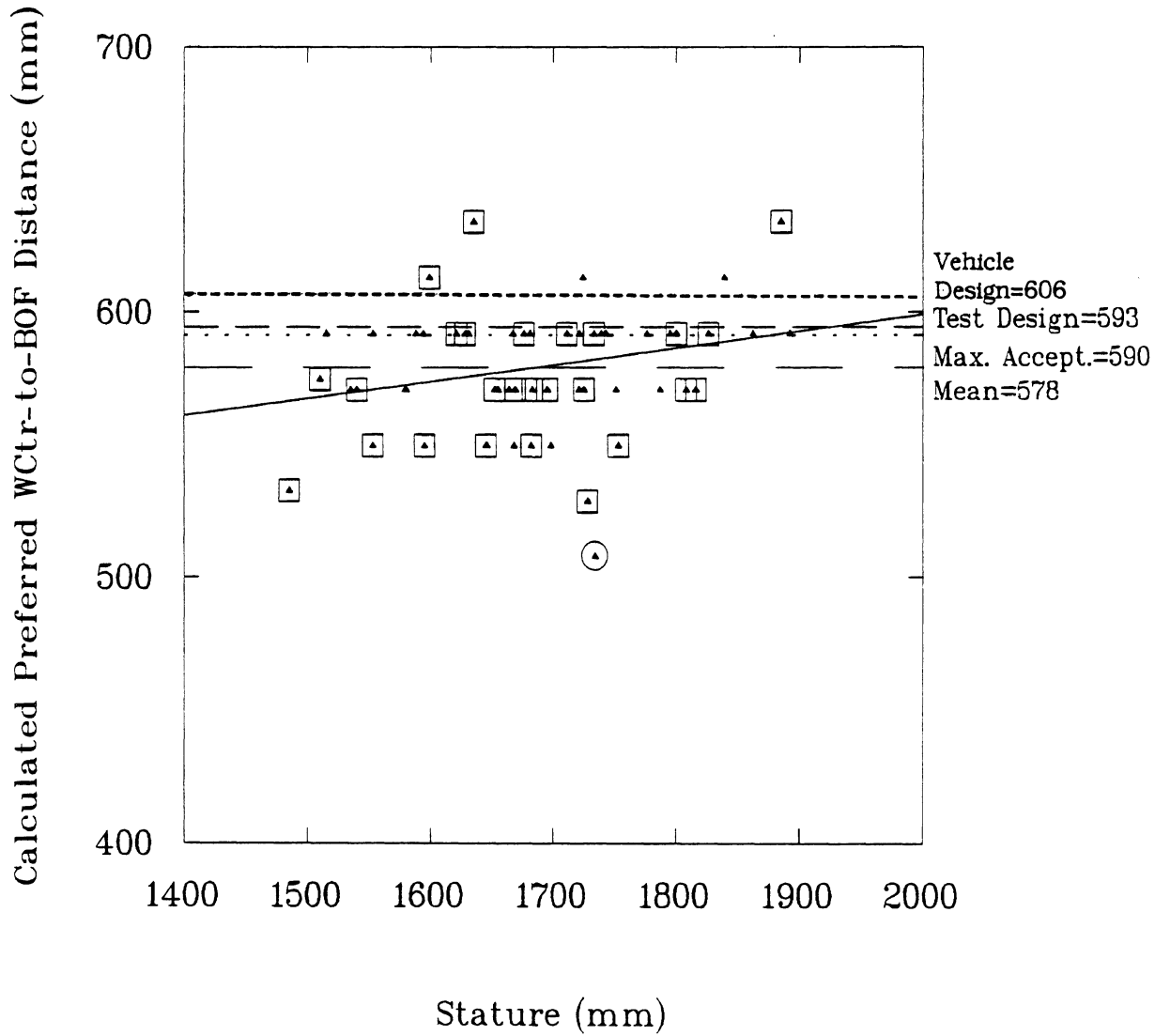


FIGURE G.17

Cadillac-Calculated Preferred
WCtr-to-BOF Distance vs. Stature

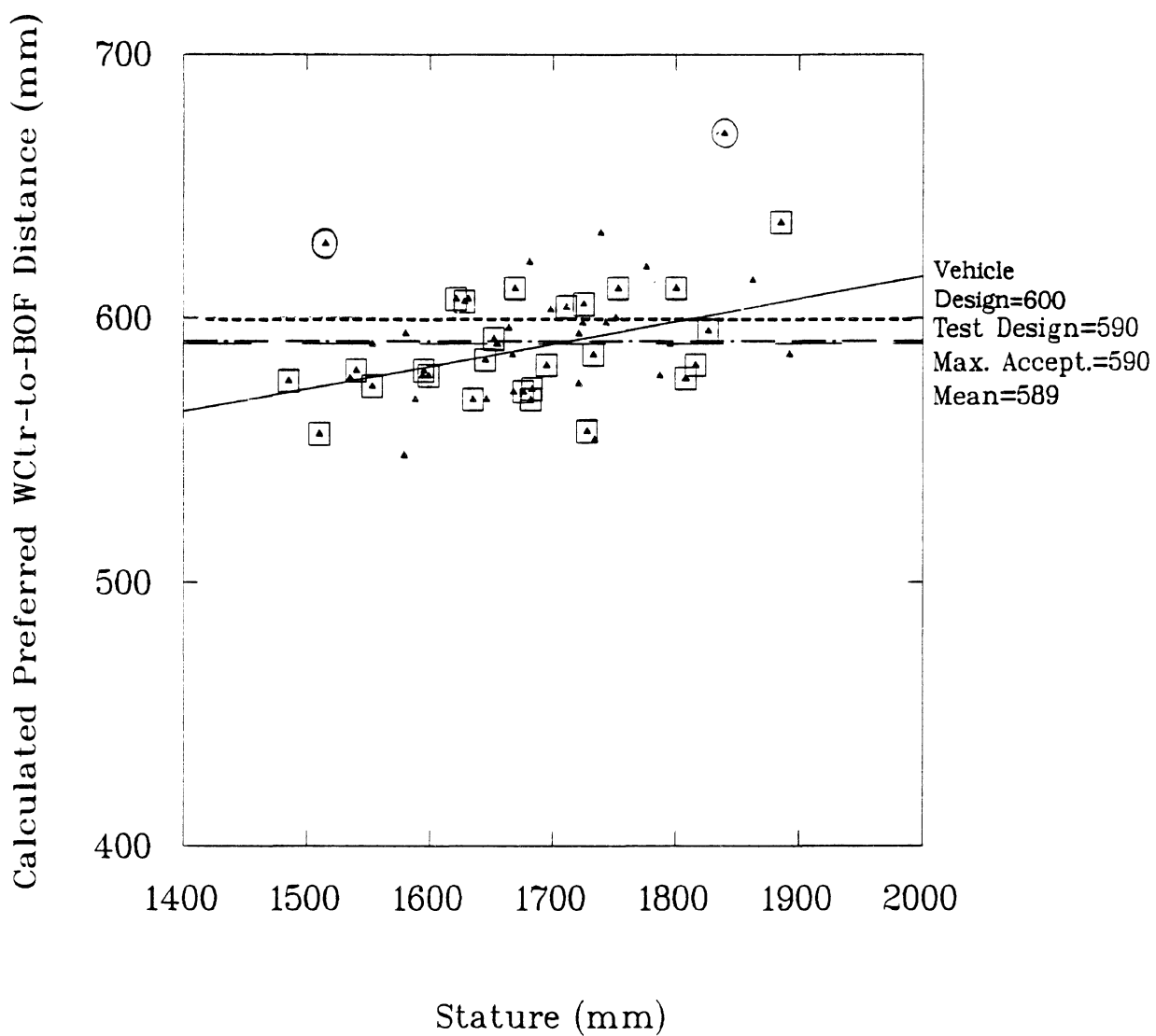


FIGURE G.18

Camaro-Calculated Preferred WCtr-to-BOF Distance vs. Stature

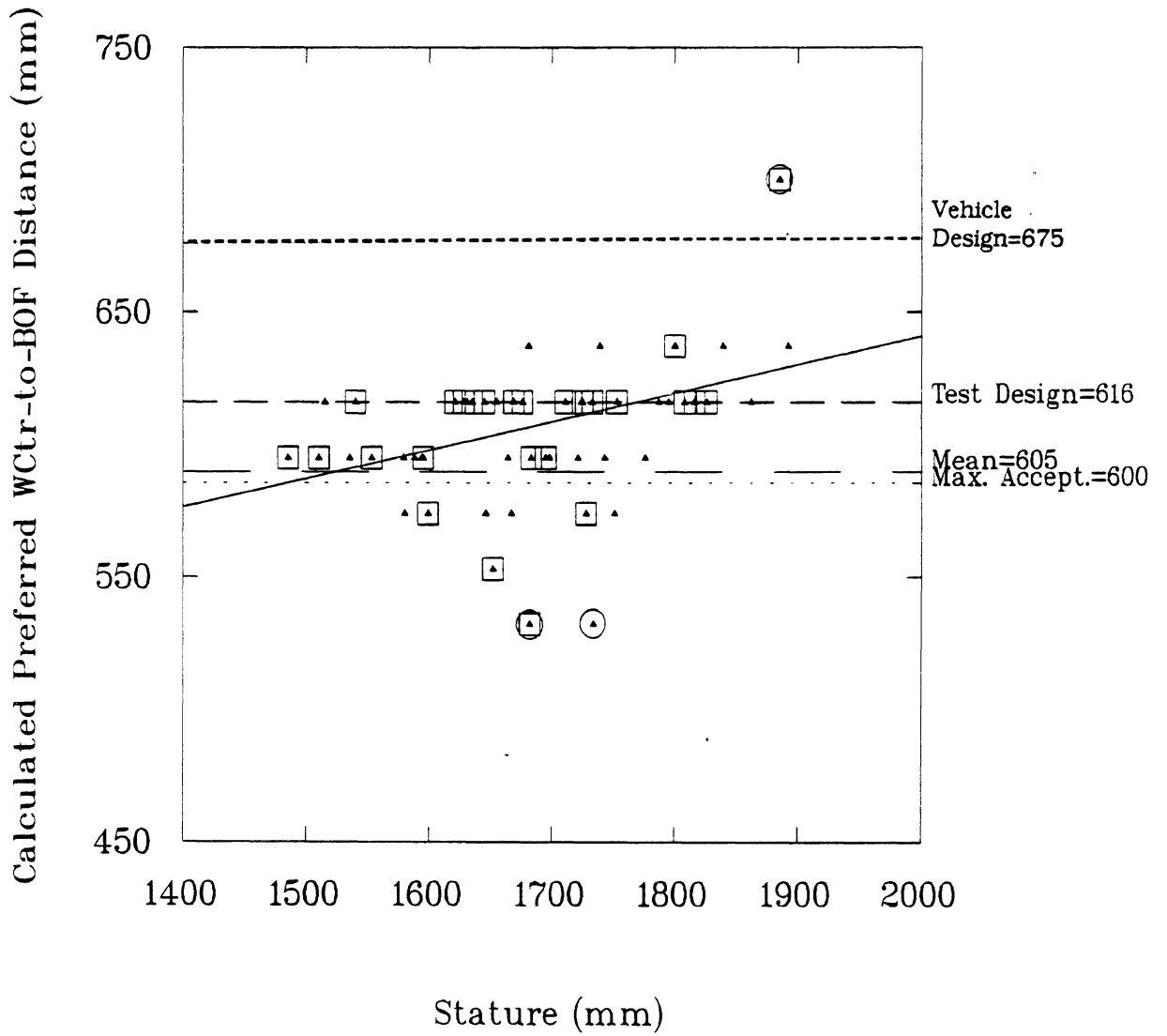


FIGURE G.19

Monte Carlo-Calculated Preferred
WCtr-to-BOF Distance vs. Stature

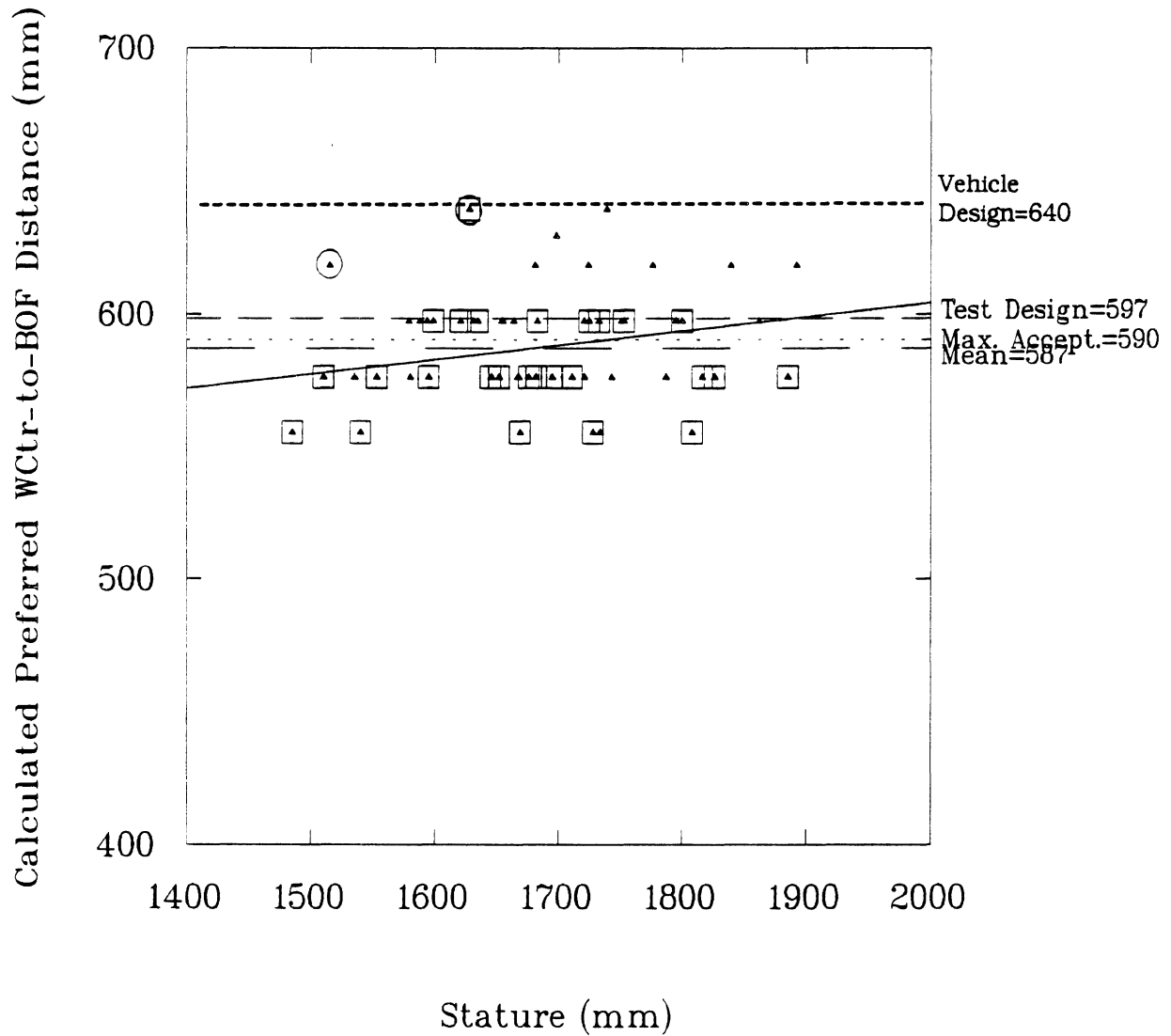


FIGURE G.20

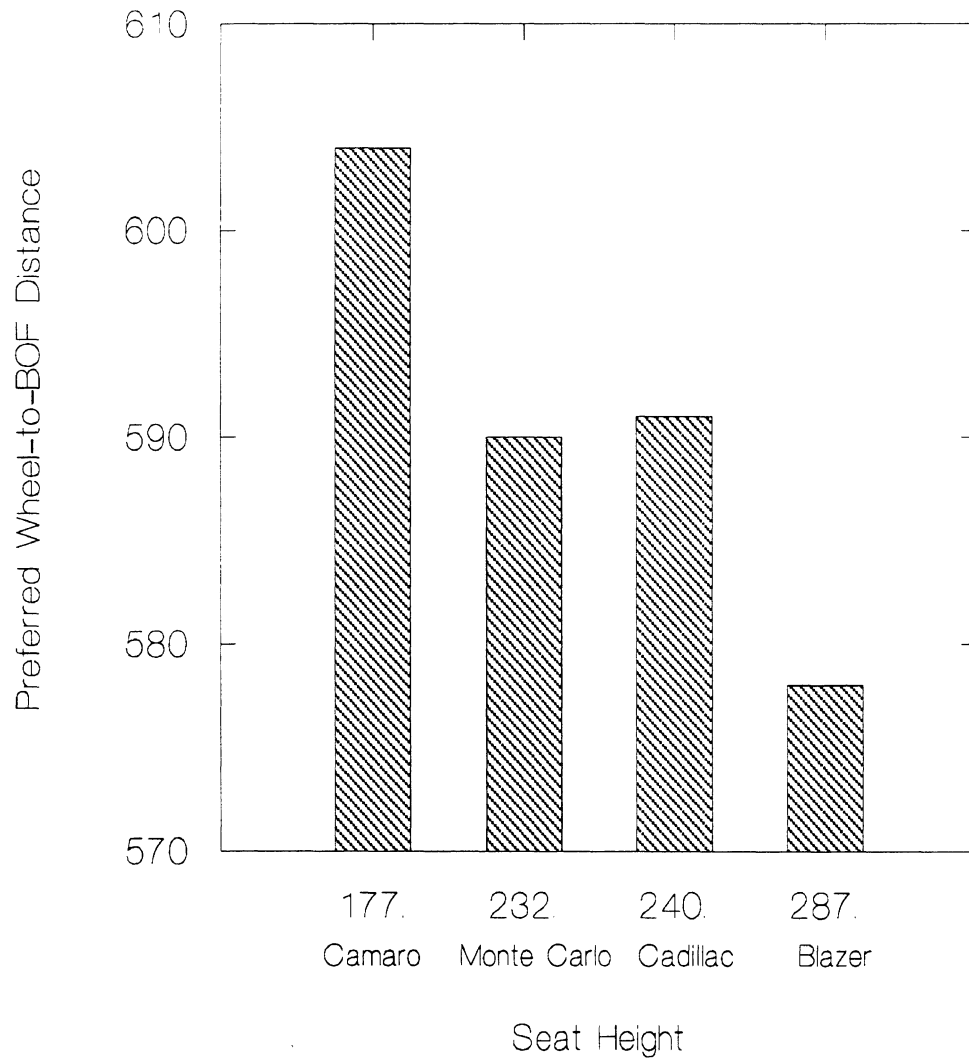


FIGURE G.21

APPENDIX H
PHASE I EYE POSITION RESULTS

TABLE H.1

PHASE I: EYELLIPSE DATA SUMMARY

Eyellipse Parameters	Blazer			Cadillac			Camaro			Monte Carlo		
	Observed	Model	Diff.	Observed	Model	Diff.	Observed	Model	Diff.	Observed	Model	Diff.
EYELLIPSE CENTROID												
X	2362.8	2334	28.8	3138.3	3066.5	71.8	3092.7	3083.8	8.9	3110.4	3082.6	27.8
Y	338.7	365.8	-27.1	357.3	401.2	-43.9	366.3	395	-28.7	358.3	402.1	-43.8
Z	1487.1	1472.3	14.8	1336.9	1325.2	11.7	1256.1	1233.2	22.9	1329.4	1311.5	17.9
XY												
Major Axis	222.0	198.0	24.0	226.1	198.0	28.1	239.1	198.0	41.1	243.0	198.0	45.0
Minor Axis	59.4	105.0	-45.6	68.6	105.0	-36.4	61.0	105.0	-44.0	62.0	105.0	-43.0
XZ												
Major Axis	228.0	198.0	30.0	229.4	198.0	31.4	243.3	198.0	45.0	245.2	198.0	47.2
Minor Axis	84.0	86.0	-2.0	74.6	86.0	-11.4	71.5	86.0	-14.5	86.0	86.0	0

Eye Ellipse for Blazer (Top View)

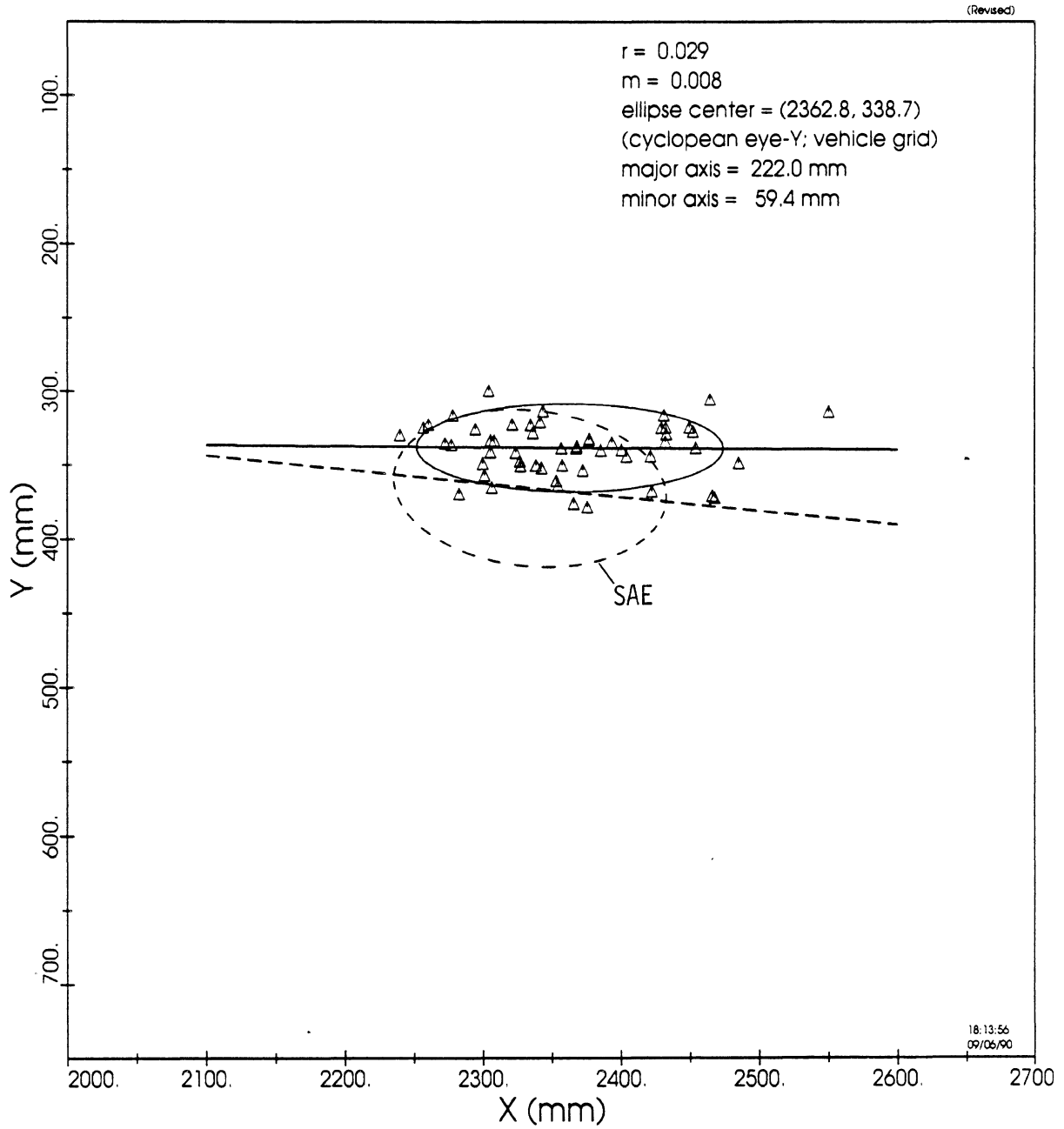


FIGURE H.1

Eye Ellipse for Blazer (Side View)

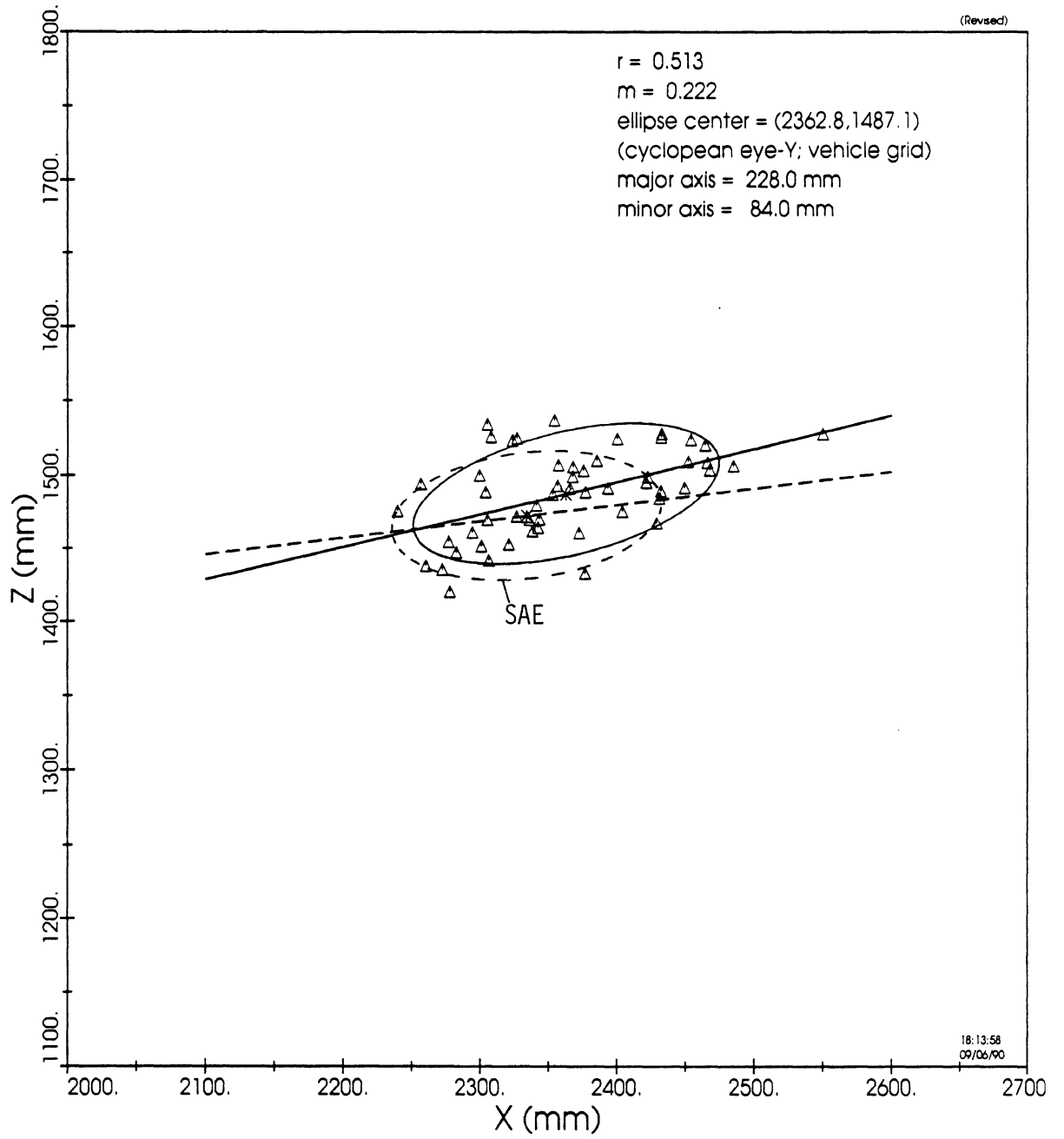


FIGURE H.2

Eye Ellipse for Cadillac (Top View)

(Revised)

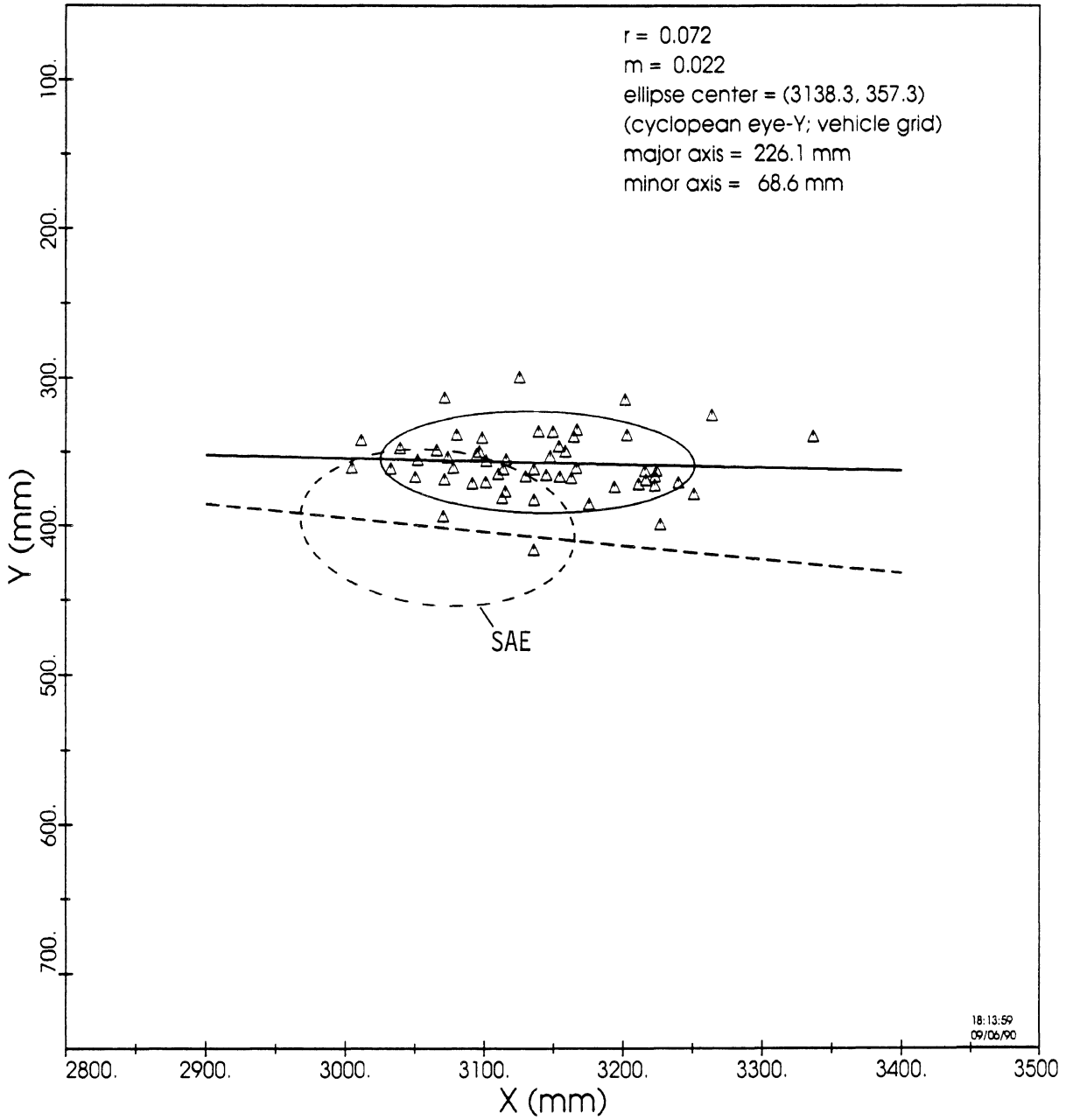


FIGURE H.3

Eye Ellipse for Cadillac (Side View)

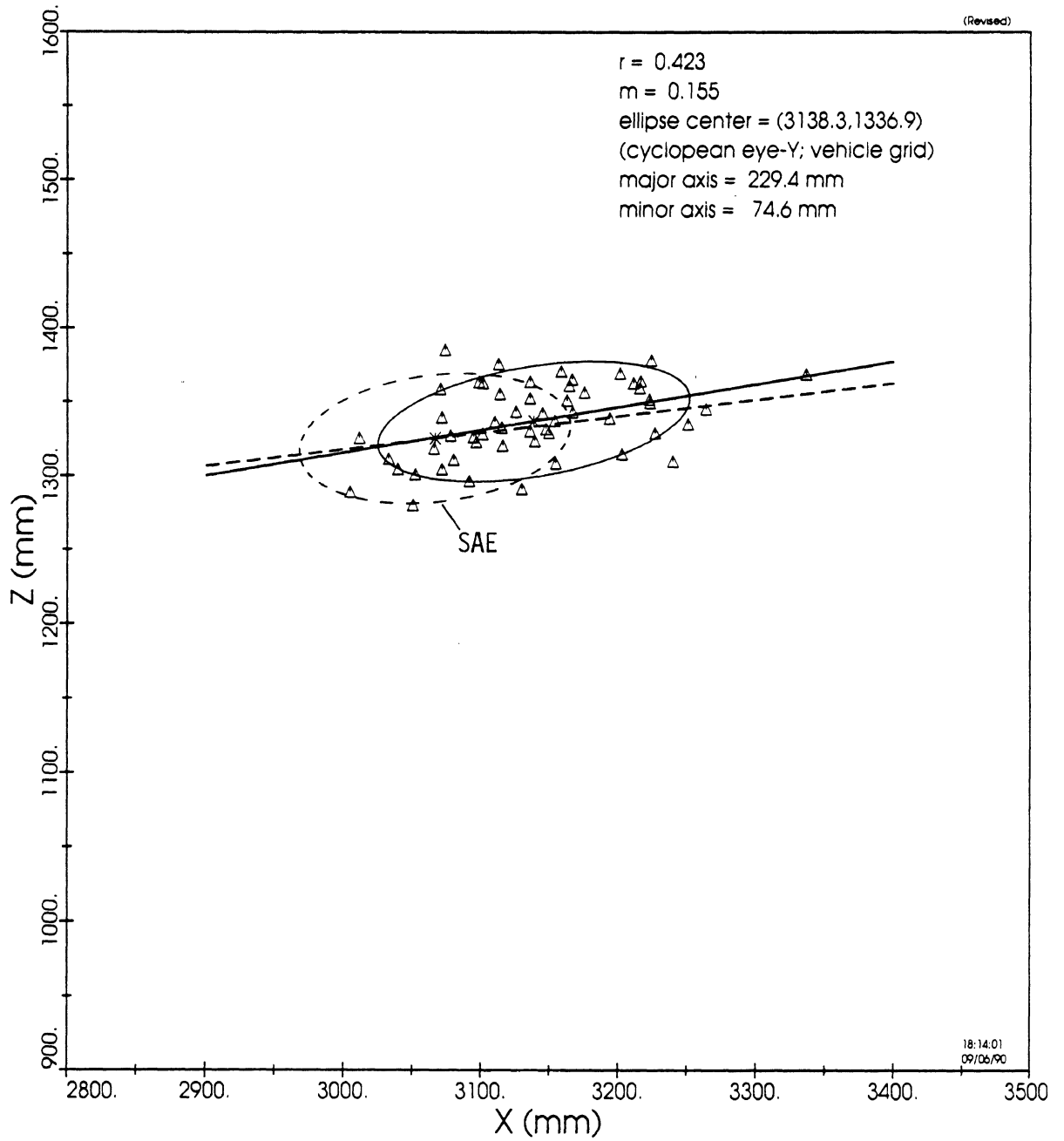


FIGURE H.4

Eye Ellipse for Camaro (Top View)

(Revised)

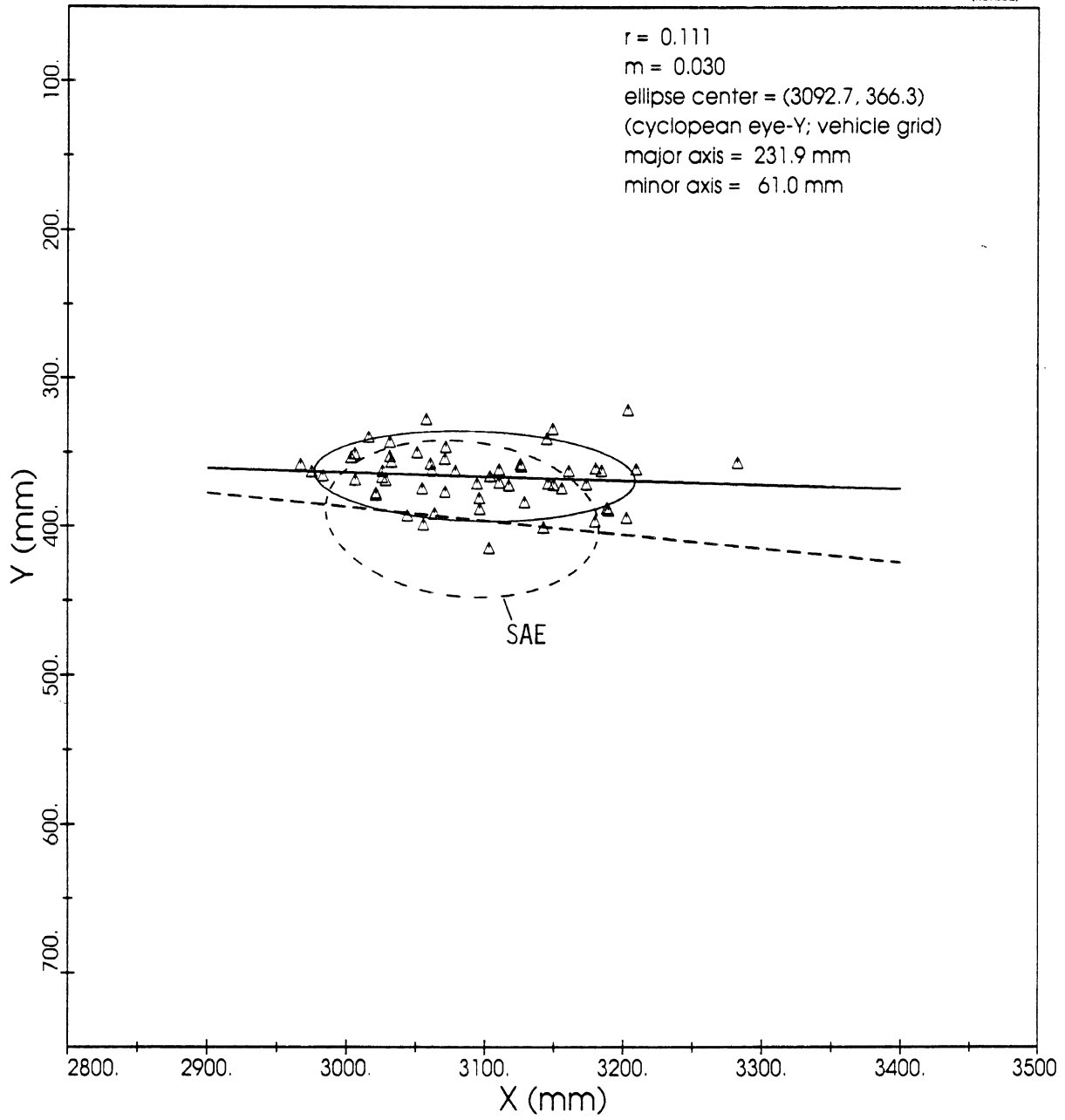


FIGURE H.5

Eye Ellipse for Camaro (Side View)

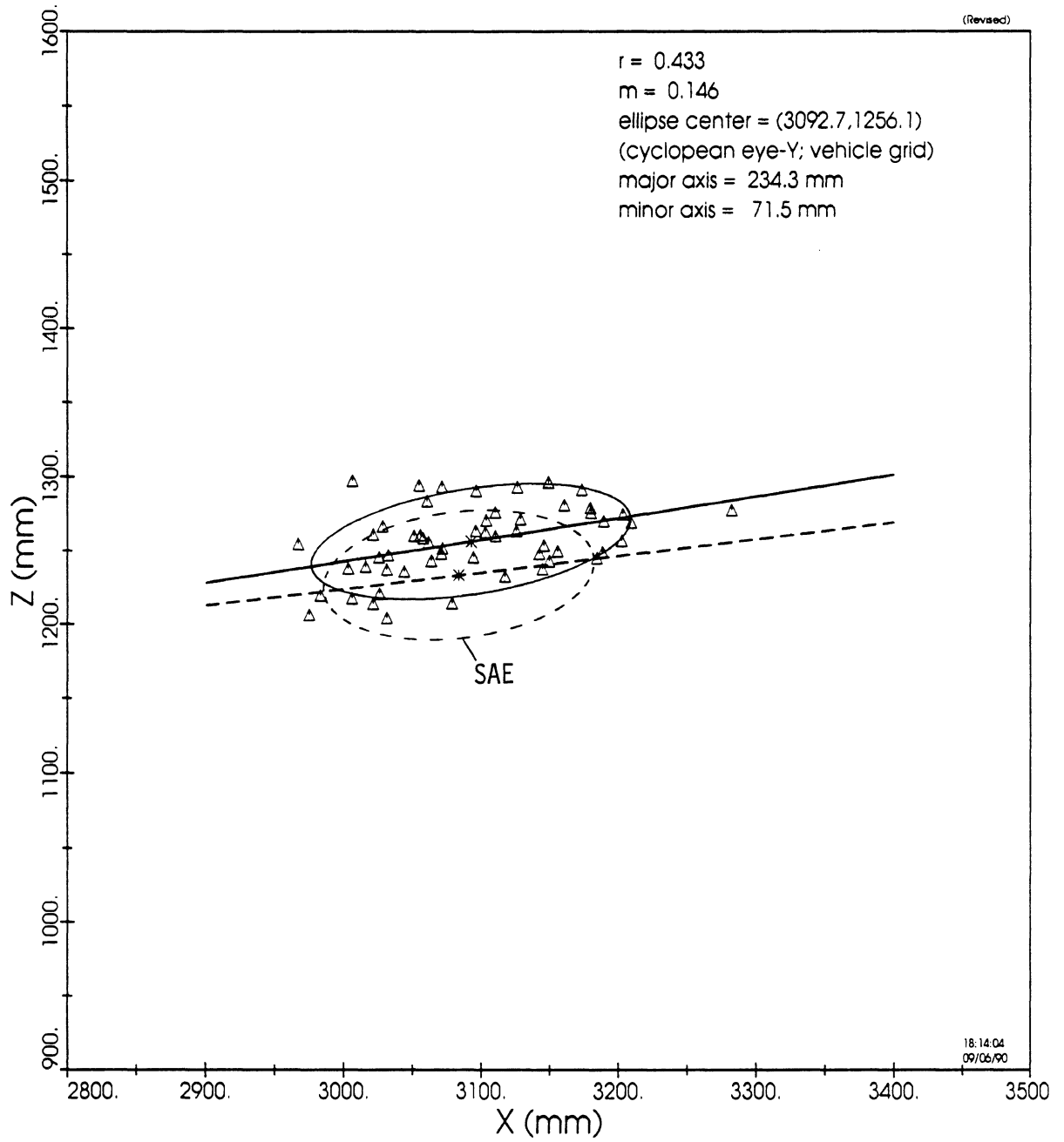


FIGURE H.6

Eye Ellipse for Monte Carlo (Top View)

(Revised)

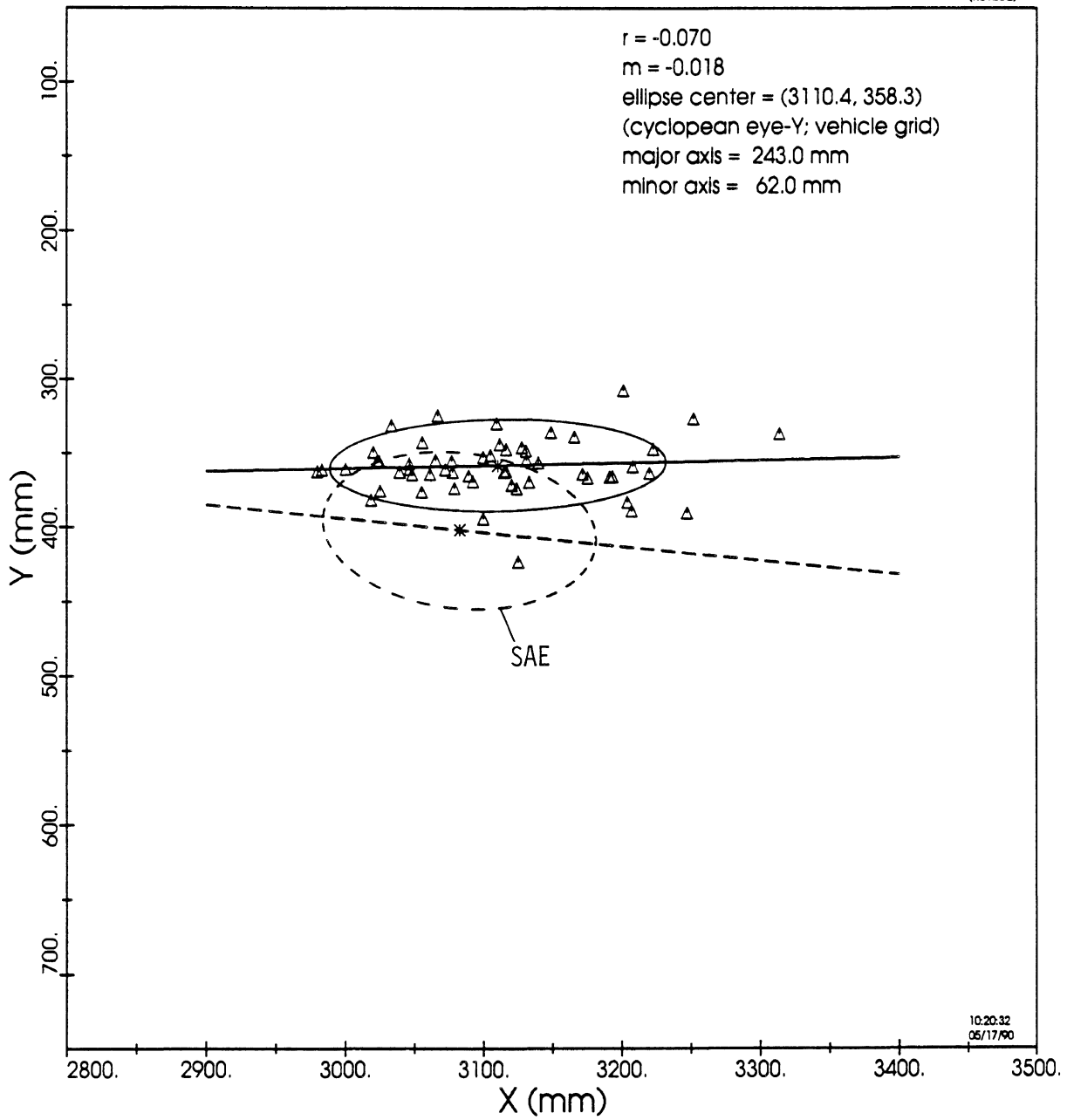


FIGURE H.7

Eye Ellipse for Monte Carlo (Side View)

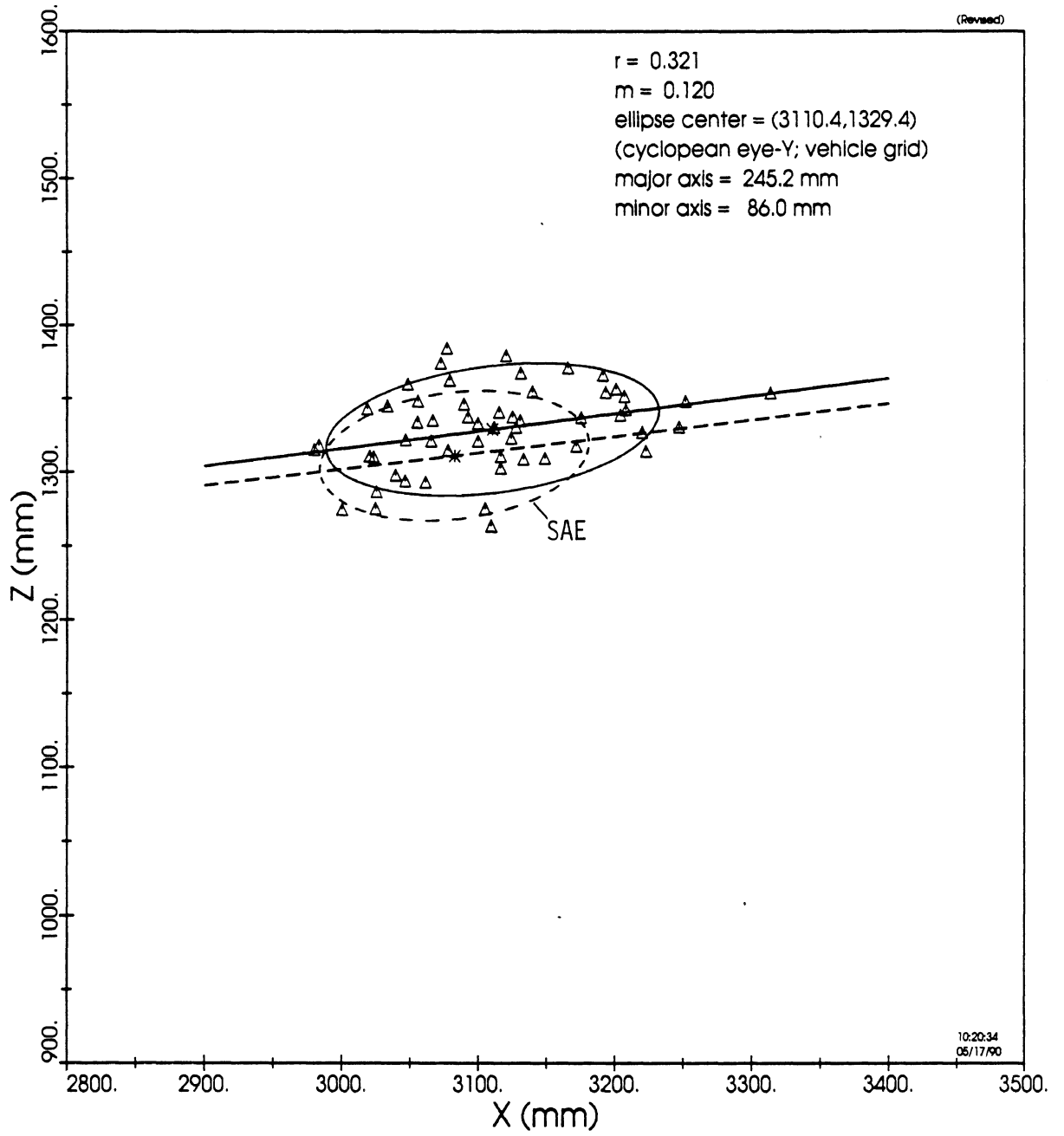


FIGURE H.8

APPENDIX I
PHASE II RESULTS

TABLE I.1

PHASE II: SEAT POSITION DATA SUMMARY*

Group		Cadillac (X in mm)		Oldsmobile (X in mm)		Camaro Ph.1 (X in mm)		Camaro Ph. 2 (X in mm)		Pontiac (X in mm)	
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	3043	9	2994	20	2941	5	2952	24	2968	22
2	6	3082	10	3071	31	3020	9	3032	31	3032	22
3	5	3101	19	3069	22	3040	18	3019	27	3047	13
4	5	3113	39	3066	31	3038	27	3057	10	3061	20
5	6	3139	17	3107	29	3069	15	3034	31	3089	25
All Females	27	3097	41	3063	44	3023	49	3020	43	3041	46
6	5	3086	29	3067	38	3031	24	3044	39	3037	20
7	6	3116	26	3104	38	3051	22	3065	38	3065	30
8	6	3136	19	3116	26	3076	35	3091	50	3081	31
9	6	3160	29	3156	33	3114	17	3100	41	3142	20
10	5	3189	21	3181	13	3118	58	3151	16	3150	11
All Males	28	3137	42	3125	49	3078	46	3090	50	3095	49
All Subjects	55	3117	46	3095	55	3051	55	3055	58	3069	55
All Subjects Weighted	55	3117		3095		3052		3057		3069	

*data given in vehicle coordinates with respect to X-coordinates of SAE J826 H-point calibration

TABLE I.2

PHASE II: SEATBACK RECLINER DATA SUMMARY*

Group		Cadillac ** (degrees)		Oldsmobile (degrees)		Camaro Ph. 1 (degrees)		Camaro Ph. 2 (degrees)	
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	14.4	2.7	25.8	2.2	28.1	3.3	25.9	2.7
2	6	21.3	3.5	25.0	3.0	29.0	4.9	24.3	3.0
3	5	17.4	1.5	23.4	2.7	27.5	5.6	24.7	4.3
4	5	16.6	3.4	25.0	3.6	27.5	5.1	23.5	1.1
5	6	18.0	0.6	23.3	1.8	25.5	2.8	25.5	1.5
All Females	27	17.4	3.2	24.5	2.7	27.5	4.3	24.8	2.7
6	5	20.9	3.8	25.0	2.8	28.1	2.3	25.9	3.8
7	6	19.7	4.8	24.0	4.4	29.8	4.9	25.0	3.8
8	6	19.8	3.0	22.7	2.9	25.0	3.2	22.3	4.5
9	6	22.2	2.4	26.0	2.3	28.8	4.5	26.8	3.5
10	5	23.0	3.0	25.8	3.8	29.3	3.4	25.3	3.6
All Males	28	21.1	3.5	24.6	3.3	28.1	4.0	25.0	3.9
All Subjects	55	19.0	4.6	24.6	3.0	27.8	4.1	24.9	3.3
All Subjects Weighted	55	19.4		24.6		27.9		24.8	

*angles given with respect to SAE J826 H-point calibration at or near design back angle

**back angles include adjustment for tilt of power seat from design pan angle

TABLE I.3

PHASE II: TILT-WHEEL ANGLE DATA SUMMARY*

Group		Cadillac (degrees)		Oldsmobile (degrees)		Camaro Ph. 1 (degrees)		Camaro Ph. 2 (degrees)		Pontiac (degrees)	
	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	5	21.0	3.5	19.0	4.5	21.5	5.0	22.5	2.2	19.0	5.7
2	6	19.3	5.2	19.3	2.6	21.5	3.2	22.3	4.9	21.0	4.5
3	5	14.0	4.5	26.0	6.1	16.5	5.0	15.5	5.5	27.0	6.5
4	5	19.0	4.5	24.0	2.7	18.5	4.5	17.5	2.2	23.0	4.5
5	6	14.3	2.6	25.2	2.0	15.7	3.8	14.0	2.7	29.3	5.2
All Females	27	17.5	4.8	22.7	4.6	18.7	4.7	18.4	5.0	24.0	6.2
6	5	16.0	7.9	22.0	8.2	19.5	8.4	19.5	8.4	27.0	6.5
7	6	17.7	2.6	21.8	2.0	19.8	2.6	19.8	5.2	22.7	4.1
8	6	14.3	4.1	24.3	8.2	18.2	2.6	19.8	6.1	26.0	4.8
9	6	22.7	5.2	21.0	8.9	24.0	6.1	20.7	7.4	22.7	10.3
10	5	19.0	2.7	20.0	4.2	21.5	5.0	22.5	5.5	21.0	5.0
All Males	28	18.0	5.3	21.9	6.5	20.6	5.3	20.4	6.1	23.9	6.4
All Subjects	55	17.7	5.0	22.3	5.6	19.7	5.0	19.4	5.7	23.9	6.3
All Subjects Weighted	55	17.9		22.3		19.8		19.5		23.7	

*angle of steering wheel plane with respect to vertical

Camaro Phase Two Preferred Seat Position

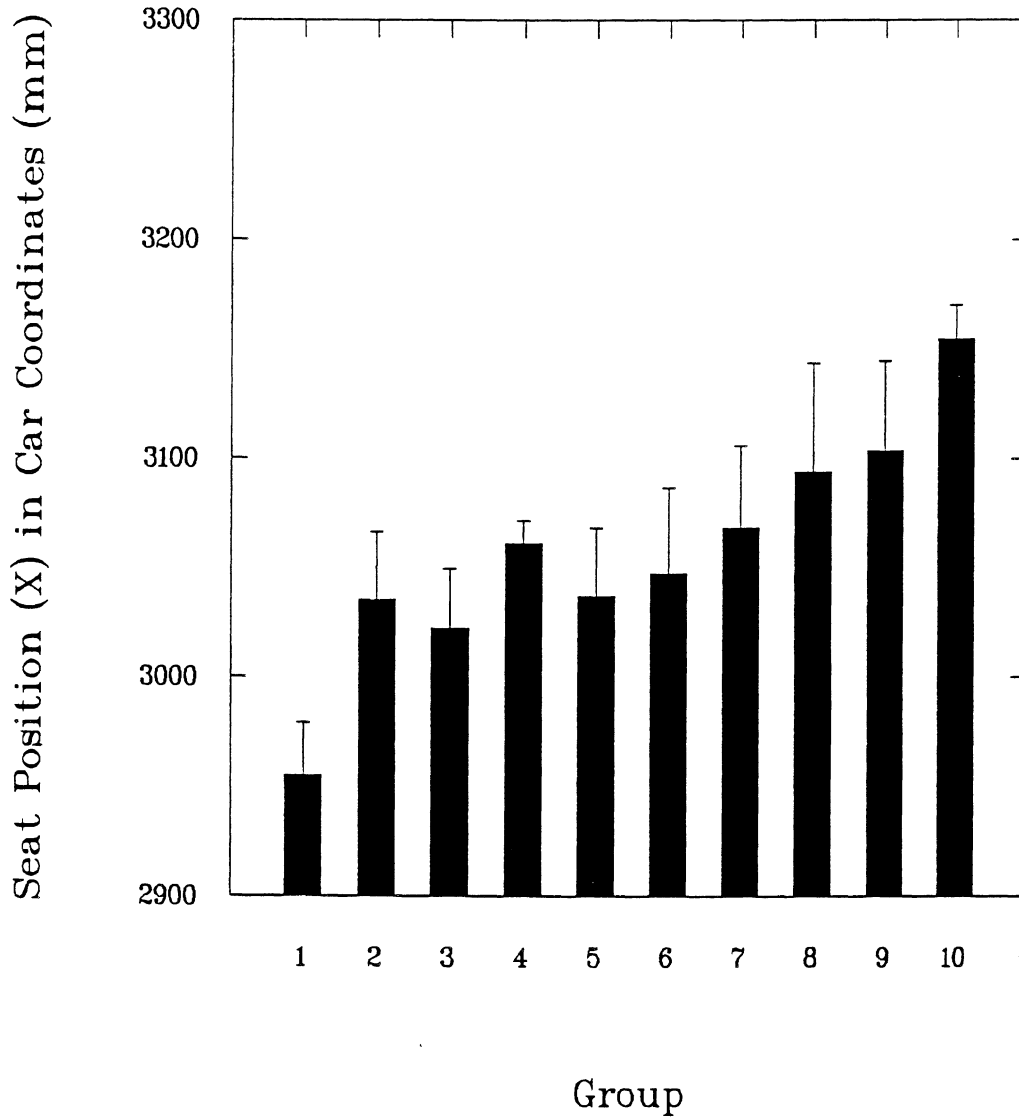


FIGURE I.1

Oldsmobile Preferred Seat Position

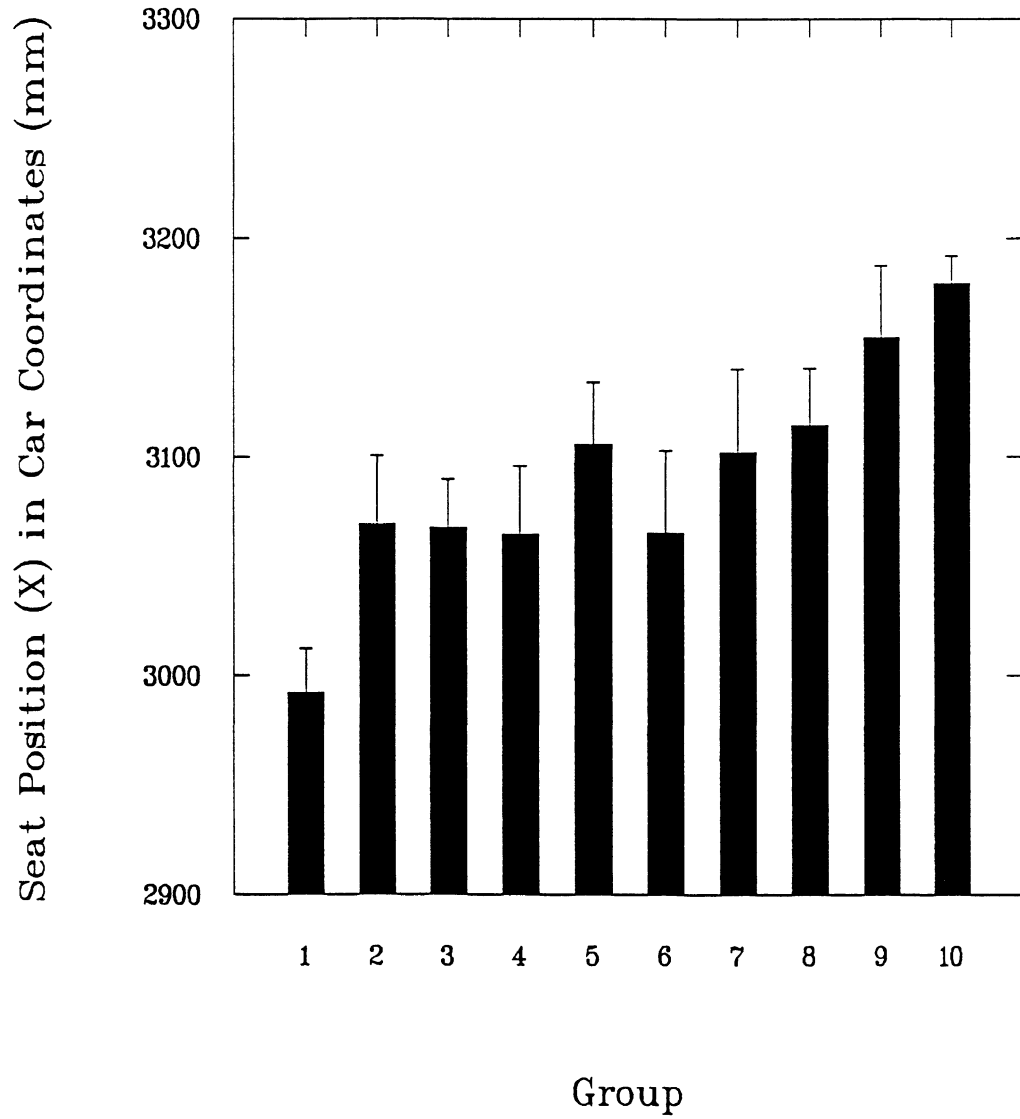


FIGURE I.2

Pontiac Preferred Seat Position

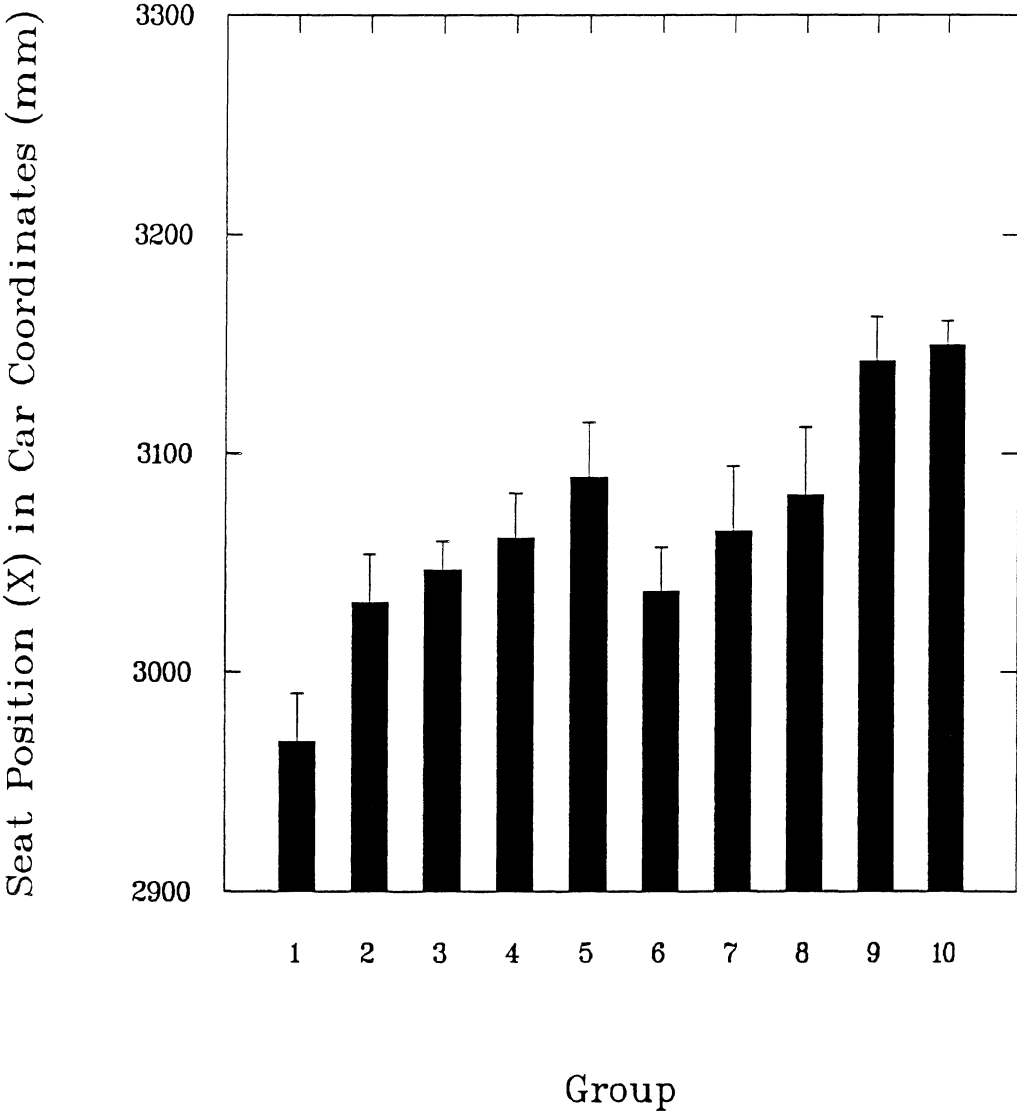


FIGURE I.3

Camaro Phase Two Preferred Seat Back Angle

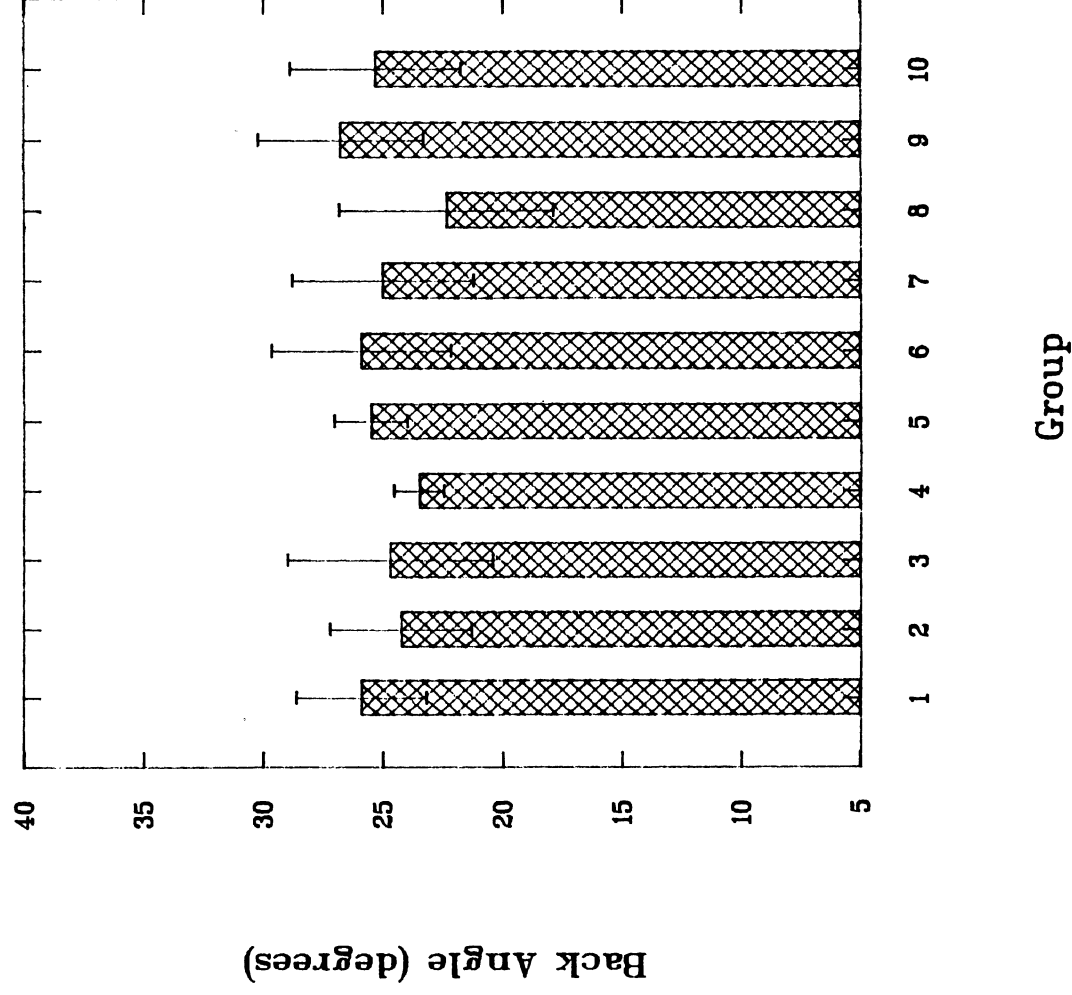


FIGURE I.4

Oldsmobile Preferred Seat Back Angle

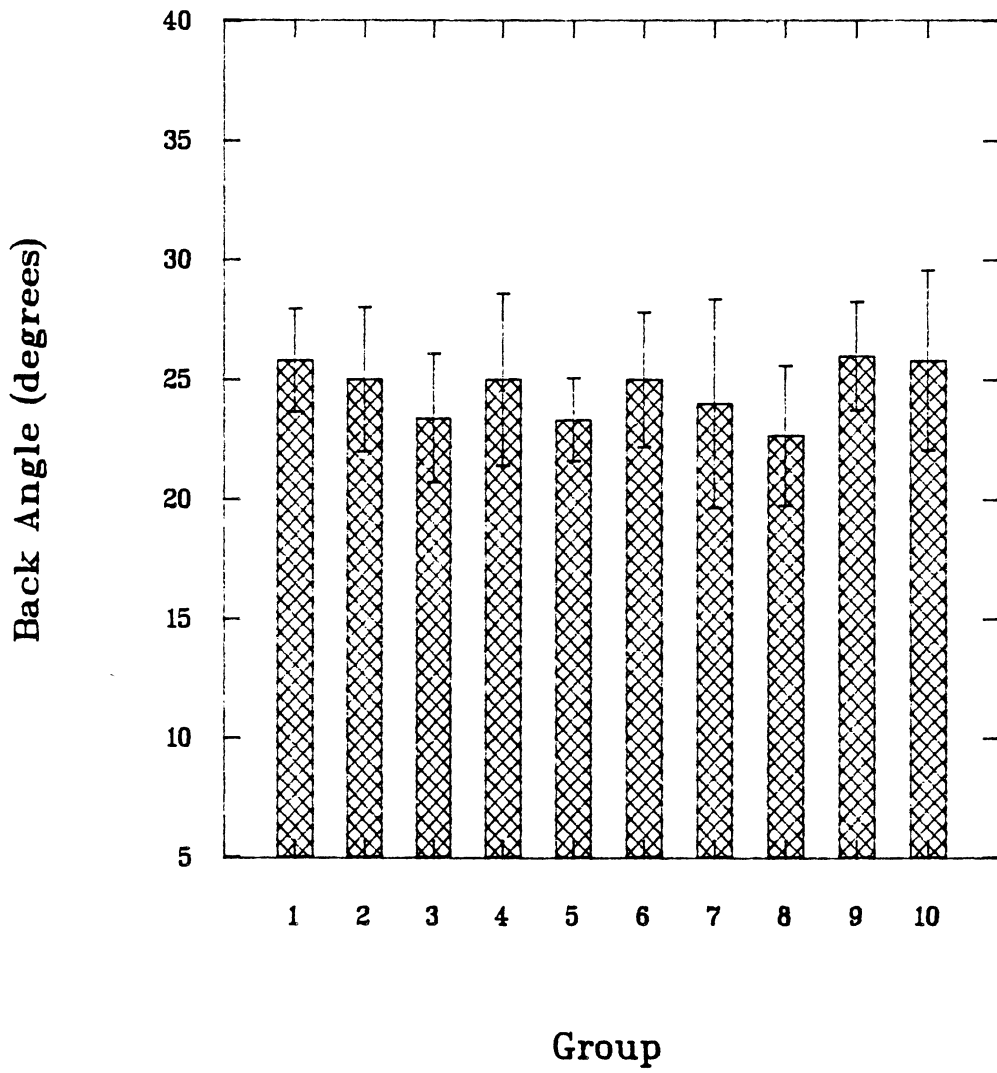


FIGURE I.5

Camaro Phase Two Preferred Tilt-Wheel Angle

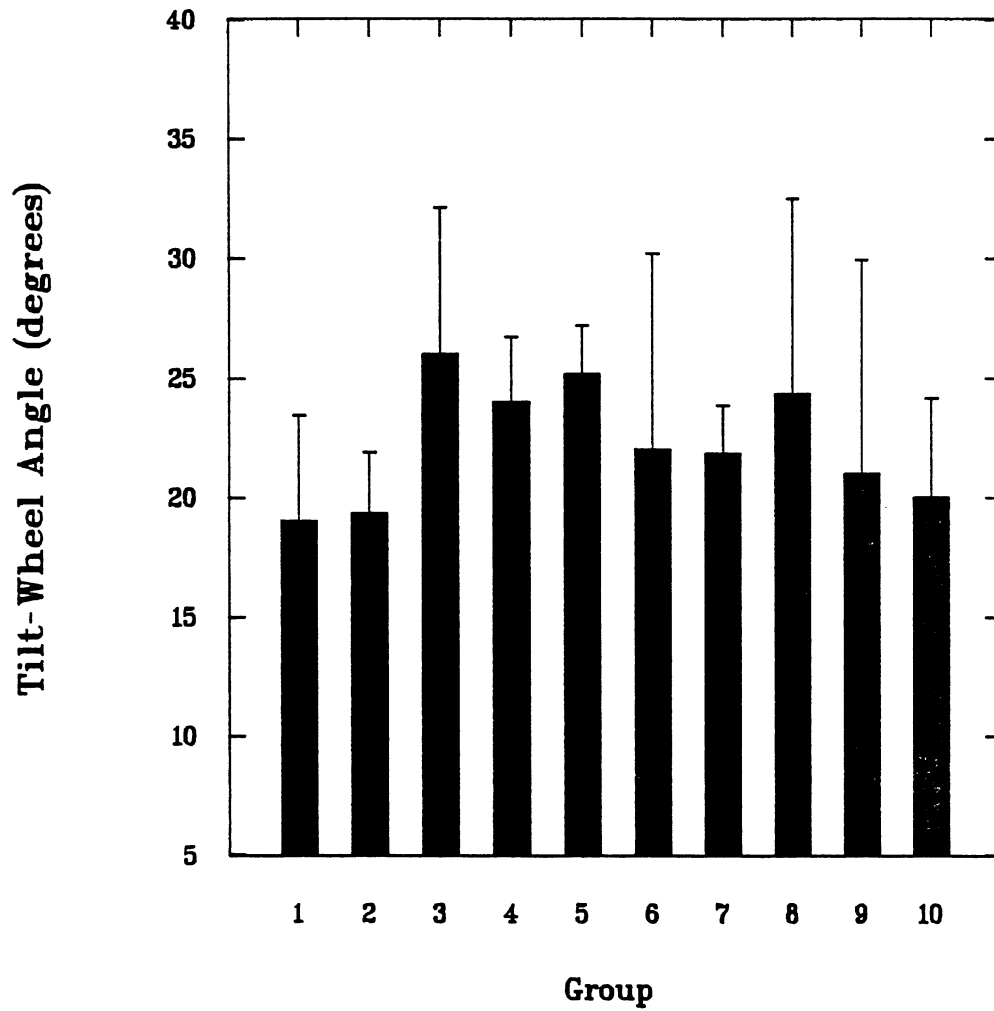


FIGURE I.6

Oldsmobile Preferred Tilt-Wheel Angle

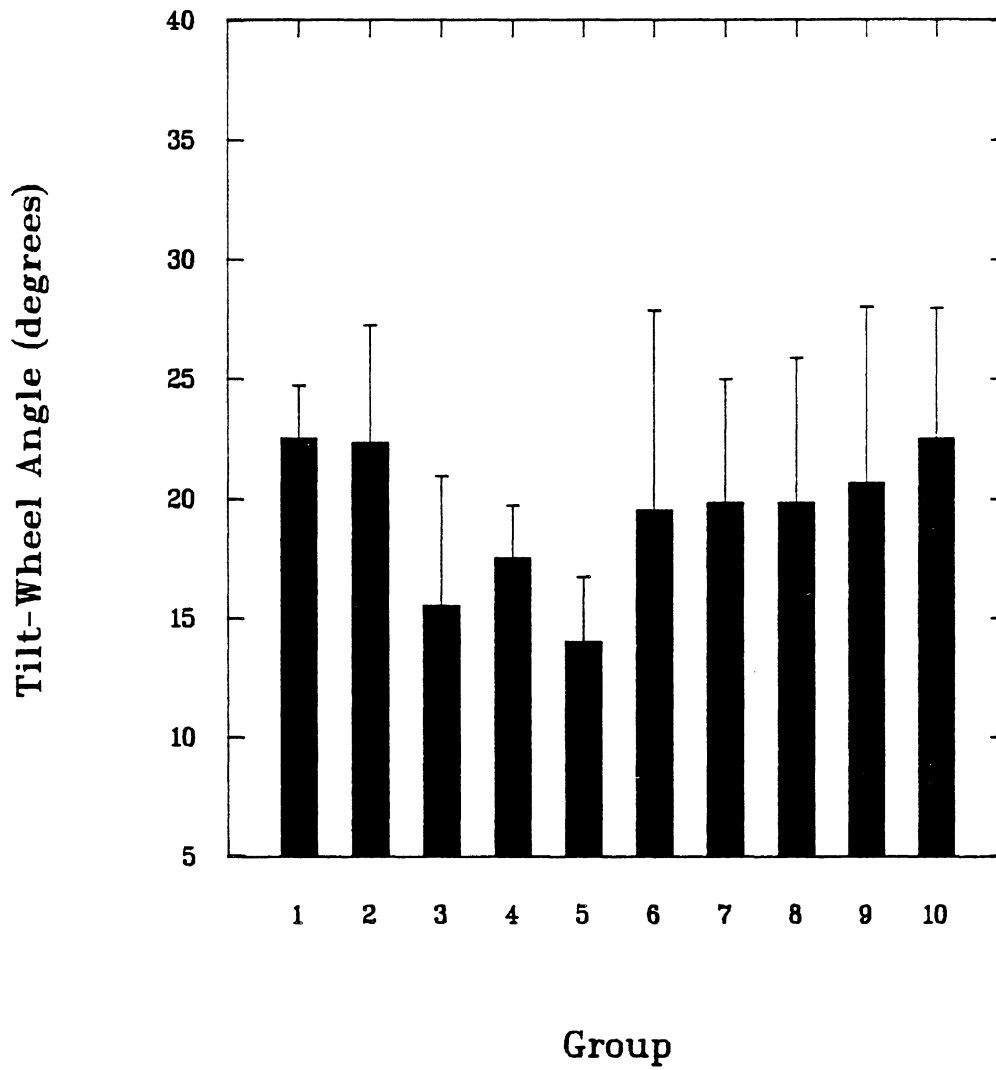


FIGURE I.7

Pontiac Tilt-Wheel Angle

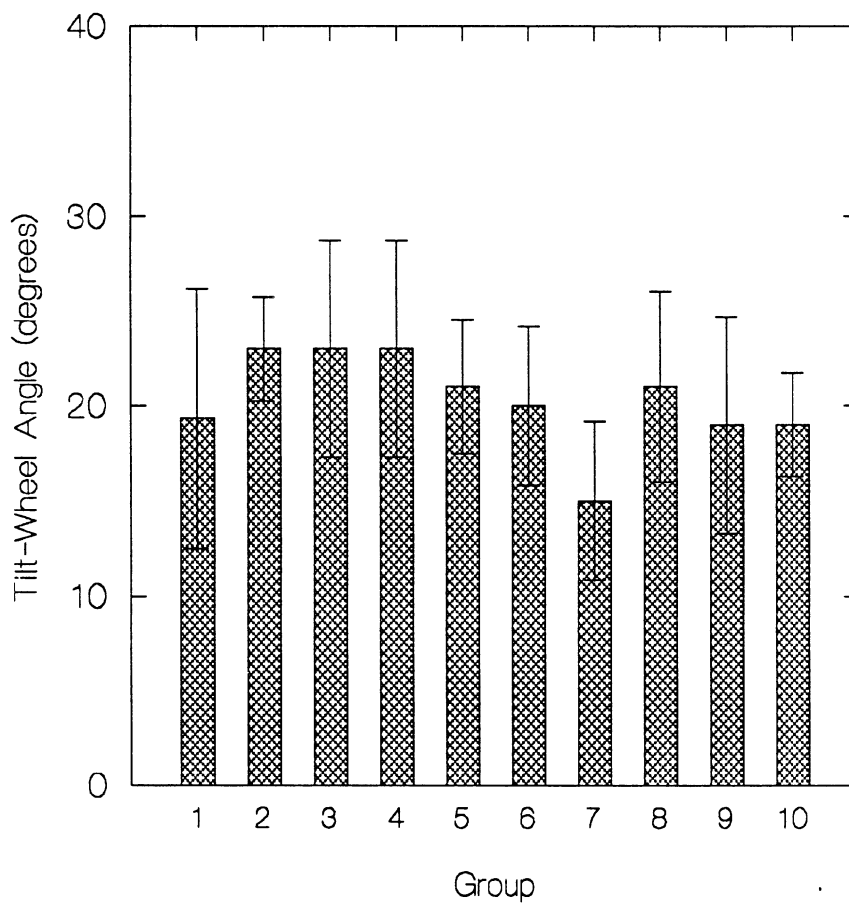


FIGURE I.8

TABLE I.4

PHASE II: PEDAL ADJUSTMENT DATA SUMMARY*

Group	Camaro (mm from BOF)		Oldsmobile (mm from BOF)		
	n	mean	s.d.	mean	s.d.
1	5	66	27	32	34
2	6	82	23	40	18
3	5	58	27	34	24
4	5	64	20	20	23
5	6	30	36	20	10
All Females	27	69	25	35	23
6	5	67	46	31	16
7	6	74	38	34	28
8	6	62	49	23	19
9	6	45	29	31	26
10	5	49	21	12	12
All Males	28	54	38	25	20
All Subjects	55	60	34	28	22

*data given in mm from the design BOF location of the pedal

Mean Camaro Pedal Position by Group

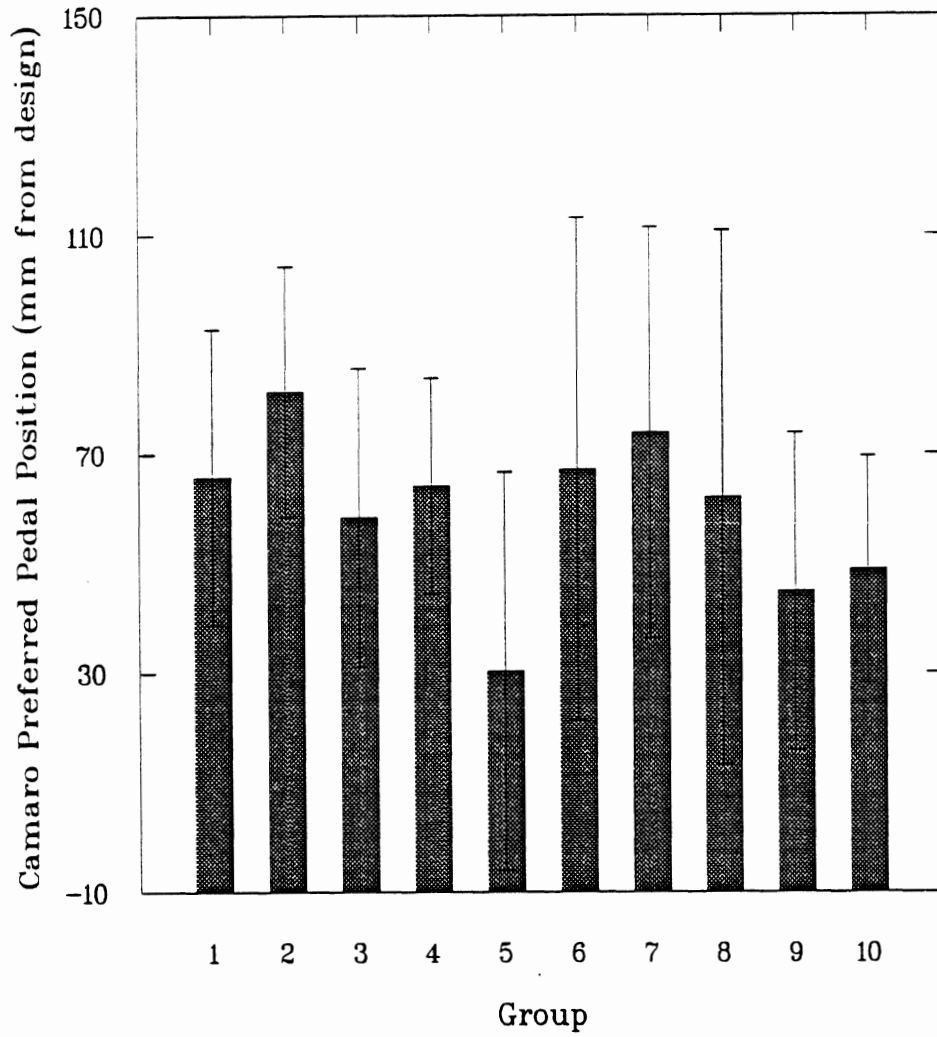


FIGURE I.9

Mean Oldsmobile Pedal Position by Group

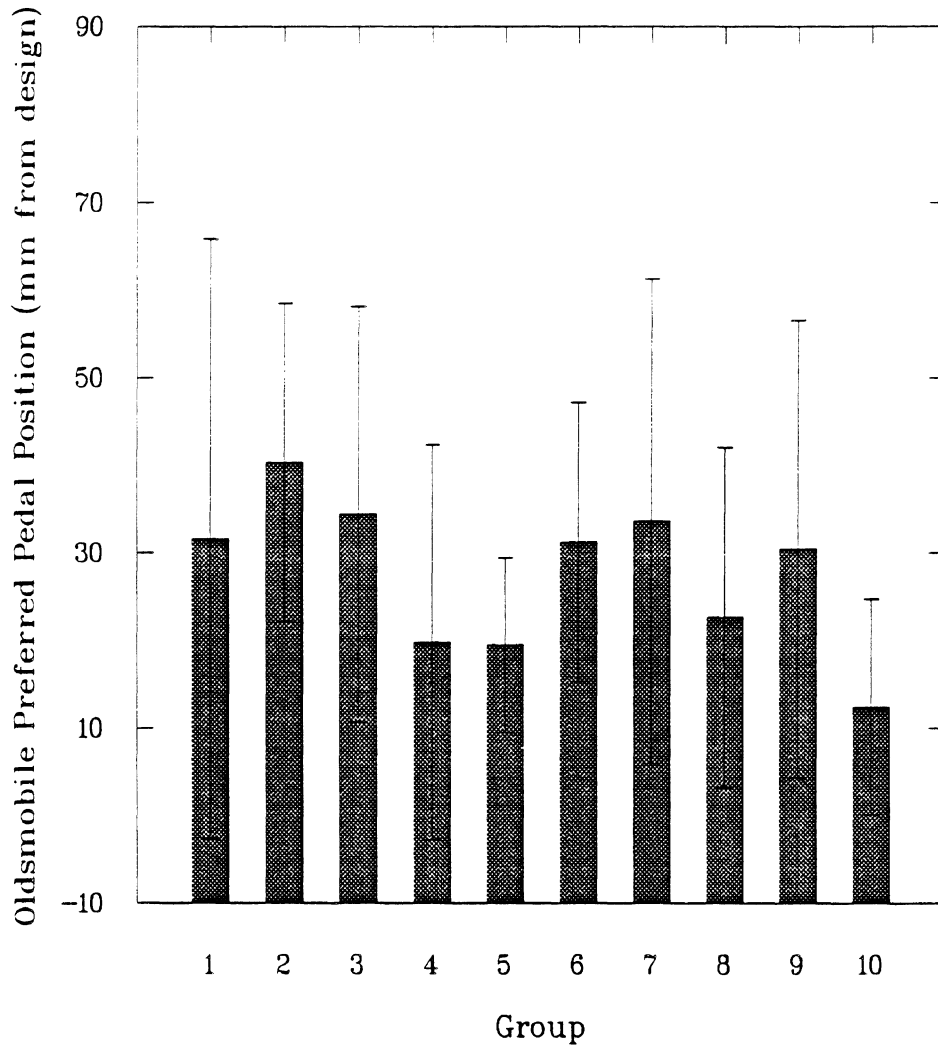


FIGURE I.10

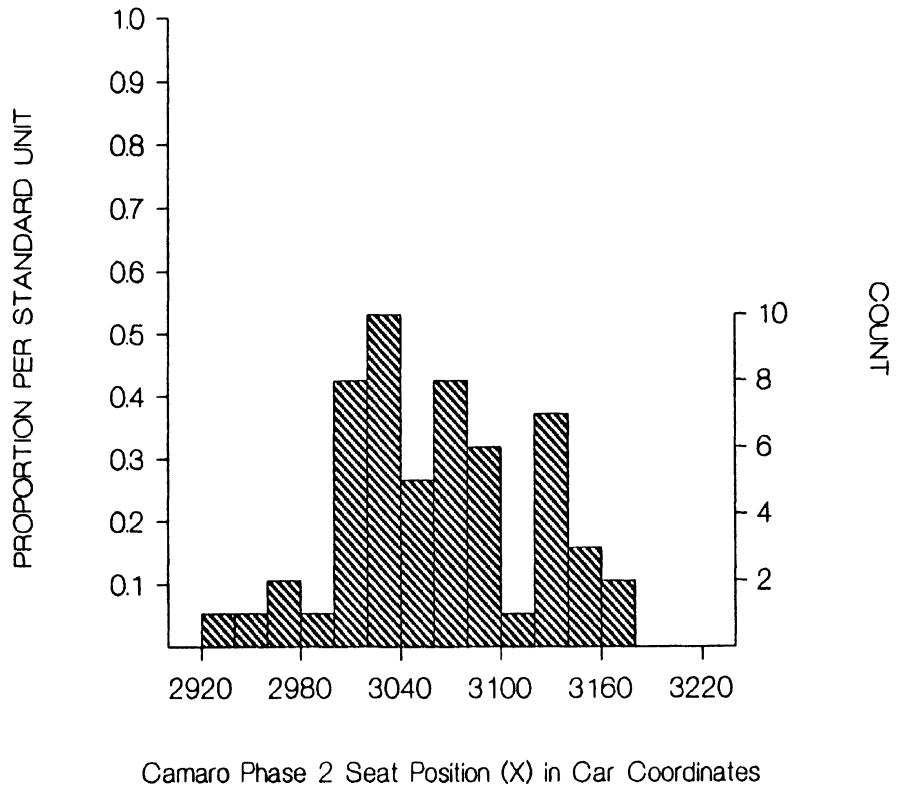


FIGURE I.11

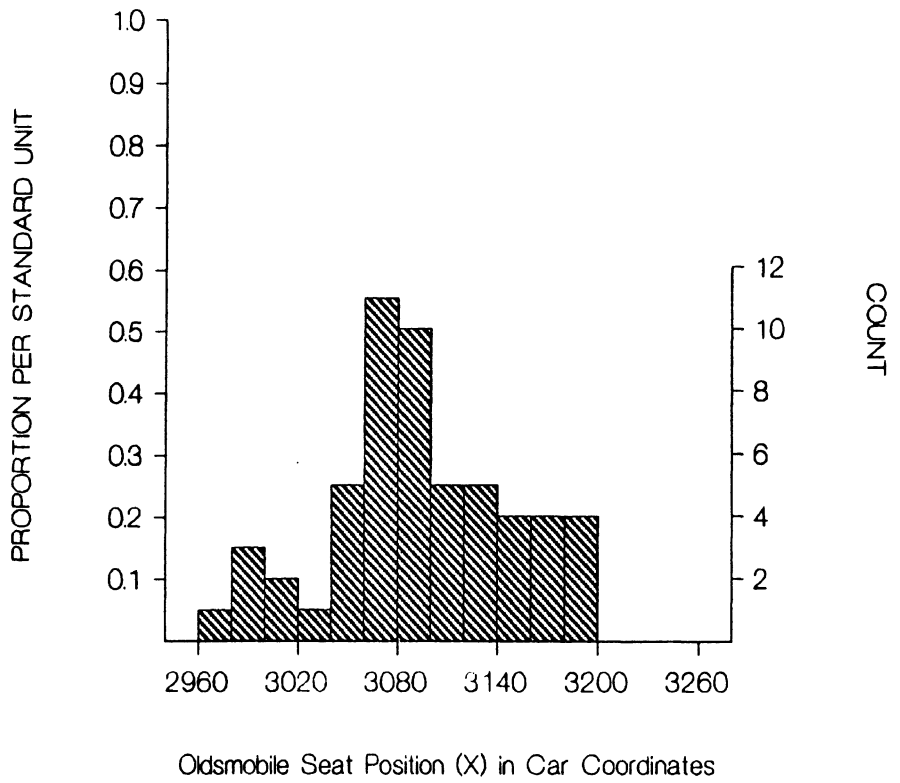
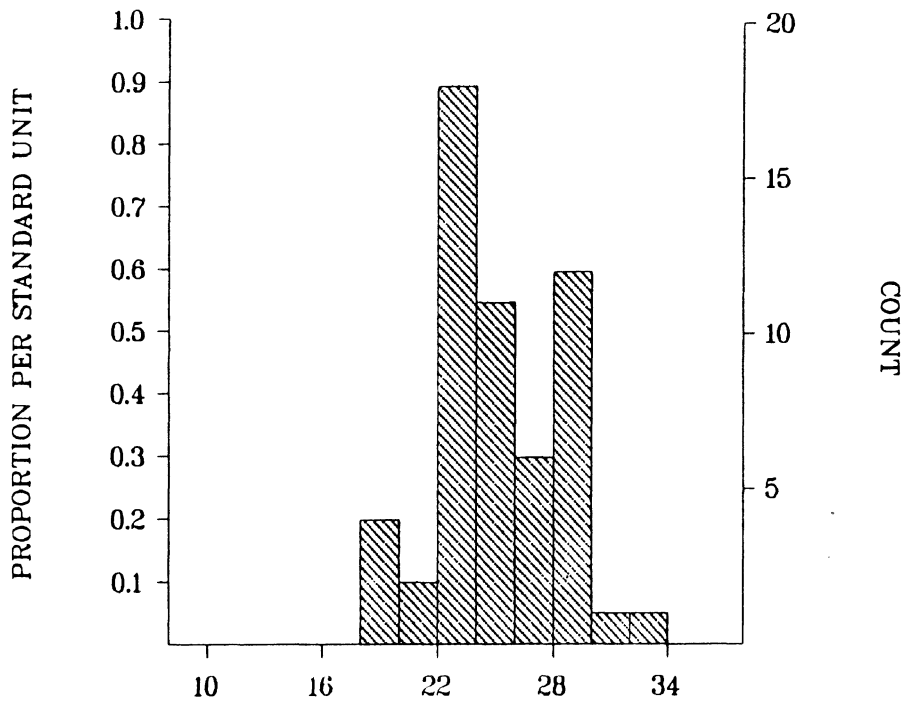
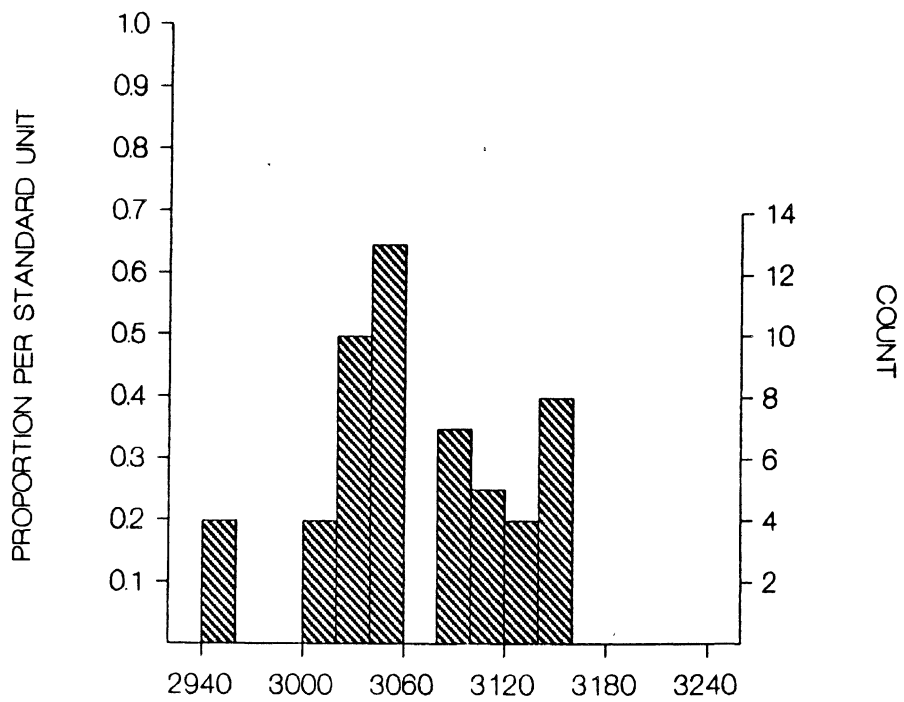


FIGURE I.12



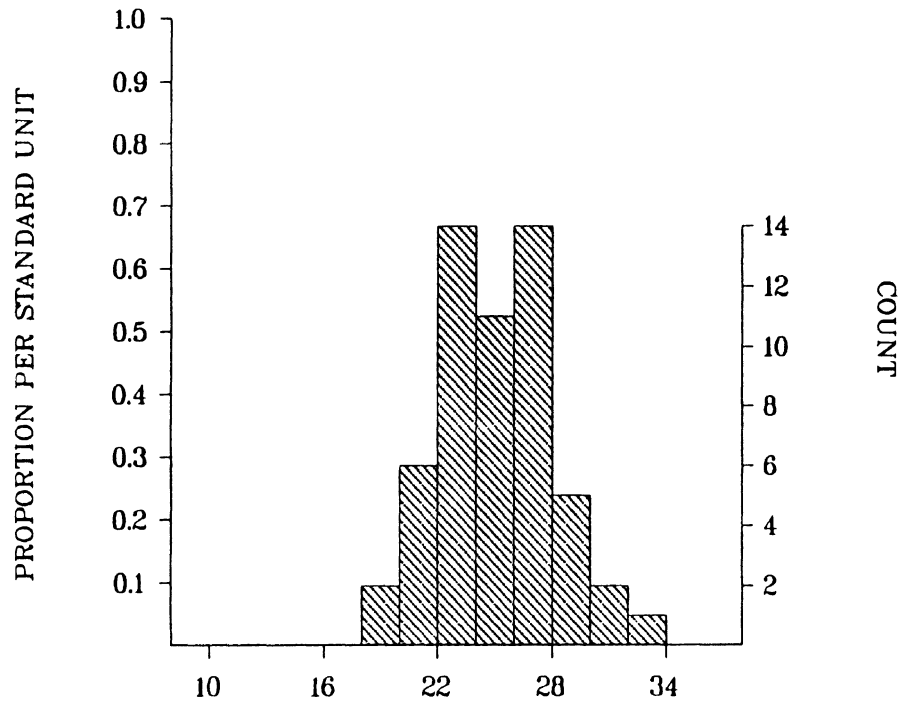
Camaro Phase 2 Seat Back Angle (degrees) Relative to Vertical

FIGURE I.13



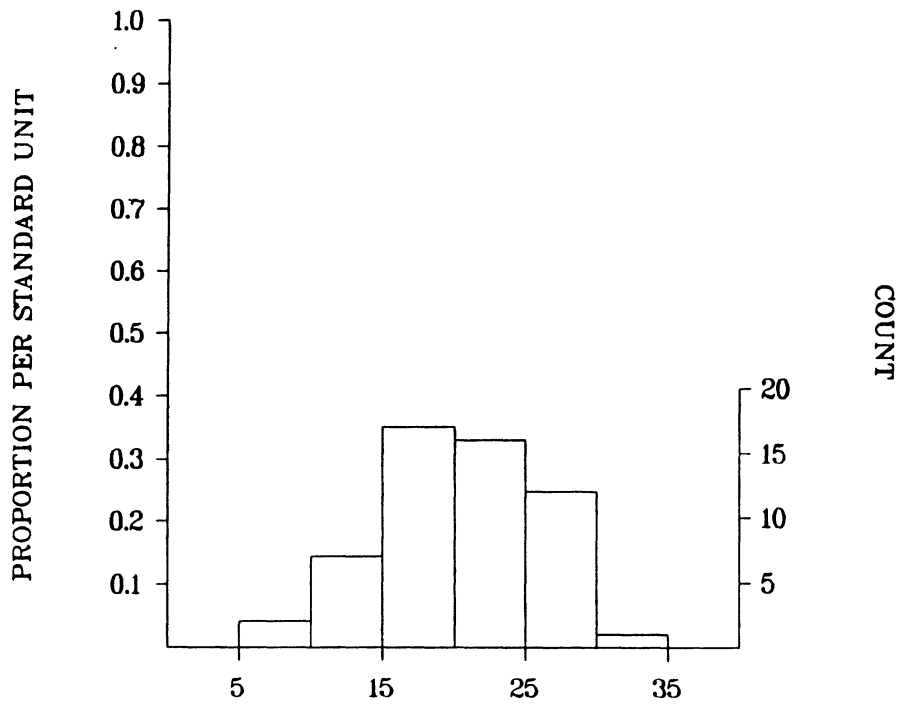
Pontiac Seat Position (X) in Car Coordinates

FIGURE I.14



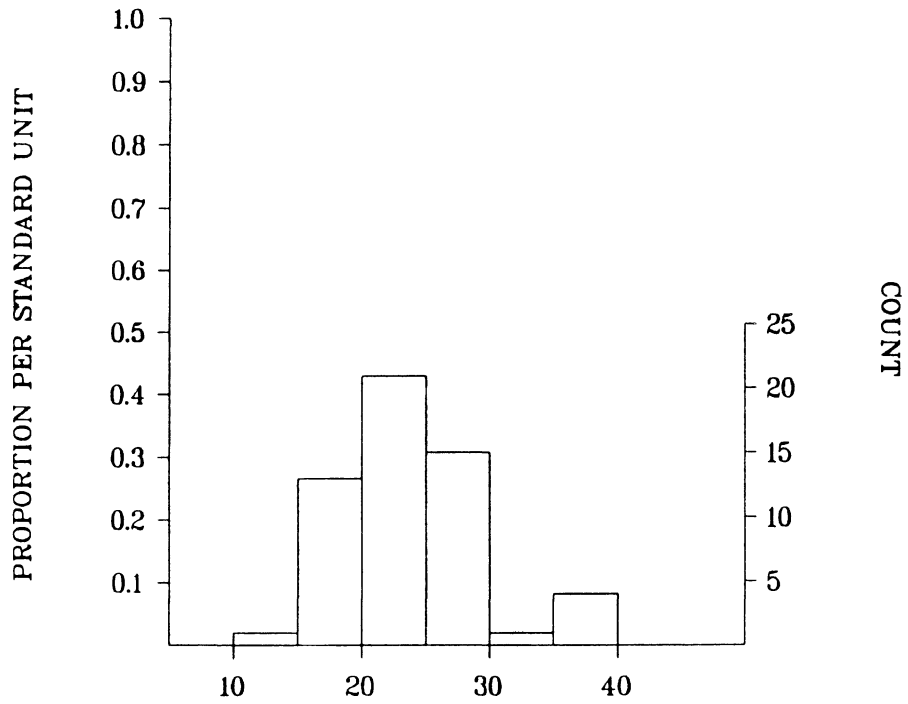
Oldsmobile Seat Back Angle (degrees) Relative to Vertical

FIGURE I.15



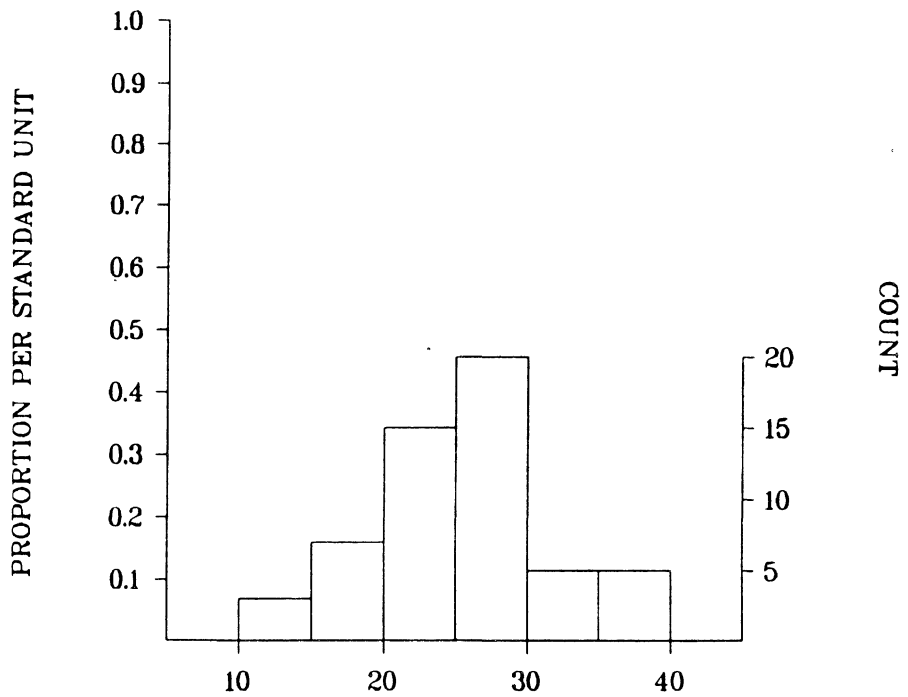
Camaro Phase 2 Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE I.16



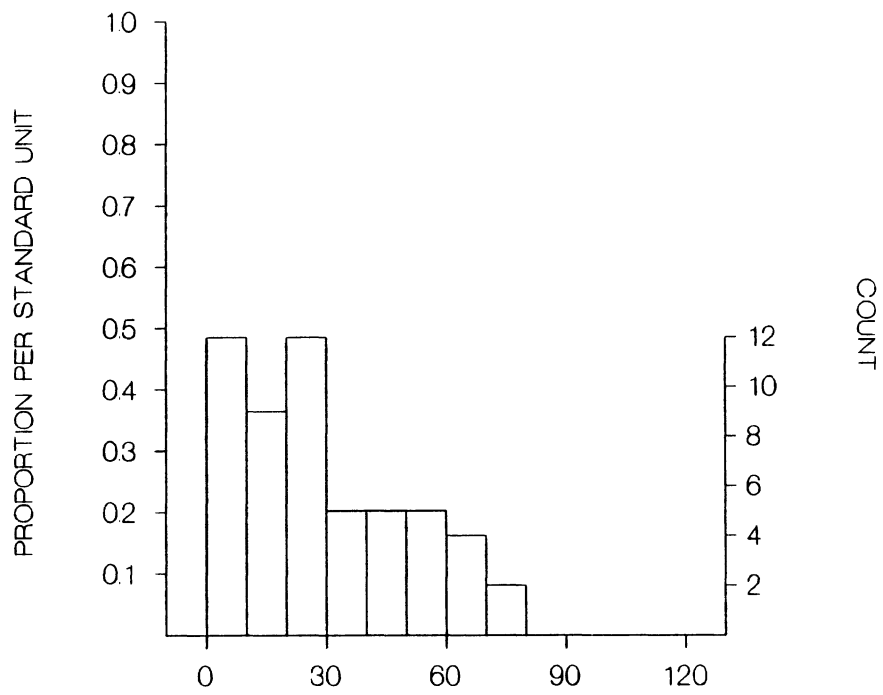
Oldsmobile Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE I.17



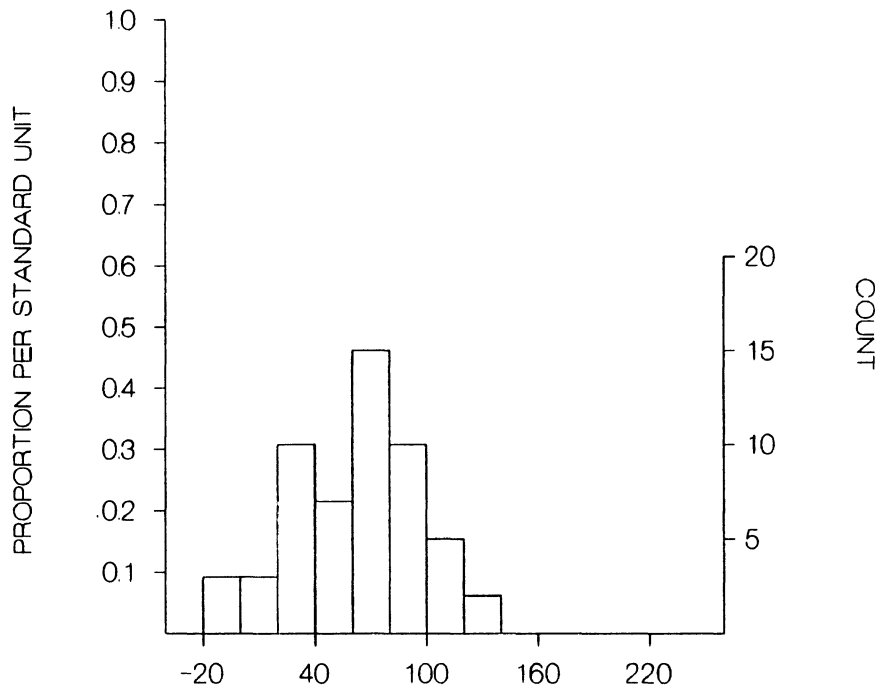
Pontiac Tilt-Wheel Angle (degrees) Relative to Horizontal

FIGURE I.18



Oldsmobile Preferred Pedal Position (X) in mm from BOF

FIGURE I.19



Camaro Preferred Pedal Position (X) in mm from BOF

FIGURE I.20

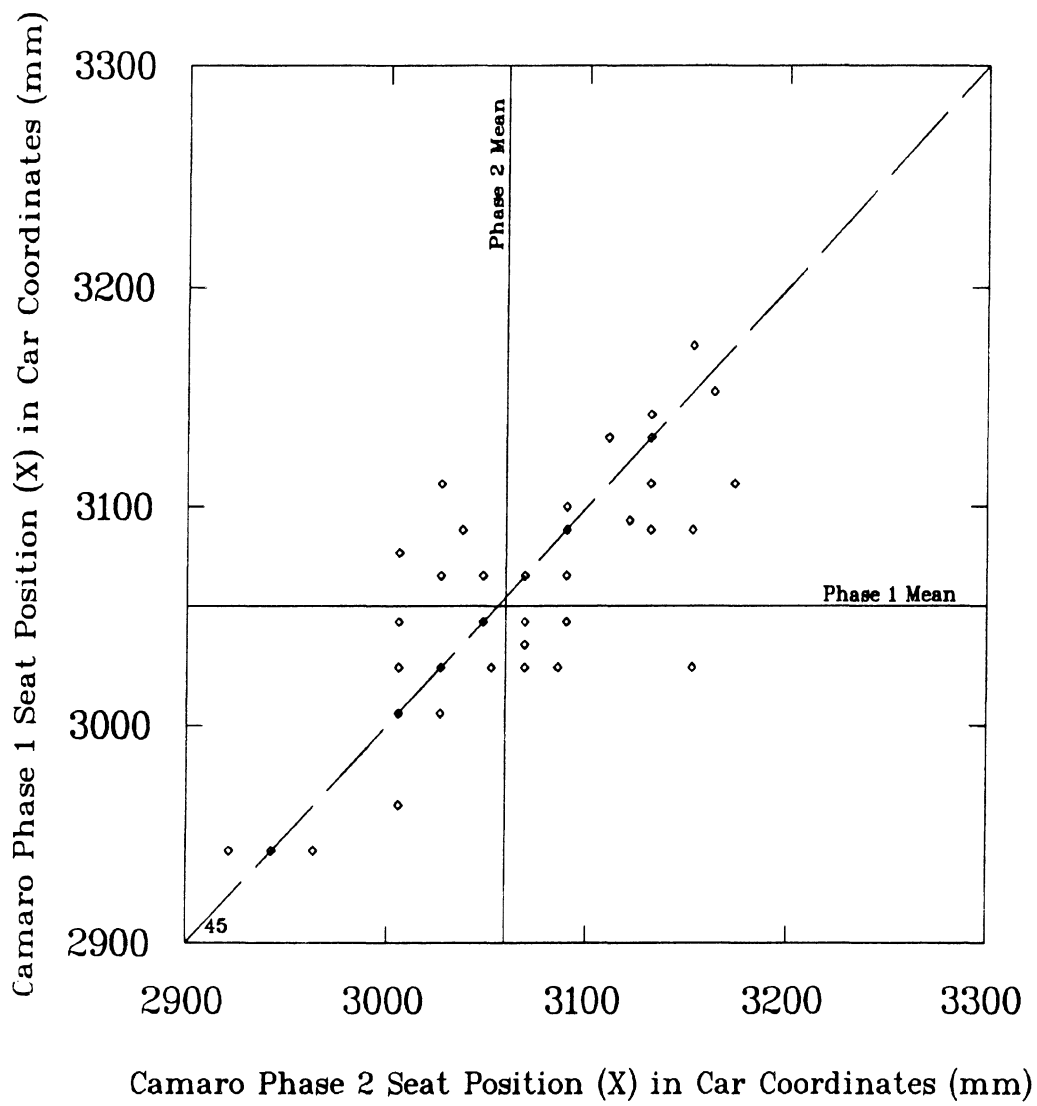


FIGURE I.21

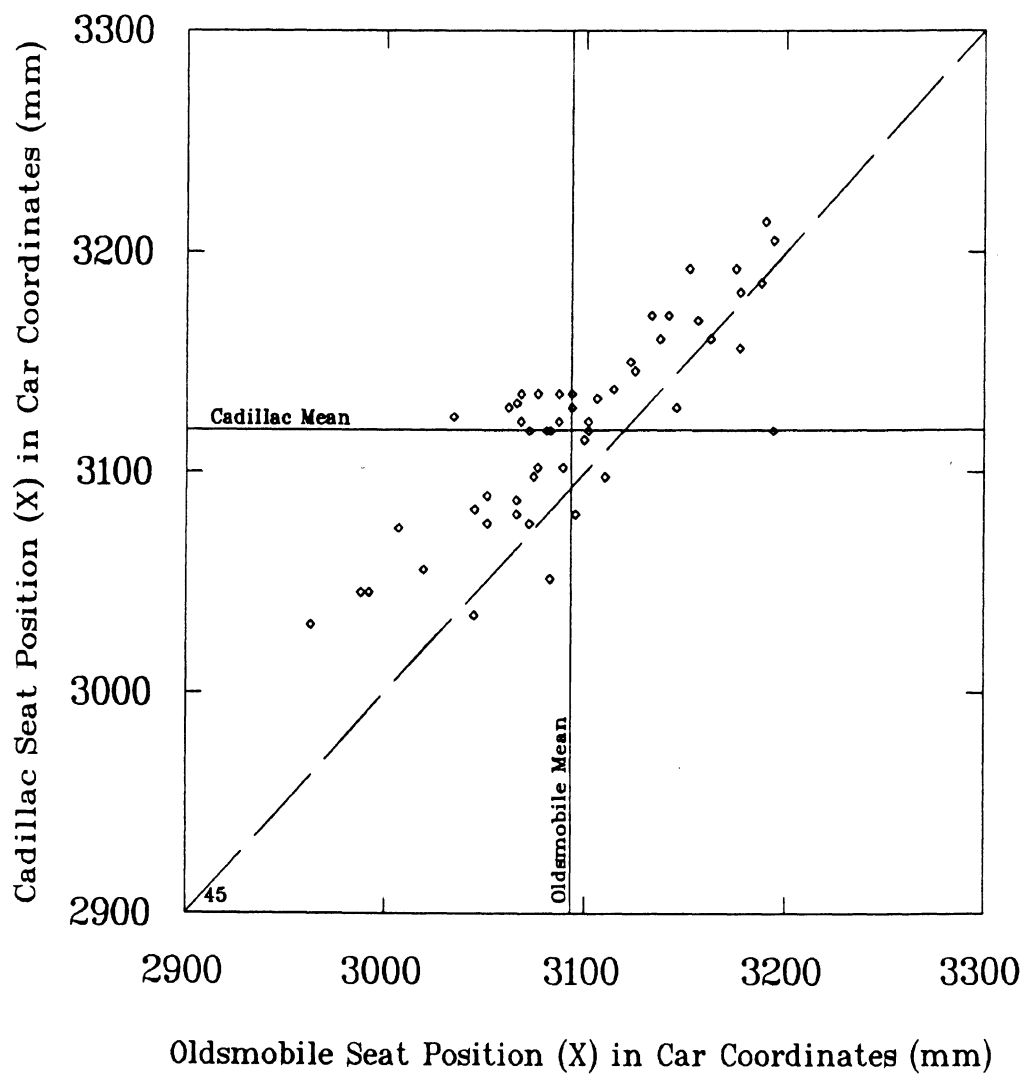
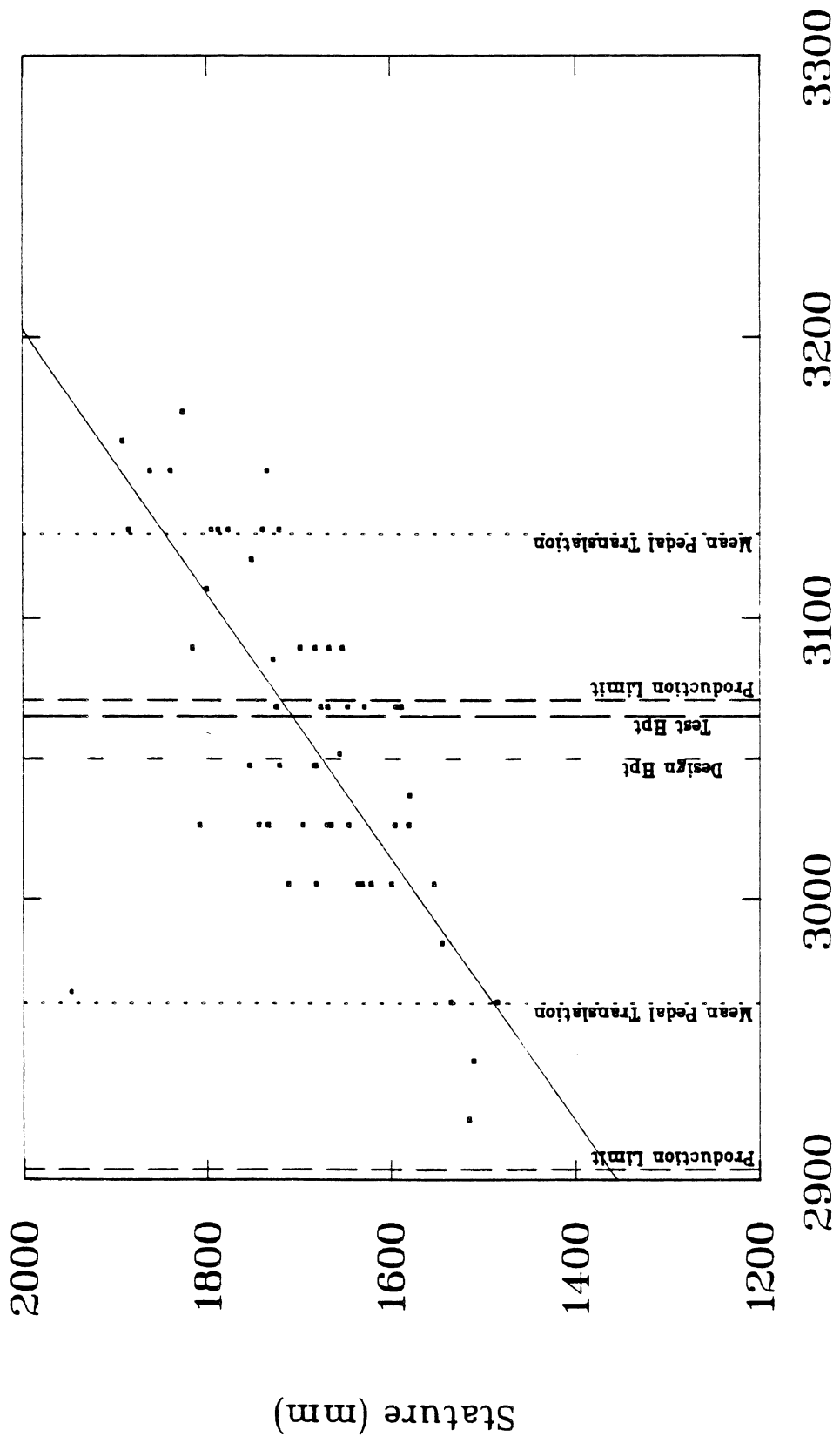
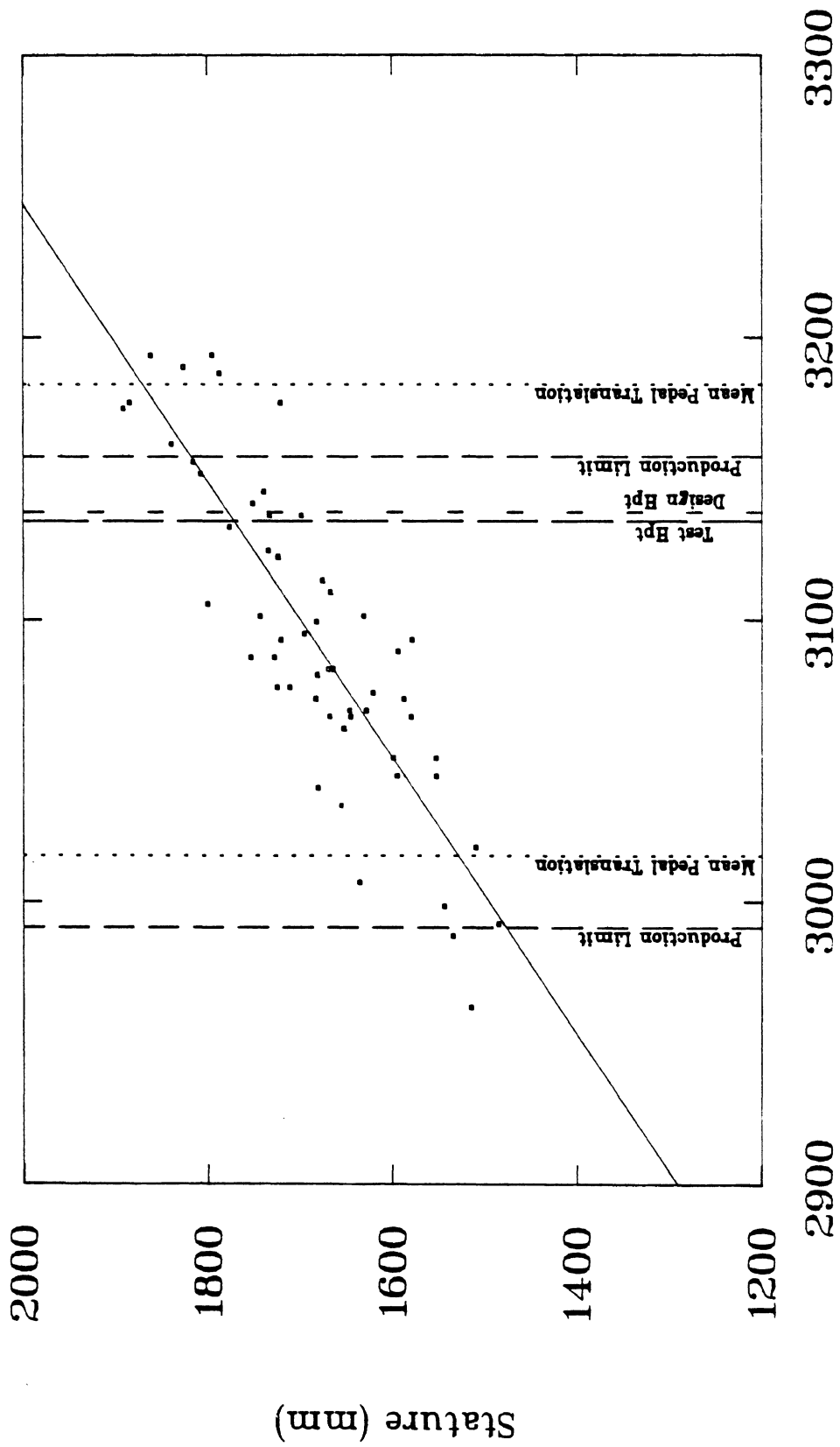


FIGURE I.22



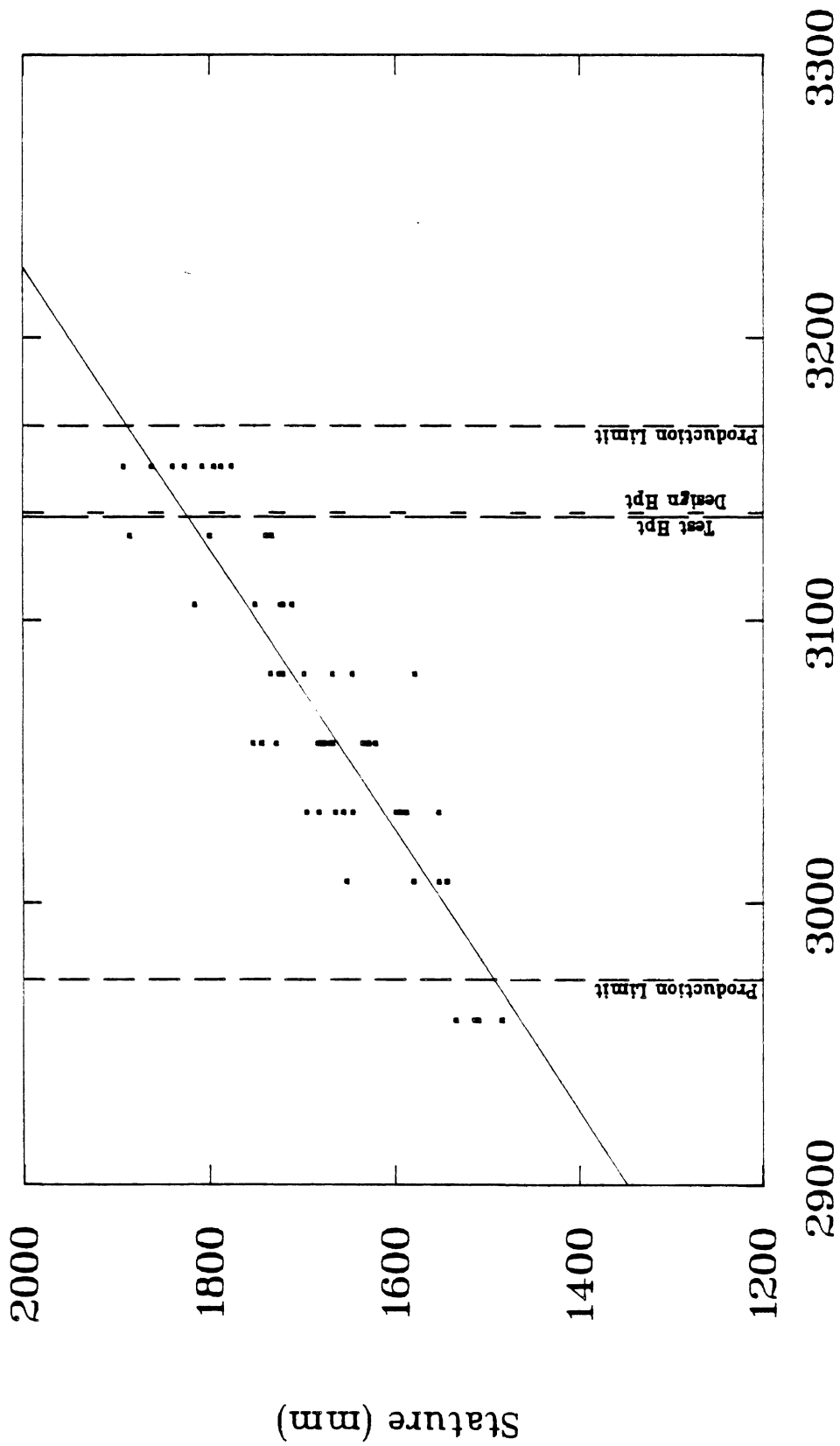
Camaro Phase 2 Seat Position in Car Coordinates (mm)

FIGURE I.23



Oldsmobile Seat Position in Car Coordinates (mm)

FIGURE I.24



Pontiac Seat Position in Car Coordinates (mm)

FIGURE I.25

TABLE I.5

PHASE II: EYELLIPSE DATA SUMMARY

Eyellipse Parameters	Static Pontiac 6000		
	Observed	Model	Diff.
EYELLIPSE CENTROID			
X	3123.2	3131.5	8.3
Y	369.6	334.7	-34.9
Z	1085.4	1119.2	33.8
XY			
Major Axis	198.0	199.8	1.8
Minor Axis	105.0	71.0	-34.0
XZ			
Major Axis	198.0	199.8	1.8
Minor Axis	86.0	95.3	9.3

Eye Ellipse for P6000 (Top View)

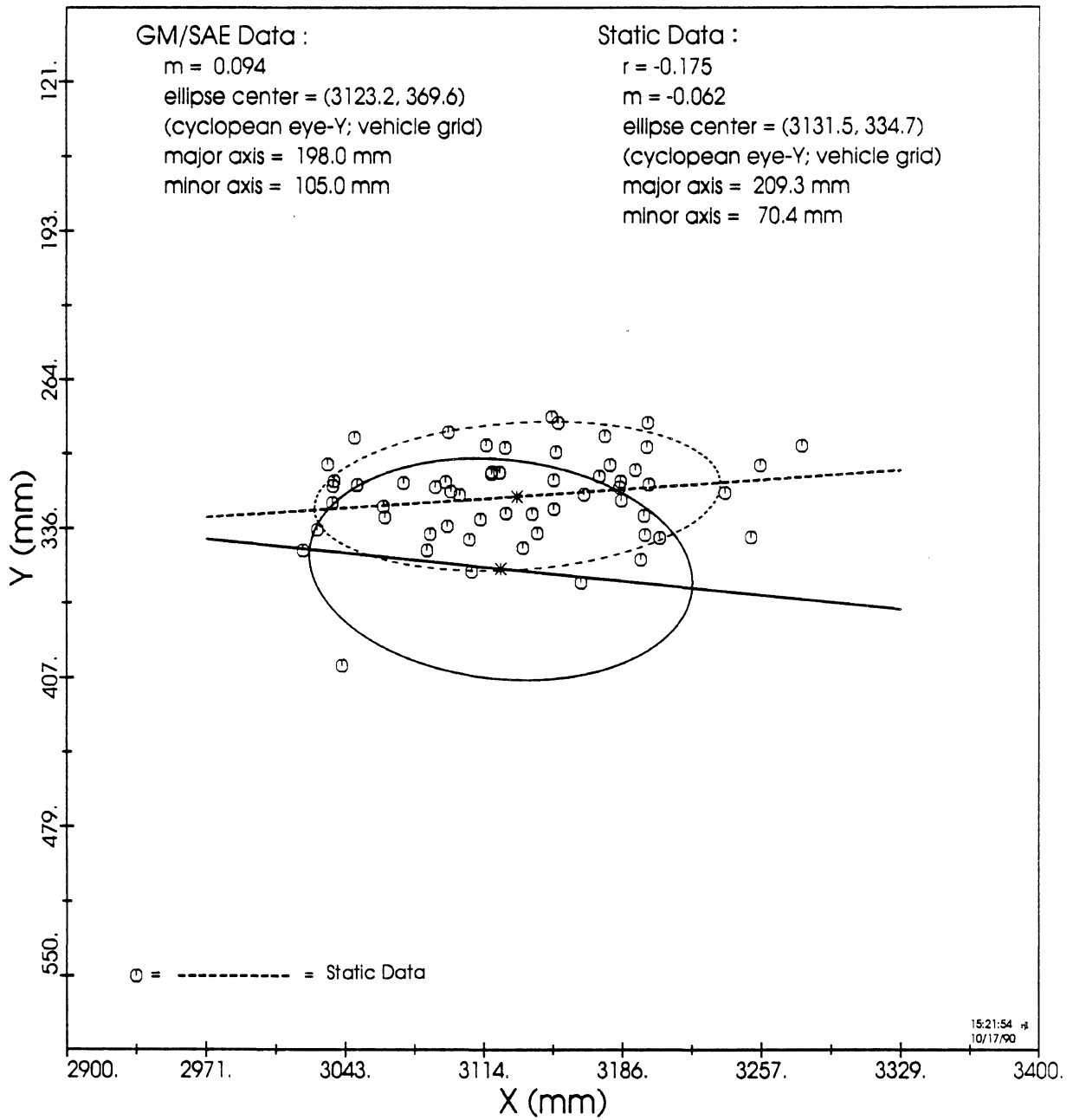


FIGURE I.26

Eye Ellipse for P6000 (Side View)

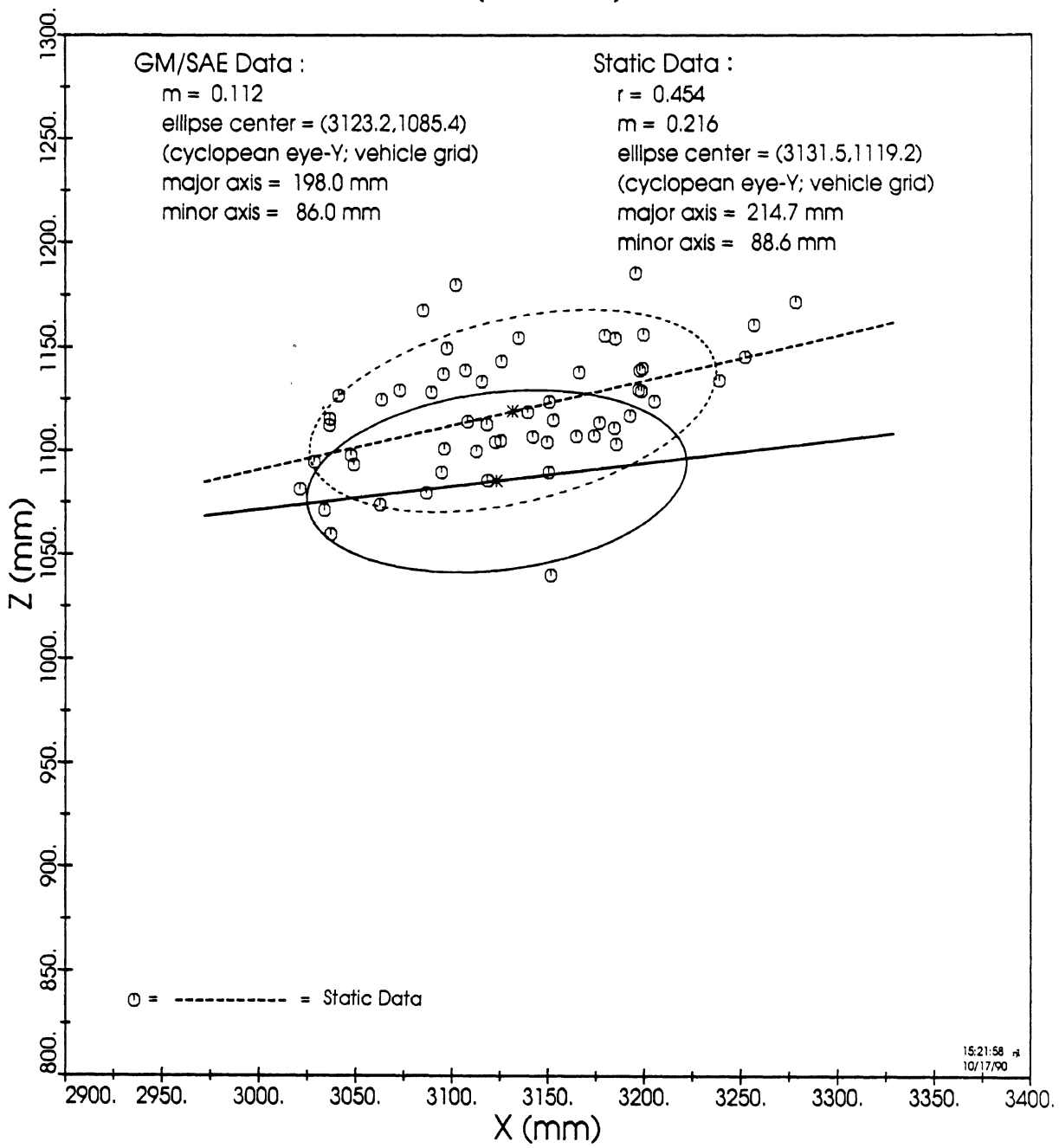


FIGURE I.27

APPENDIX J
PHASE III RESULTS
DYNAMIC VERSUS STATIC SEAT AND EYE POSITION IN PONTIAC 6000

TABLE J.1

PHASE THREE SEAT POSITION AND TILT-WHEEL ANGLE DATA SUMMARY*

Group	Phase		Seat Position				Tilt Wheel Angle			
			Phase II		Phase III		Phase II		Phase III	
	II	III	Pontiac Static (X in mm)		Pontiac Dynamic (X in mm)		Pontiac Static (degrees)		Pontiac Dynamic (degrees)	
	n	n	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	6	5	2968	22	2973	20	19.0	5.7	19.3	6.8
2	5	6	3032	22	3004	61	21.0	4.5	23.0	2.7
3	5	5	3047	13	3029	28	27.0	6.5	23.0	5.7
4	5	5	3061	20	3049	37	23.0	4.5	23.0	5.7
5	5	6	3089	25	3088	30	29.3	5.2	21.0	3.5
All Females	26	27	3041	46	3026	53	24.0	6.2	21.8	5.0
6	5	5	3037	20	3034	11	27.0	6.5	20.0	4.2
7	5	6	3065	30	3073	22	22.7	4.1	15.0	4.2
8	5	6	3081	31	3102	28	26.0	4.8	21.0	5.0
9	5	6	3142	20	3132	20	22.7	10.3	19.0	5.7
10	5	5	3150	11	3156	11	21.0	5.0	19.0	2.7
All Males	25	28	3095	49	3099	48	23.9	6.4	18.8	4.6
All Subjects	51	55	3069	55	3062	62	23.9	6.3	20.3	5.0

*seat position data given in vehicle coordinates with respect to X-coordinates of SAE J826 H-Point calibration

Pontiac 6000 Dynamic Testing

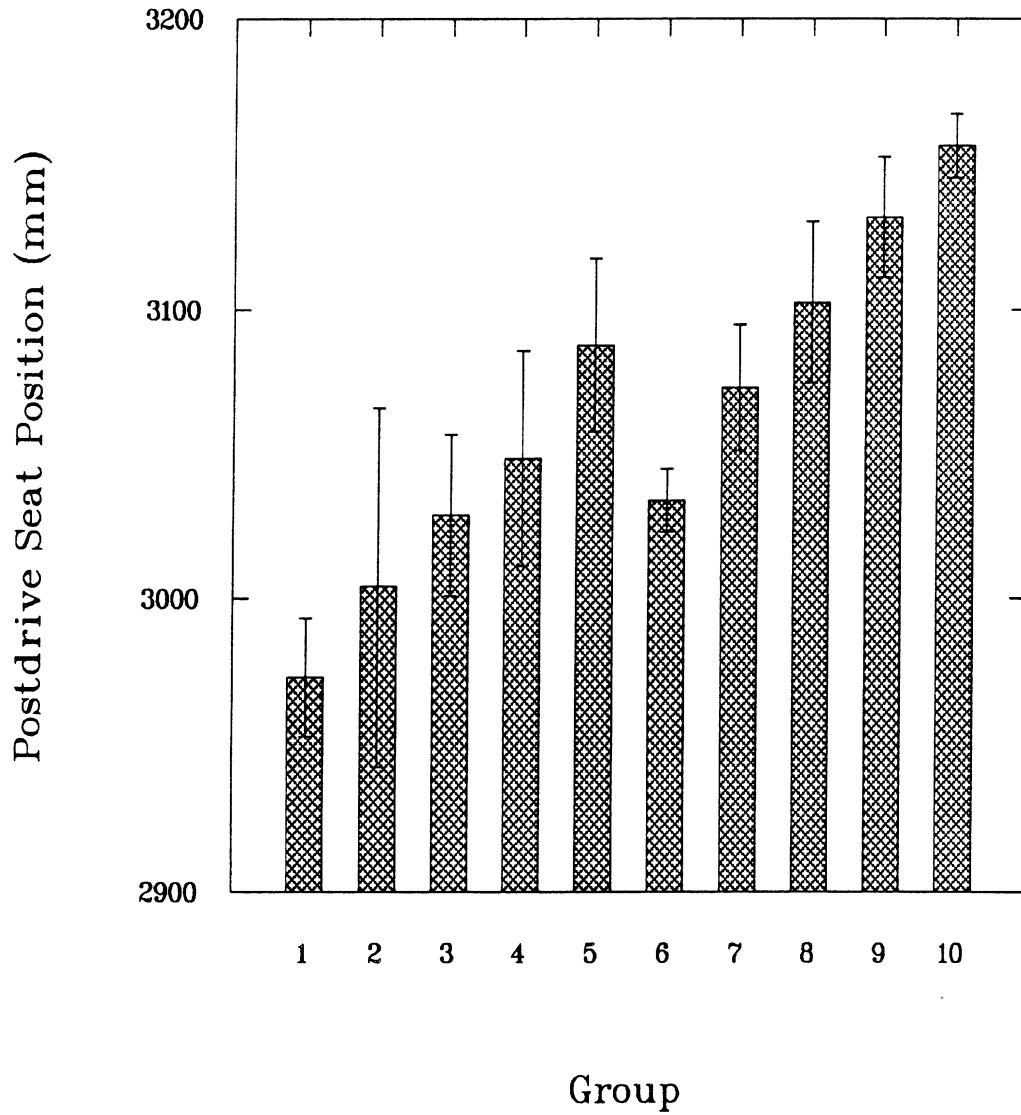


FIGURE J.1

Pontiac 6000 Dynamic Testing

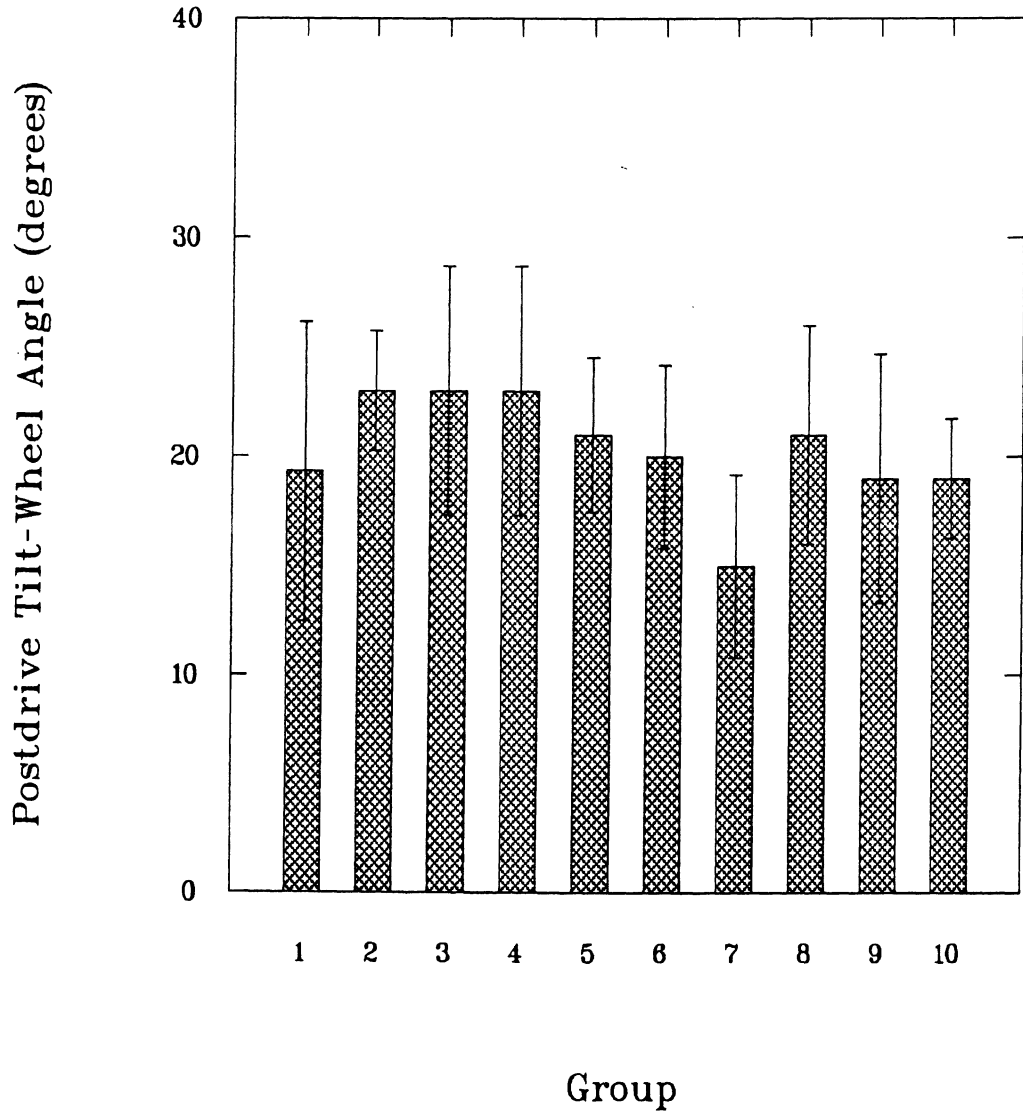


FIGURE J.2

Pontiac 6000 Dynamic vs. Static

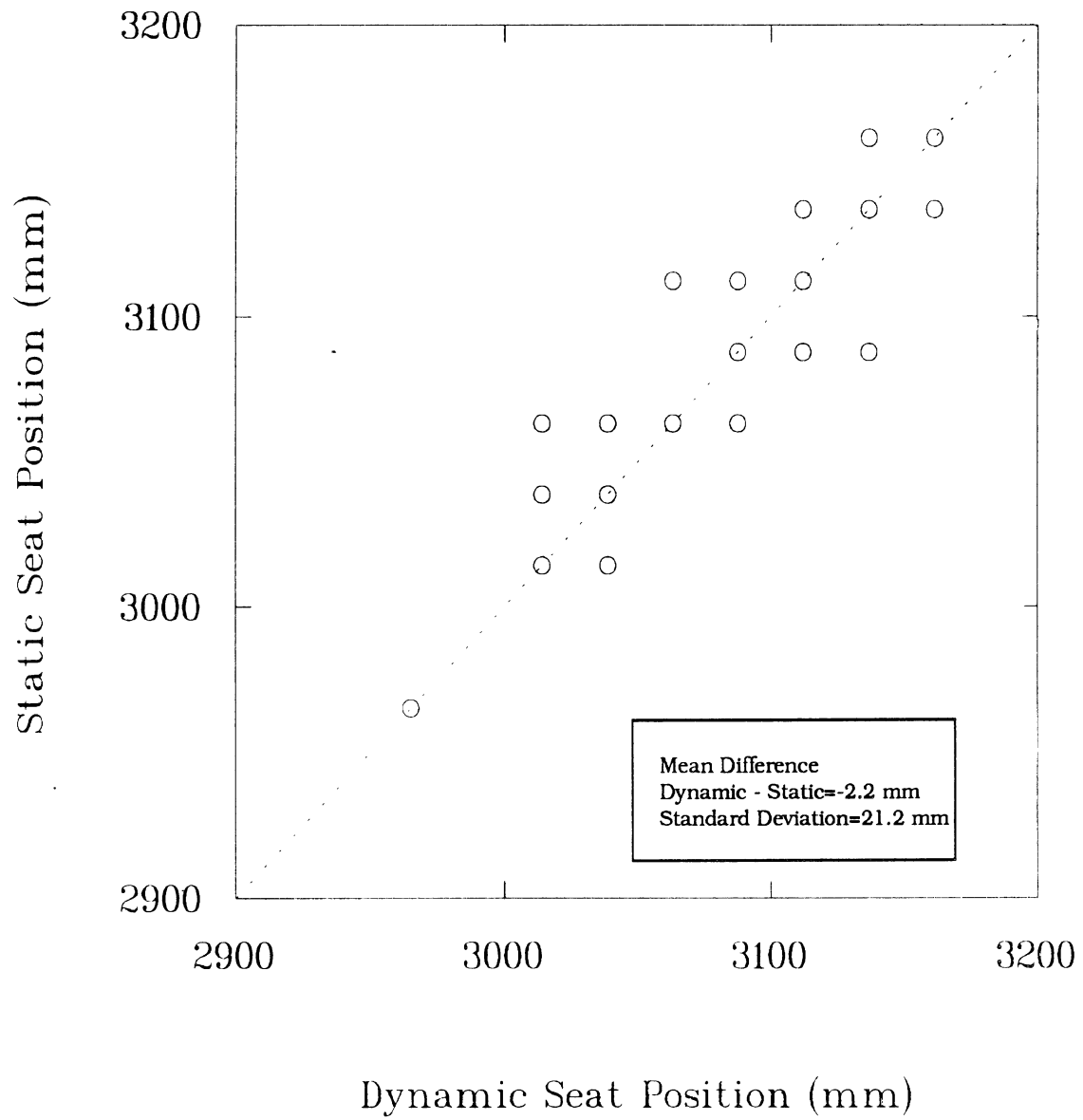


FIGURE J.3

Pontiac 6000 Dynamic vs. Static

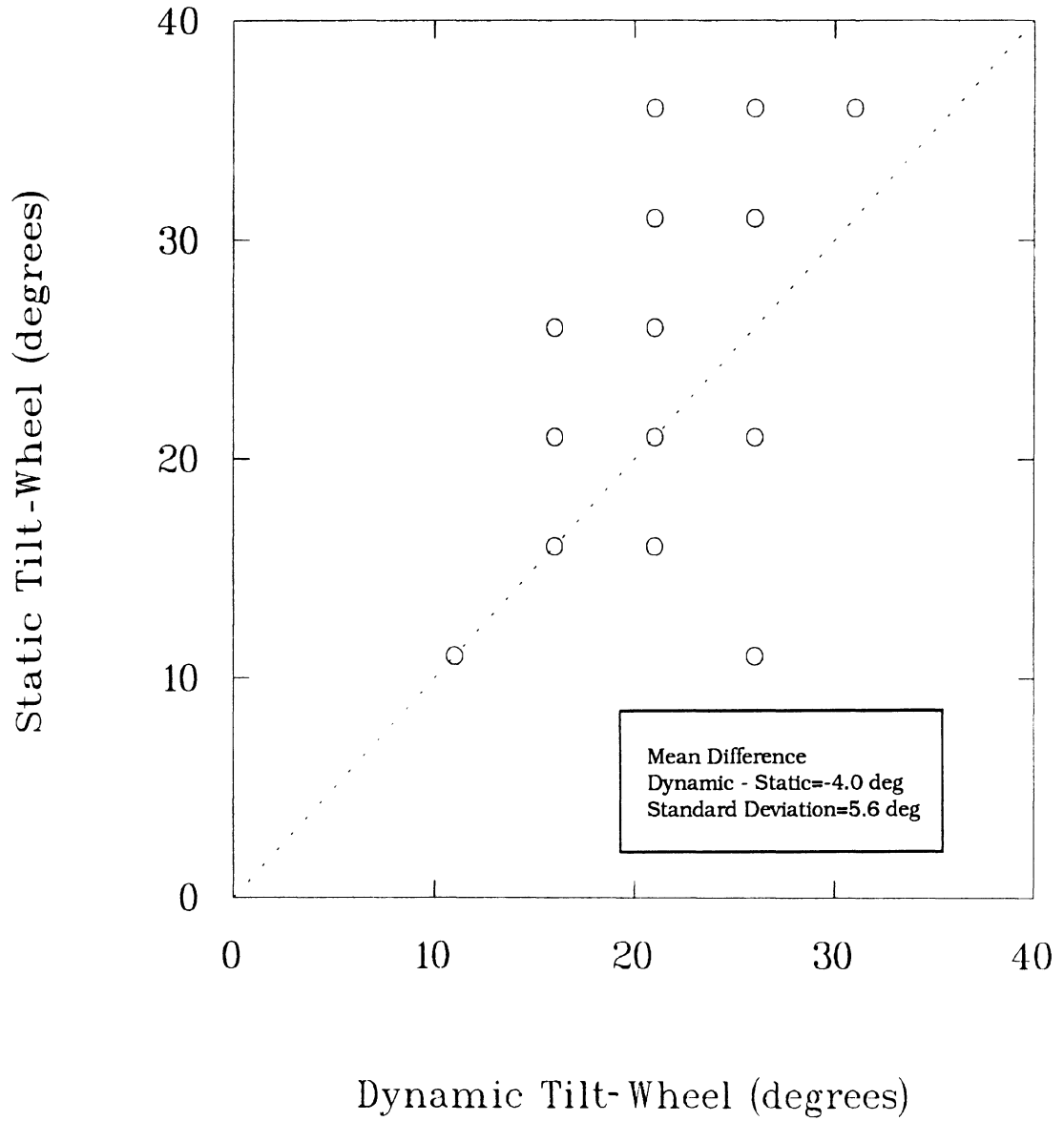


FIGURE J.4

TABLE J.2

PHASE III: EYELLIPSE DATA SUMMARY

Eyellipse Parameters	Pontiac 6000 Dynamic Test			Pontiac 6000 Dynamic Test		
	Observed	Model	Diff.	Observed	Model	Diff.
EYELLIPSE CENTROID						
X	3131.4	3123.2	8.2	3137.2	3123.2	14
Y	334.7	369.6	-34.9	336.7	369.6	-32.9
Z	1119.2	1085.4	33.8	1099.8	1085.4	14.4
XY						
Major Axis	209.2	198.0	11.2	237.2	198.0	39.2
Minor Axis	70.4	105.0	-34.6	75.4	105.0	-29.6
XZ						
Major Axis	214.7	198.0	16.0	242.7	198.0	44.7
Minor Axis	88.8	86.0	2.8	79.1	86.0	-6.9

Eye Ellipse for P6000 (Side View)

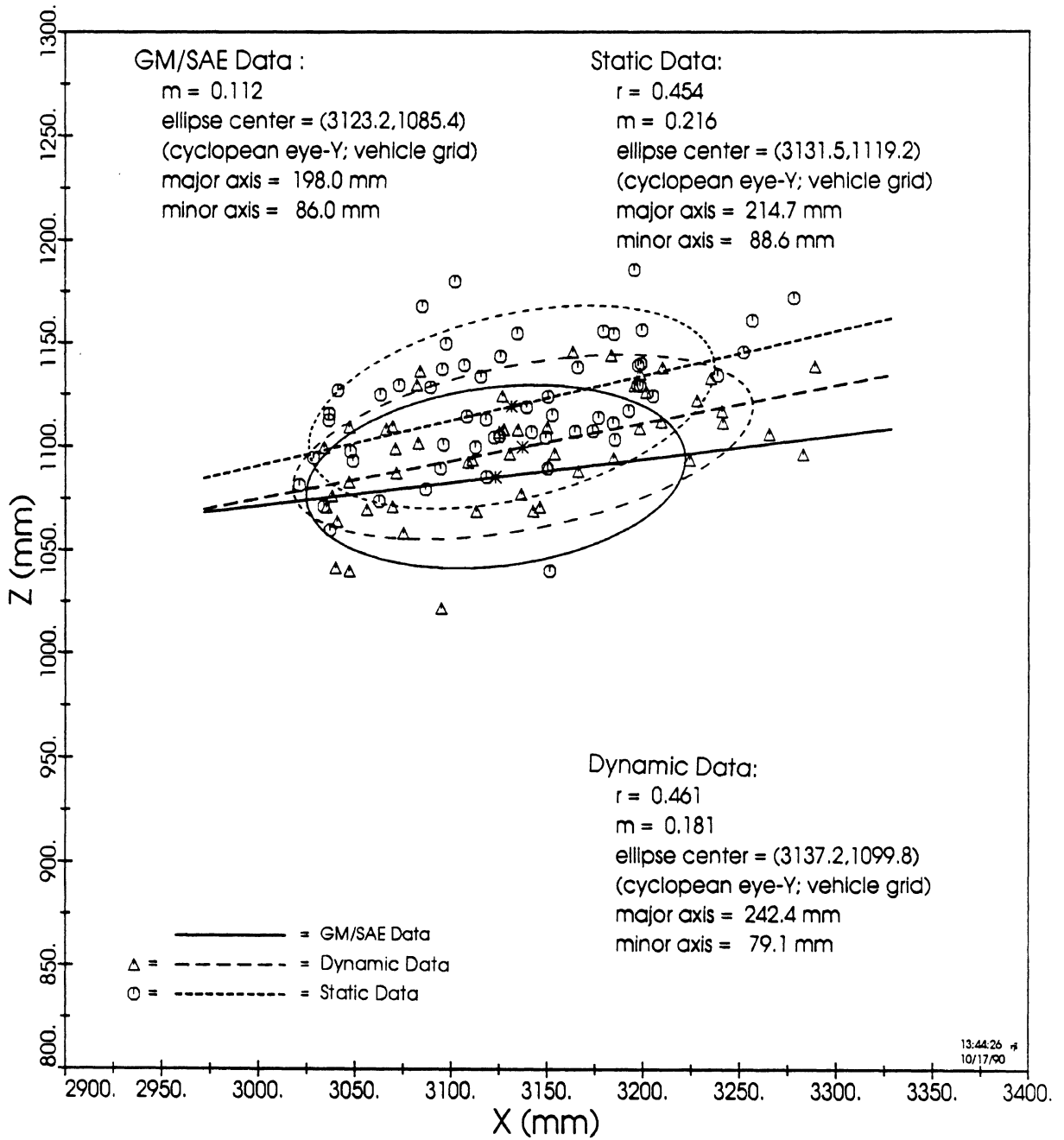


FIGURE J.5

Eye Ellipse for P6000 (Top View)

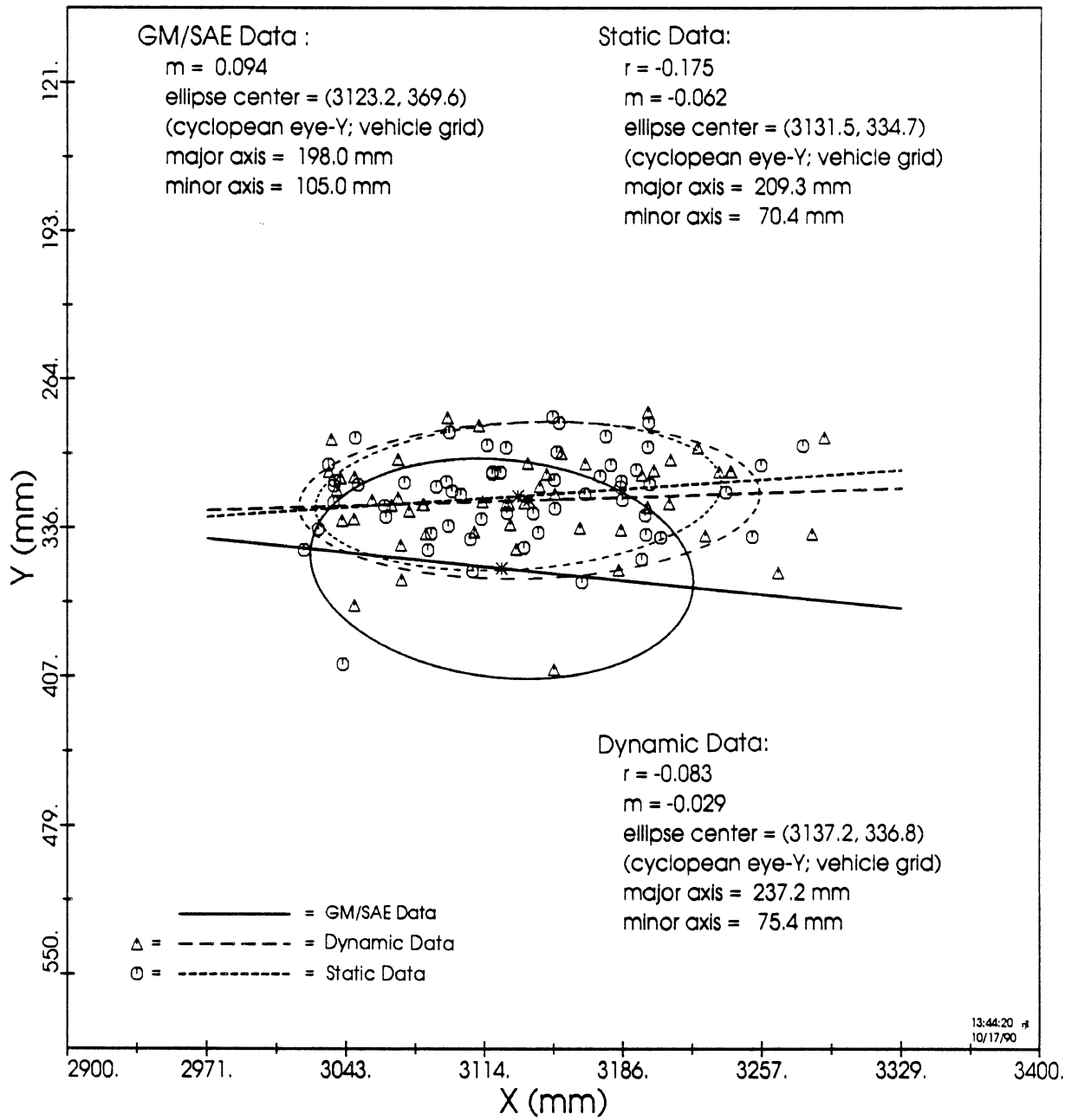


FIGURE J.6

APPENDIX K
DATA BY SUBJECT

ANTHROPOMETRIC DATA (file=anthro.dat)

<u>Variable</u>	<u>Description</u>
subject#	Subject identifying number
sex	Subject gender (1=male, 2=female)
group	Stature grouping (1-10)
ign	Intragroup number
imp/dom	Import or domestic driver (1=import, 2=domestic)
age	Age (yrs)
weight	Weight (lbs)
stature	Height (mm)
sithght	Sitting height (mm)
eyehght	Eye height (sitting, mm)
shldhght	Shoulder height (sitting, mm)
kneehght	Knee height (sitting, mm)
hipbrth	Hip breadth (sitting, mm)
buttknee	Buttock-to-knee length (sitting, mm)
shldbth	Shoulder breadth (sitting, mm)
shldlbow	Shoulder-to-elbow length (mm)
forearm	Forearm length (elbow to fingertip, mm)
maxreach	Maximum reach from wall (standing, mm)
maxgrasp	Maximum grasping reach from wall (standing, mm)
ipd	Interpupillary distance (center to center, mm)

ANTHROPOMETRIC DATA

subject#	sex	group	ign	imp/dom	age	weight	stature	sithght	eyehght	shldhght
20101.1	2	1	1	1	28	127	1540	828	734	575
20102.1	2	1	2	1	45	105	1485	800	706	553
20103.2	2	1	3	2	34	111	1515	823	720	532
20105.2	2	1	5	2	32	105	1535	805	706	534
20106.1	2	1	6	1	27	109	1510	839	730	552
20201.1	2	2	1	1	20	111	1553	805	851	480
20204.2	2	2	4	2	65	181	1553	814	720	556
20203.2	2	2	3	2	47	155	1594	828	731	536
20205.2	2	2	5	2	45	155	1579	798	674	523
20206.2	2	2	6	2	27	127	1588	846	715	564
20207.2	2	2	7	2	40	200	1580	834	727	584
20301.1	2	3	1	1	28	140	1599	869	770	593
20302.1	2	3	2	1	22	116	1595	789	702	544
20303.1	2	3	3	1	39	182	1621	835	741	549
20304.2	2	3	4	2	38	180	1631	886	785	613
20306.1	2	3	6	1	23	151	1628	843	730	563
20402.1	2	4	2	1	44	153	1676	900	793	615
20403.2	2	4	3	2	23	129	1654	844	745	549
20404.2	2	4	4	2	30	126	1655	850	758	581
20405.2	2	4	5	2	56	180	1646	851	749	589
20406.2	2	4	6	2	34	114	1668	854	734	542
20501.1	2	5	1	1	34	145	1733	905	784	602
20502.1	2	5	2	1	44	129	1711	868	779	568
20504.2	2	5	4	2	29	133	1698	876	761	595
20505.2	2	5	5	2	19	124	1724	899	770	611
20506.2	2	5	6	2	36	144	1681	855	772	580
20507.1	2	5	7	1	41	156	1669	889	803	601
10602.1	1	6	2	1	50	146	1645	885	802	581
10603.1	1	6	3	1	29	146	1652	872	723	572
10604.2	1	6	4	2	58	144	1667	855	758	587
10605.2	1	6	5	2	47	166	1664	857	771	658
10606.1	1	6	6	1	25	169	1635	828	743	553
10701.1	1	7	1	1	27	160	1725	923	801	635
10702.1	1	7	2	1	33	170	1682	871	793	589
10703.1	1	7	3	1	51	176	1683	869	769	586
10704.2	1	7	4	2	59	189	1721	882	794	580
10705.2	1	7	5	2	33	178	1721	893	778	610
10706.1	1	7	6	1	19	152	1695	855	750	556
10802.1	1	8	2	1	22	135	1728	904	792	605
10804.2	1	8	4	2	38	232	1751	919	823	9999
10806.2	1	8	6	2	67	174	1743	895	777	619
10807.2	1	8	7	2	49	183	1739	882	793	572
10809.2	1	8	9	2	34	148	1734	893	801	610
10810.1	1	8	10	1	33	186	1753	911	815	609
10901.1	1	9	1	1	27	217	1800	905	785	613
10902.1	1	9	2	1	25	182	1816	956	803	625
10903.2	1	9	3	2	33	197	1787	930	810	584
10904.2	1	9	4	2	39	204	1795	925	812	632
10905.2	1	9	5	2	21	187	1776	893	792	589
10906.1	1	9	6	1	43	217	1808	945	806	587
11001.1	1	10	1	1	33	215	1885	950	843	665
11004.2	1	10	4	2	26	192	1892	956	839	640
11005.2	1	10	5	2	26	188	1839	925	825	657
11006.1	1	10	6	1	24	277	1826	866	720	589
11007.2	1	10	7	2	33	187	1862	889	804	597
20104.2	2	1	4	2	62	188	1544	816	725	554
20407.1	2	4	7	1	43	153	1681	896	791	605

* 9999 indicates missing data

ANTHROPOMETRIC DATA

subject#	kneehght	hipbrth	buttknee	shldbrth	shldlbw	forearm	maxreach	maxgrasp	ipd
20101.1	473	381	524	384	300	415	727	655	58
20102.1	471	376	517	344	322	390	711	641	53
20103.2	485	375	514	388	318	415	772	697	55
20105.2	496	370	551	365	314	401	701	646	54
20106.1	465	350	486	373	318	9999	726	665	55
20201.1	488	366	586	385	334	423	736	662	54
20204.2	515	379	558	427	321	429	792	696	55
20203.2	524	425	587	395	331	429	778	718	57
20205.2	529	389	583	383	358	436	767	717	56
20206.2	475	368	560	417	347	432	735	681	57
20207.2	485	448	603	402	320	432	842	758	54
20301.1	479	320	564	388	325	405	741	665	59
20302.1	521	347	576	386	346	455	809	735	56
20303.1	509	466	622	435	333	431	780	713	57
20304.2	511	401	597	405	337	426	797	714	59
20306.1	509	414	592	402	306	434	795	750	56
20402.1	514	374	576	398	343	454	810	705	59
20403.2	515	330	569	375	348	446	765	699	54
20404.2	513	374	595	401	345	428	755	668	56
20405.2	508	432	591	420	407	466	844	773	61
20406.2	497	361	586	385	358	430	808	715	52
20501.1	554	385	620	418	372	441	789	708	60
20502.1	561	356	595	381	375	472	847	765	57
20504.2	530	352	611	375	344	450	730	778	53
20505.2	554	329	584	394	370	445	784	721	49
20506.2	536	388	621	410	348	446	790	700	61
20507.1	518	447	595	394	355	443	793	746	59
10602.1	530	361	572	419	365	463	824	741	56
10603.1	517	489	362	443	346	443	831	763	54
10604.2	544	351	570	416	351	470	825	737	61
10605.2	525	395	562	457	374	471	784	772	56
10606.1	537	364	581	473	356	465	815	761	57
10701.1	539	374	585	403	350	459	801	721	58
10702.1	508	375	586	438	338	456	807	746	65
10703.1	515	360	580	460	358	455	847	782	62.5
10704.2	571	415	618	465	392	484	870	734	62
10705.2	576	398	616	432	395	504	916	800	68
10706.1	557	343	593	446	379	478	827	768	56
10802.1	554	365	566	400	375	488	836	758	62
10804.2	575	411	660	452	374	478	814	726	64.5
10806.2	589	385	596	456	383	494	886	799	59
10807.2	546	423	626	434	364	488	830	776	64
10809.2	520	354	584	446	363	498	863	754	53
10810.1	568	420	597	463	373	484	836	778	58
10901.1	582	388	636	447	391	506	852	786	66
10902.1	589	359	615	466	384	505	944	854	62
10903.2	558	389	605	444	364	482	876	802	60
10904.2	559	370	624	450	389	488	890	790	61.5
10905.2	561	409	628	465	391	501	856	775	62
10906.1	591	449	611	481	377	516	935	834	74
11001.1	595	395	651	465	401	528	946	844	63
11004.2	609	375	655	494	415	523	917	826	60
11005.2	595	378	636	469	412	535	949	855	64
11006.1	581	464	700	512	396	560	949	856	64
11007.2	568	387	650	457	375	523	925	812	61
20104.2	505	410	586	417	322	427	752	715	56
20407.1	521	432	590	410	356	443	826	749	51

* 9999 indicates missing data

PHASE ONE DATA (file=phase1.dat)

<u>Variable</u>	<u>Description</u>
subject #	Subject identifying number
blazback	Blazer post-drive seat recliner angle (with respect to vertical)
blaztilt	Blazer post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
blazseat	Blazer post-drive seat position (X in vehicle coordinates)
blazpr	Blazer most rearward acceptable seat position in relation to the pedals (X in vehicle coordinates)
blazpf	Blazer most forward acceptable seat position in relation to the pedals (X in vehicle coordinates)
blazpp	Blazer ideal seat position with respect to pedals (X in vehicle coordinates)
blazwr	Blazer most rearward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
blazwf	Blazer most forward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
blazwp	Blazer ideal seat position with respect to steering wheel (X in vehicle coordinates)
cadback	Cadillac post-drive seat recliner angle (with respect to vertical, incorporating seat pan angle measurement)
cadtilt	Cadillac post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
cadseat	Cadillac post-drive seat position (X in vehicle coordinates)
cadpr	Cadillac most rearward acceptable seat position in relation to the pedals (X in vehicle coordinates)
9cadpf	Cadillac most forward acceptable seat position in relation to the pedals (X in vehicle coordinates)
cadpp	Cadillac ideal seat position with respect to pedals (X in vehicle coordinates)
cadwr	Cadillac most rearward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
cadwf	Cadillac most forward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
cadwp	Cadillac ideal seat position with respect to steering wheel (X in vehicle coordinates)
cam1back	Camaro post-drive seat recliner angle (with respect to vertical)
cam1tilt	Camaro post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
cam1seat	Camaro post-drive seat position (X in vehicle coordinates)
cam1pr	Camaro most rearward acceptable seat position in relation to the pedals (X in vehicle coordinates)
cam1pf	Camaro most forward acceptable seat position in relation to the pedals (X in vehicle coordinates)
cam1pp	Camaro ideal seat position with respect to pedals (X in vehicle coordinates)
cam1wr	Camaro most rearward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
cam1wf	Camaro most forward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
cam1wp	Camaro ideal seat position with respect to steering wheel (X in vehicle coordinates)
montback	Monte Carlo post-drive seat recliner angle (with respect to vertical)

PHASE ONE DATA (file=phase1.dat)—Continued

<u>Variable</u>	<u>Description</u>
monttilt	Monte Carlo post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
montseat	Monte Carlo post-drive seat position (X in vehicle coordinates)
montpr	Monte Carlo most rearward acceptable seat position in relation to the pedals (X in vehicle coordinates)
montpf	Monte Carlo most forward acceptable seat position in relation to the pedals (X in vehicle coordinates)
montpp	Monte Carlo ideal seat position with respect to pedals (X in vehicle coordinates)
montwr	Monte Carlo most rearward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
montwf	Monte Carlo most forward acceptable seat position in relation to the steering wheel (X in vehicle coordinates)
montwp	Monte Carlo ideal seat position with respect to steering wheel (X in vehicle coordinates)

PHASE ONE DATA 7/24/90

subject#	blazback	blaztilt	blazseat	blazpr	blazpf	blazpp	blazwr	blazwf	blazwp
20101	27	16.5	2229	2292	2229	2250	2292	2229	2271
20102	23	31.5	2229	2229	2229	2229	2292	2292	2292
20103	31	26.5	2229	2292	2229	2229	2334	2229	2229
20105	25	26.5	2250	2271	2229	2250	2292	2250	2271
20106	27	26.5	2355	2271	2229	2229	2292	2229	2250
20201	31	26.5	2271	2292	2229	2250	2313	2250	2292
20204	21	21.5	2292	2334	2271	2313	2355	2292	2313
20203	19	26.5	2334	2355	2313	2334	2376	2313	2334
20205	19	21.5	2334	2418	2313	2376	2439	2334	2397
20206	25	26.5	2292	2313	2250	2292	2355	2250	2292
20207	29	26.5	2292	2355	2271	2313	2397	2292	2334
20301	23	16.5	2313	2334	2250	2313	2376	2250	2292
20302	19	26.5	2313	2355	2229	2313	2418	2292	2355
20303	21	21.5	2313	2334	2250	2292	2376	2250	2292
20304	19	11.5	2334	2397	2271	2334	2376	2229	2334
20306	19	16.5	2334	2397	2292	2355	2397	2292	2355
20402	21	16.5	2355	2397	2313	2376	2439	2334	2376
20403	19	16.5	2271	2292	2250	2271	2355	2250	2292
20404	21	21.5	2313	2355	2271	2313	2418	2271	2334
20405	19	26.5	2376	2418	2334	2376	2460	2313	2418
20406	27	26.5	2355	2397	2355	2355	2418	2313	2397
20501	21	21.5	2397	2439	2355	2397	2439	2334	2397
20502	19	21.5	2397	2439	2355	2397	2439	2334	2397
20504	19	16.5	2376	2418	2313	2376	2460	2292	2418
20505	19	21.5	2397	2418	2355	2397	2439	2334	2376
20506	29	11.5	2313	2376	2271	2313	2376	2271	2313
20507	19	21.5	2334	2376	2292	2334	2418	2334	2355
10602	31	21.5	2292	2313	2271	2292	2355	2334	2334
10603	25	21.5	2313	2397	2229	2313	2439	2229	2334
10604	25	11.5	2334	2376	2334	2355	2376	2313	2355
10605	19	11.5	2292	2355	2229	2313	2397	2271	2334
10606	19	11.5	2313	2334	2292	2334	2376	2292	2292
10701	31	26.5	2355	2355	2334	2355	2376	2334	2376
10702	21	21.5	2355	2376	2292	2355	2460	2355	2397
10703	19	21.5	2334	2376	2313	2334	2397	2334	2355
10704	21	26.5	2355	2397	2355	2376	2418	2334	2397
10705	19	26.5	2376	2418	2355	2376	2460	2334	2376
10706	23	16.5	2313	2355	2271	2313	2376	2292	2334
10802	19	21.5	2292	2334	2250	2292	2376	2313	2355
10804	23	21.5	2397	2418	2313	2397	2460	2334	2418
10806	23	26.5	2376	2418	2355	2376	2397	2334	2376
10807	19	21.5	2397	2439	2397	2418	2439	2355	2418
10809	23	21.5	2376	2397	2313	2334	2439	2376	2418
10810	19	11.5	2355	2418	2313	2355	2439	2376	2397
10901	19	21.5	2397	2439	2355	2355	2439	2334	2355
10902	31	31.5	2397	2439	2355	2397	2418	2397	2418
10903	25	16.5	2397	2439	2334	2397	2460	2313	2418
10904	31	31.5	2397	2460	2376	2439	2460	2376	2439
10905	23	31.5	2418	2439	2334	2397	2439	2355	2397
10906	21	21.5	2418	2439	2313	2397	2460	2355	2418
11001	25	26.5	2460	2460	2376	2439	2439	2376	2397
11004	25	26.5	2439	2460	2334	2439	2460	2355	2439
11005	29	26.5	2439	2460	2334	2439	2460	2334	2418
11006	21	21.5	2439	2460	2439	2439	2460	2439	2439
11007	19	21.5	2439	2460	2334	2460	2460	2334	2460
20104	9999	9999	9999	9999	9999	9999	9999	9999	9999
20407	9999	9999	9999	9999	9999	9999	9999	9999	9999

**9999 denotes missing data

PHASE ONE DATA 7/24/90

subject#	cadback	cadtilt	cadseat	cadpr	cadpf	cadpp	cadwr	cadwf	cadwp
20101	11	16	3044	3086	3044	3065	3128	3054	3075
20102	13	26	3044	3058	3033	3044	3075	3050	3058
20103	16	21	3029	3086	2991	3052	3130	2993	3014
20105	14	21	3044	3075	3039	3054	3100	3058	3067
20106	18	21	3054	3075	2999	3031	3113	3033	3065
20201	26.5	21	3033	3065	3002	3046	3086	3018	3062
20204	19	21	3075	3100	2997	3056	3113	3033	3056
20203	18	21	3100	3125	3083	3092	3117	3088	3104
20205	9999	16	3128	3212	3096	3149	3212	3117	3191
20206	23	26	3075	3128	2981	3054	3096	3023	3075
20207	20	11	3079	3107	3039	3081	3130	3046	3077
20301	20	11	3088	3117	3018	3069	3121	3054	3081
20302	17	21	3081	3134	3044	3092	3201	3058	3102
20303	16	11	3096	3155	3054	3092	3170	3044	3075
20304	17	11	3121	3178	3044	3113	3199	3044	3096
20306	17	16	3121	3170	3054	3146	3193	3079	3130
20402	17	16	3136	3159	3058	3107	3172	3083	3125
20403	13	16	3044	3092	3044	3060	3102	3044	3060
20404	15	16	3123	3159	3083	3117	3149	3065	3117
20405	16	26	3134	3170	3086	3138	3201	3117	3159
20406	22	21	3130	3170	3020	3128	3155	3071	3146
20501	18	16	3159	3170	3107	3155	3170	3081	3159
20502	19	16	3134	3212	3117	3163	3212	3100	3149
20504	18	11	3159	3212	3075	3172	3212	3071	3159
20505	17	16	3149	3176	3113	3142	3180	3092	3134
20506	18	11	3117	3212	3075	3138	3212	3044	3107
20507	18	16	3117	3191	3075	3107	3121	3023	3086
10602	23.5	26	3086	3111	3065	3088	3128	3060	3094
10603	22	16	3128	3159	2987	3077	3191	2970	3075
10604	16	21	3096	3117	3100	3113	3159	3113	3117
10605	25	11	3050	3100	3016	3050	3104	3018	3044
10606	18	6	3073	3117	3054	3079	3117	3083	3100
10701	28	21	3100	3123	3075	3096	3123	3052	3081
10702	20	21	3113	3138	3065	3096	3128	3062	3117
10703	19	16	3117	3165	3079	3096	3184	3079	3113
10704	18	16	3134	3180	3096	3138	3191	3058	3134
10705	13	16	3155	3199	2997	3142	3212	3109	3157
10706	20	16	3079	3117	3065	3075	3121	3044	3083
10802	24	16	3121	3138	3054	3107	3212	3094	3140
10804	19	16	3170	3188	3073	3163	3212	3052	3153
10806	17	16	3117	3176	3117	3144	3176	3113	3136
10807	23	16	3128	3176	3115	3159	3170	3081	3117
10809	19	16	3144	3203	3071	3121	3212	3081	3157
10810	17	6	3134	3191	3088	3191	3212	3119	3170
10901	22	16	3132	3212	3115	3159	3174	3107	3138
10902	21.5	26	3167	3201	3138	3170	3180	3165	3178
10903	24	16	3184	3186	3140	3170	3212	3092	3182
10904	22.5	26	3117	3180	3107	3149	3197	3100	3149
10905	18	26	3170	3212	3142	3182	3197	3107	3153
10906	25	26	3191	3199	3079	3167	3212	3117	3180
11001	23	21	3180	3205	3163	3205	3170	3100	3159
11004	28	21	3191	3233	3086	3180	3212	3096	3184
11005	22	16	3159	3212	3096	3197	3180	3138	3117
11006	22	21	3212	3212	3149	3212	3212	3170	3207
11007	20	16	3203	3212	3136	3212	3212	3100	3188
20104	9999	9999	9999	9999	9999	9999	9999	9999	9999
20407	9999	9999	9999	9999	9999	9999	9999	9999	9999

**9999 denotes missing data

PHASE ONE DATA 7/24/90

subject#	camlback	camltilt	camlseat	camlpr	camlpf	camlpp	camlwr	camlwf	camlwp
20101	26	16.5	2950	3013	2929	2971	3034	2950	2971
20102	26	26.5	2939	2961	2940	2961	3003	2961	2982
20103	26	16.5	2939	3003	2919	2940	3066	2919	2940
20105	29	26.5	2939	2961	2919	2940	3003	2919	2961
20106	33.5	21.5	2939	2961	2919	2940	3003	2940	2961
20201	32	21.5	2960	3003	2940	2982	3024	2961	3003
20204	32	21.5	3023	3045	2982	3024	3108	3024	3045
20203	21.5	21.5	3023	3045	3003	3024	3066	3024	3045
20205	35	26.5	3086	3150	3087	3129	3171	3108	3150
20206	27.5	21.5	3023	3045	2982	3024	3087	2982	3045
20207	26	16.5	3002	3045	2961	2982	3066	2940	3024
20301	24.5	11.5	3044	3066	3024	3024	3087	3003	3066
20302	23	21.5	3023	3087	2961	3024	3129	2982	3045
20303	32	21.5	3023	3066	2982	3024	3108	2982	3024
20304	23	11.5	3044	3087	3003	3045	3129	3003	3045
20306	35	16.5	3065	3108	3045	3087	3150	3066	3087
20402	24.5	11.5	3034	3055	3013	3055	3097	3013	3055
20403	35	21.5	3002	3045	3003	3024	3066	3003	3024
20404	27.5	21.5	3023	3045	2982	3024	3087	2961	3024
20405	21.5	21.5	3065	3108	3003	3066	3150	3024	3108
20406	29	16.5	3065	3087	3003	3066	3129	3024	3066
20501	29	16.5	3065	3108	3024	3066	3087	3024	3066
20502	23	16.5	3076	3139	3034	3097	3139	3076	3097
20504	23	11.5	3097	3139	2992	3097	3139	2992	3118
20505	27.5	21.5	3065	3087	3045	3066	3108	3024	3066
20506	27.5	11.5	3044	3087	2982	3066	3108	2982	3045
20507	23	16.5	3065	3087	3024	3066	3150	3003	3066
10602	27.5	21.5	3023	3066	3024	3045	3087	3024	3045
10603	26	21.5	3044	3087	2877	3024	3150	2961	3087
10604	30.5	31.5	3065	3087	3024	3045	3087	3045	3087
10605	30.5	11.5	3023	3045	2982	3024	3045	3003	3045
10606	26	11.5	3002	3024	2982	3024	3087	2940	3024
10701	36.5	21.5	3044	3066	3024	3045	3066	3024	3045
10702	26	16.5	3044	3045	3003	3045	3129	3087	3129
10703	24.5	21.5	3044	3045	3024	3045	3129	3045	3066
10704	32	16.5	3065	3108	3066	3087	3150	3024	3108
10705	26	21.5	3086	3108	3045	3087	3150	3087	3108
10706	33.5	21.5	3023	3066	3003	3024	3108	3024	3045
10802	20	16.5	3023	3087	3003	3045	3150	3024	3087
10804	26	16.5	3090	3112	3024	3066	3150	3024	3108
10806	27.5	21.5	3065	3108	3045	3066	3108	3045	3087
10807	23	21.5	3128	3150	3087	3129	3150	3066	3108
10809	24.5	16.5	3086	3108	3024	3066	3171	3066	3150
10810	29	16.5	3065	3087	3003	3045	3087	3003	3045
10901	23	16.5	3128	3171	3087	3150	3171	3087	3129
10902	29	26.5	3086	3129	3066	3108	3129	3066	3108
10903	32	16.5	3107	3129	3045	3108	3129	3045	3108
10904	29	31.5	3128	3150	3108	3150	3150	3087	3150
10905	24.5	26.5	3128	3150	3066	3108	3150	3066	3129
10906	35	26.5	3107	3129	3024	3108	3150	3024	3108
11001	27.5	26.5	3139	3181	3118	3181	3160	3076	3097
11004	29	21.5	3149	3171	3066	3150	3171	3045	3129
11005	35	26.5	3023	3171	3066	3129	3171	3045	3108
11006	29	16.5	3107	3150	3087	3129	3150	3108	3129
11007	26	16.5	3170	3171	3045	3171	3171	3024	3171
20104	9999	9999	9999	9999	9999	9999	9999	9999	9999
20407	9999	9999	9999	9999	9999	9999	9999	9999	9999

**9999 denotes missing data

PHASE ONE DATA 7/24/90

subject#	montback	montilt	montseat	montpr	montpf	montpp	montwr	montwf	montwp
20101	22	19	3014	3056	3014	3035	3098	3056	3077
20102	23.5	34	2972	2993	2951	2972	3014	2993	3014
20103	23.5	24	2972	3077	2951	2972	3098	2951	2951
20105	20.5	29	3024	3046	3025	3025	3067	3025	3046
20106	23.5	24	2982	3004	2941	2983	3046	2983	3004
20201	28	29	3035	3056	3014	3035	3077	3014	3056
20204	31	24	3066	3088	3046	3067	3088	3046	3088
20203	20.5	19	3066	3088	3025	3067	3088	3046	3067
20205	26.5	19	3108	3130	3067	3130	3172	3046	3130
20206	23.5	29	3066	3088	3025	3067	3130	3025	3067
20207	25	24	3045	3109	3025	3067	3172	3046	3088
20301	22	14	3087	3130	3046	3088	3109	3067	3088
20302	22	24	3045	3109	3025	3067	3172	3046	3088
20303	20.5	24	3066	3109	3004	3067	3151	3025	3067
20304	25	9	3066	3109	3025	3067	3151	3025	3067
20306	20.5	19	3087	3151	3067	3109	3172	3067	3067
20402	20.5	14	3066	3088	3067	3067	3088	3088	3088
20403	20.5	19	3014	3056	3014	3014	3077	2972	3014
20404	22	24	3087	3130	3025	3088	3151	3025	3088
20405	20.5	29	3108	3130	3025	3109	3172	3046	3130
20406	28	19	3087	3130	3025	3109	3172	3046	3130
20501	32.5	19	3129	3172	3088	3151	3172	3046	3151
20502	22	19	3108	3151	3046	3109	3172	3067	3130
20504	20.5	14	3129	3193	3067	3151	3193	2993	3119
20505	23.5	19	3108	3151	3109	3130	3151	3067	3109
20506	23.5	14	3045	3130	3035	3077	3161	2993	3056
20507	34	19	3087	3109	3046	3067	3172	3046	3109
10602	28	29	3066	3088	3046	3067	3109	3067	3088
10603	23.5	19	3066	3130	2941	3046	3161	2941	3067
10604	28	24	3066	3109	3046	3067	3130	3067	3088
10605	20.5	9	3066	3109	3046	3088	3109	3046	3088
10606	20.5	9	3045	3088	2993	3035	3077	2993	3035
10701	34	24	3087	3109	3067	3088	3109	3067	3088
10702	26.5	24	3066	3109	3025	3067	3130	3067	3088
10703	20.5	19	3087	3109	3046	3067	3130	3046	3067
10704	22	19	3108	3151	3067	3130	3172	3067	3130
10705	20.5	19	3108	3130	3067	3109	3151	3109	3130
10706	25	19	3066	3109	3014	3056	3119	3014	3077
10802	20.5	24	3045	3088	3025	3067	3172	3067	3109
10804	22	19	3129	3172	3025	3130	3193	3046	3130
10806	23.5	24	3108	3130	3067	3109	3151	3088	3130
10807	20.5	24	3150	3193	3109	3172	3193	3088	3130
10809	20.5	14	3129	3151	3088	3130	3193	3109	3172
10810	20.5	14	3108	3172	3067	3109	3151	3088	3109
10901	20.5	24	3150	3193	3109	3172	3193	3130	3172
10902	25	19	3150	3193	3088	3130	3172	3130	3151
10903	28	19	3150	3172	3109	3151	3193	3088	3172
10904	26.5	24	3171	3193	3151	3193	3193	3151	3193
10905	25	29	3129	3172	3088	3151	3172	3088	3130
10906	25	19	3129	3172	3046	3130	3193	3067	3172
11001	20.5	29	3171	3193	3130	3172	3193	3151	3193
11004	28	44	3171	3193	3088	3172	3193	3067	3151
11005	34	34	3108	3193	3046	3151	3193	3046	3130
11006	22	24	3192	3214	3130	3193	3214	3172	3214
11007	32.5	24	3192	3193	3067	3193	3193	3046	3193
20104	9999	9999	9999	9999	9999	9999	9999	9999	9999
20407	9999	9999	9999	9999	9999	9999	9999	9999	9999

**9999 denotes missing data

PHASE TWO DATA (file=phase2.dat)

<u>Variable</u>	<u>Description</u>
subject#	Subject identifying number
oldsback	Oldsmobile post-drive seat recliner angle (with respect to vertical)
oldstilt	Oldsmobile post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
oldsseat	Oldsmobile post-drive seat position (X in vehicle coordinates)
oldsped	Oldsmobile post-drive pedal position (X coordinate from design position)
cam2back	Camaro post-drive seat recliner angle (with respect to vertical)
cam2tilt	Camaro post-drive tilt-wheel angle (angle of steering wheel plane with respect to vertical)
cam2seat	Camaro post-drive seat position (X in vehicle coordinates)
cam2ped	Camaro post-drive pedal position (X coordinate from design position)
ponttilt	Pontiac 6000 static tilt-wheel angle (angle of steering wheel plane with respect to vertical)
pontseat	Pontiac 6000 static seat position (X in vehicle coordinates)

PHASE TWO DATA 7/24/90

subject#	oldsback	oldstilt	oldsseat	oldsped	cam2back	cam2tilt	cam2seat	cam2ped
	9999	9999	9999	9999	9999	9999	9999	9999
20101	9999	9999	9999	9999	9999	9999	9999	9999
20102	24	16	2994	56	22	21.5	2960	90
20103	27	16	2964	0	26.5	21.5	2918	21
20105	27	16	2990	25	29.5	26.5	2960	65
20106	23	21	3021	77	26.5	21.5	2939	69
20201	27	16	3046	41	29.5	26.5	3002	86
20204	25	21	3053	20	25	26.5	3002	63
20203	24	21	3090	63	22	21.5	3065	109
20205	20	21	3095	25	22	16.5	3034	48
20206	25	16	3074	32	22	26.5	3065	101
20207	29	21	3067	61	25	16.5	3023	82
20301	25	26	3053	61	25	16.5	3002	76
20302	21	21	3046	23	22	21.5	3023	88
20303	20	26	3076	11	28	16.5	3002	21
20304	26	36	3103	59	29.5	6.5	3002	40
20306	25	21	3069	18	19	16.5	3065	67
20402	21	26	3116	43	23.5	16.5	3065	92
20403	9999	9999	9999	9999	9999	9999	9999	9999
20404	26	21	3036	45	23.5	16.5	3048	74
20405	22	26	3069	11	23.5	16.5	3065	63
20406	30	26	3067	0	22	16.5	3065	50
20501	22	26	3139	5	26.5	11.5	3023	-11
20502	23	26	3078	13	23.5	11.5	3002	-11
20504	26	26	3139	19	25	16.5	3086	67
20505	22	21	3124	19	25	16.5	3065	53
20506	22	26	3082	29	28	11.5	3002	19
20507	25	26	3084	32	25	16.5	3023	65
10602	27	16	3067	23	29.5	21.5	3023	88
10603	27	21	3063	54	22	26.5	3086	124
10604	23	16	3111	18	22	26.5	3086	80
10605	21	21	3084	30	29.5	16.5	3023	38
10606	27	36	3008	9999	26.5	6.5	3002	6
10701	32	21	3078	13	31	21.5	3065	84
10702	22	21	3101	32	23.5	21.5	3086	122
10703	23	21	3074	20	22	26.5	3044	46
10704	25	21	3095	3	26.5	16.5	3044	21
10705	19	26	3179	62	20.5	11.5	3128	105
10706	23	21	3097	72	26.5	21.5	3023	65
10802	18	26	3088	45	18	21.5	3082	107
10804	24	21	3143	23	19	16.5	3118	84
10806	25	16	3103	0	29.5	26.5	3023	-11
10807	26	16	3147	0	25	26.5	3128	38
10809	22	31	3126	27	19	16.5	3149	116
10810	21	36	3088	41	23.5	11.5	3044	38
10901	28	21	3107	0	23.5	21.5	3107	32
10902	22	16	3158	36	28	26.5	3086	74
10903	28	26	3189	59	28	11.5	3128	34
10904	26	16	3195	59	23.5	26.5	3128	53
10905	27	11	3134	2	25	26.5	3128	76
10906	25	36	3153	27	32.5	11.5	3023	0
11001	26	21	3179	0	20.5	21.5	3128	32
11004	29	16	3176	13	25	21.5	3160	65
11005	30	16	3164	23	29.5	31.5	3149	63
11006	22	21	3191	26	23.5	21.5	3170	63
11007	22	26	3195	0	28	16.5	3149	21
20104	28	26	3000	0	25	21.5	2981	84
20407	26	21	3042	0	25	21.5	3044	42

**9999 denotes missing data

PHASE TWO DATA 7/24/90

subject#	pontilt	pontseat
20101	9999	9999
20102	11	2959
20103	21	2959
20105	16	2959
20106	26	2959
20201	16	3008
20204	16	3032
20203	21	3032
20205	26	3081
20206	26	3032
20207	21	3008
20301	21	3032
20302	21	3032
20303	26	3057
20304	36	3057
20306	31	3057
20402	26	3057
20403	9999	9999
20404	21	3032
20405	16	3081
20406	26	3081
20501	26	3130
20502	36	3106
20504	26	3081
20505	26	3106
20506	36	3057
20507	26	3057
10602	21	3032
10603	21	3008
10604	26	3057
10605	31	3032
10606	36	3057
10701	26	3081
10702	21	3032
10703	26	3057
10704	16	3081
10705	26	3106
10706	21	3032
10802	26	3057
10804	26	3106
10806	21	3057
10807	21	3130
10809	31	3081
10810	31	3057
10901	21	3130
10902	26	3106
10903	31	3155
10904	11	3155
10905	11	3155
10906	36	3155
11001	21	3130
11004	16	3155
11005	16	3155
11006	26	3155
11007	26	3155
20104	21	3008
20407	26	3057

**9999 denotes missing data

PHASE ONE AND PHASE TWO EYE DATA (file=ph12eye.dat)

<u>Variable</u>	<u>Description</u>
subject#	Subject identifying number
blazx	Blazer eye position X coordinate
blazy	Blazer eye position Y coordinate
blazz	Blazer eye position Z coordinate
cadx	Cadillac eye position X coordinate
cady	Cadillac eye position Y coordinate
cadz	Cadillac eye position Z coordinate
cam1x	Camaro eye position X coordinate
cam1y	Camaro eye position Y coordinate
cam1z	Camaro eye position Z coordinate
montx	Monte Carlo eye position X coordinate
monty	Monte Carlo eye position Y coordinate
montz	Monte Carlo eye position Z coordinate
pont1x	Pontiac 6000 static eye position X coordinate
pont1y	Pontiac 6000 static eye position Y coordinate
pont1z	Pontiac 6000 static eye position Z coordinate

PHASE ONE AND PHASE TWO EYE POSITION DATA

subject#	blazx	blazy	blazz	cadx	cady	cadz	camlx	camly	camlz
20101	2283	398	1447	3005	389	1290	2983	395	1220
20102	2260	349	1438	3033	388	1312	2975	389	1206
20103	2321	350	1453	3066	376	1319	3016	367	1239
20105	2272	362	1436	3040	374	1305	3006	377	1218
20106	2277	364	1455	3052	383	1301	3003	381	1238
20201	2377	360	1433	3130	393	1291	3079	389	1214
20204	2301	385	1452	3050	394	1280	3026	390	1221
20203	2336	357	1470	3096	378	1323	3026	395	1246
20205	2278	345	1421	3071	341	1305	3031	371	1204
20206	2341	350	1480	3139	364	1324	3071	382	1248
20207	2305	360	1470	3094	378	1327	3032	383	1247
20301	2394	365	1491	3147	382	1332	3104	396	1271
20302	2306	393	1442	3091	399	1297	3022	405	1214
20303	2342	380	1464	3115	405	1333	3044	421	1236
20304	2304	329	1489	3125	329	1344	3058	357	1259
20306	2294	354	1461	3080	366	1311	3031	380	1237
20402	2368	368	1500	3166	390	1366	3061	387	1284
20403	2240	357	1476	3011	369	1326	2967	385	1255
20404	2334	351	1472	3078	388	1327	3094	399	1246
20405	2338	381	1462	3116	385	1321	3064	422	1243
20406	2429	351	1467	3203	364	1315	3145	367	1238
20501	2377	363	1489	3163	398	1351	3126	388	1263
20502	2431	345	1484	3154	375	1337	3051	378	1260
20504	2404	371	1475	3194	400	1339	3150	399	1243
20505	2421	369	1495	3175	410	1357	3146	396	1254
20506	2372	384	1461	3154	397	1309	3117	403	1233
20507	2305	371	1534	3114	391	1356	3096	418	1291
10602	2353	389	1487	3136	410	1331	3056	427	1261
10603	2368	364	1506	3145	392	1343	3110	389	1276
10604	2366	405	1491	3070	423	1359	3142	430	1248
10605	2257	353	1494	3071	396	1340	3062	390	1256
10606	2327	376	1472	3101	399	1328	3021	407	1261
10701	2449	354	1492	3240	400	1310	3184	391	1245
10702	2300	382	1500	3110	397	1337	3028	401	1267
10703	2327	382	1525	3113	412	1376	3055	406	1294
10704	2344	345	1470	3149	367	1329	3072	377	1252
10705	2357	373	1493	3101	390	1363	3110	404	1260
10706	2357	378	1507	3136	389	1353	3096	409	1264
10802	2324	373	1524	3074	384	1386	3006	399	1297
10804	2454	371	1524	3224	395	1379	3173	404	1292
10806	2376	408	1503	3136	445	1364	3103	444	1263
10807	2385	372	1510	3158	382	1371	3129	416	1271
10809	2400	367	1525	3164	366	1361	3126	386	1293
10810	2308	363	1526	3099	369	1364	3071	406	1294
10901	2433	362	1528	3216	396	1360	3161	396	1281
10902	2485	376	1506	3223	400	1352	3180	388	1276
10903	2464	336	1520	3264	355	1346	3203	351	1275
10904	2466	402	1509	3251	409	1335	3189	420	1270
10905	2452	359	1510	3216	400	1364	3210	392	1269
10906	2354	401	1537	3211	409	1363	3180	434	1279
11001	2432	357	1526	3202	346	1370	3149	366	1296
11004	2550	345	1528	3337	369	1369	3282	387	1277
11005	2468	404	1504	3223	399	1350	3202	426	1257
11006	2432	367	1489	3167	367	1343	3156	407	1250
11007	2423	398	1499	3227	430	1329	3188	419	1249
20104	9999	9999	9999	9999	9999	9999	9999	9999	9999
20407	9999	9999	9999	9999	9999	9999	9999	9999	9999

** 9999 denotes missing data

PHASE ONE AND PHASE TWO EYE POSITION DATA

subject#	montx	monty	montz	pontlx	pontly	pontlz
20101	3025	404	1287	9999	9999	9999
20102	3000	387	1275	3037	354	1060
20103	3020	377	1312	3049	357	1093
20105	3025	382	1276	3034	346	1071
20106	3023	383	1311	3029	378	1095
20201	3105	378	1276	3118	350	1086
20204	3039	390	1298	3063	367	1074
20203	3066	383	1322	3096	333	1101
20205	3110	358	1264	3151	342	1040
20206	3100	381	1334	3118	353	1113
20207	3047	388	1323	3037	357	1115
20301	3128	376	1331	3153	329	1115
20302	3061	392	1294	3087	381	1080
20303	2980	391	1316	3150	355	1090
20304	3033	361	1346	3149	326	1104
20306	3047	385	1294	3048	335	1098
20402	3056	372	1349	3089	360	1128
20403	2983	388	1319	9999	9999	9999
20404	3133	397	1309	3095	356	1090
20405	3116	393	1304	3142	383	1107
20406	3149	362	1310	3177	332	1114
20501	3131	378	1335	3184	360	1111
20502	3112	373	1331	3174	354	1107
20504	3172	390	1318	3185	363	1103
20505	3175	391	1338	3198	336	1129
20506	3078	393	1315	3123	354	1104
20507	3077	385	1385	3097	362	1150
10602	3124	402	1324	3095	377	1137
10603	3090	392	1347	3073	355	1129
10604	3100	424	1322	3108	400	1114
10605	3019	410	1343	3036	366	1112
10606	3055	405	1334	3113	374	1100
10701	3223	377	1315	3197	382	1139
10702	3067	357	1336	3063	377	1125
10703	3079	405	1363	3126	374	1143
10704	3116	379	1311	3125	343	1105
10705	3092	403	1338	3165	410	1107
10706	3115	391	1341	3150	369	1124
10802	3048	395	1360	3115	341	1134
10804	3191	398	1366	3199	361	1156
10806	3125	453	1338	3107	385	1139
10807	3140	388	1355	3166	366	1138
10809	3131	381	1368	3135	386	1155
10810	3073	390	1375	3085	390	1168
10901	3193	399	1355	3239	366	1134
10902	3201	335	1357	3185	355	1154
10903	3252	357	1349	3256	350	1161
10904	3247	421	1331	3197	375	1130
10905	3208	390	1343	3205	386	1124
10906	3120	408	1380	3102	371	1180
11001	3166	370	1371	3179	351	1156
11004	3314	367	1354	3278	341	1172
11005	3204	415	1339	9999	9999	9999
11006	3220	395	1328	3193	354	1117
11007	3207	420	1352	3252	385	1146
20104	9999	9999	9999	3021	388	1081
20407	9999	9999	9999	3139	369	1119

** 9999 denotes missing data

PONTIAC DYNAMIC DATA (file=pont2.dat)

<u>Variable</u>	<u>Description</u>
subject#	Subject identifying number
gender	Gender (1=male, 2=female)
grpnum	Stature group number
ign	Intragroup number
impdom	Import or domestic driver (1=import, 2=domestic)
age	Age (yrs)
stature	Height (mm)
weight	Weight (lbs)
ipd	Interpupillary distance (mm)
pont2tl	Post-drive tilt-wheel angle (plane of wheel with respect to vertical)
pont2st	Post-drive seat position (X in vehicle coordinates)

PONTIAC DYNAMIC DATA

subject#	gender	grpnum	ign	impdom	age	stature	weight	ipd	pont2lt	pont2st
20102.1	2	1	2	1	45	1485	105	53	11	2965
20103.2	2	1	3	2	34	1515	111	55	21	2965
20104.2	2	1	4	2	62	1544	188	56	21	3014
20105.2	2	1	5	2	32	1535	105	54	16	2965
20106.1	2	1	6	1	27	1510	109	55	16	2965
20108.1	2	1	8	1	56	9999	184	45	31	2965
20202.1	2	2	2	1	49	1564	120	59	26	2990
20205.2	2	2	5	2	45	1579	155	56	21	3112
20208.2	2	2	8	2	40	1551	116	58	21	2965
20209.1	2	2	9	1	59	1585	108	60	26	2990
20210.2	2	2	10	2	32	1580	118	51	21	2965
20301.1	2	3	1	1	28	1599	140	59	26	3014
20302.1	2	3	2	1	22	1595	116	56	16	3039
20303.1	2	3	3	1	39	1621	182	57	21	3063
20304.2	2	3	4	2	38	1631	180	59	31	3039
20308.2	2	3	8	2	28	1630	123	51	21	2990
20404.2	2	4	4	2	30	1655	126	56	21	3039
20407.1	2	4	7	1	43	1681	153	51	16	3088
20408.1	2	4	8	1	41	1669	156	59	26	3014
20409.1	2	4	9	1	36	1668	125	55	31	3014
20410.2	2	4	10	2	39	1659	206	54	21	3088
20502.1	2	5	2	1	44	1711	129	57	26	3063
20504.2	2	5	4	2	29	1698	133	53	21	3137
20505.2	2	5	5	2	19	1724	124	49	21	3088
20508.2	2	5	8	2	40	1704	169	57	21	3063
20509.1	2	5	9	1	29	1685	134	51	16	3088
10602.1	1	6	2	1	50	1645	146	56	16	3039
10603.1	1	6	3	1	29	1652	146	54	16	3039
10605.2	1	6	5	2	47	1664	166	56	21	3039
10606.1	1	6	6	1	25	1635	169	57	26	3014
10607.2	1	6	7	2	57	1647	148	57	21	3039
10703.1	1	7	3	1	51	1674	183	64	16	3063
10704.2	1	7	4	2	59	1721	189	62	16	3088
10708.1	1	7	8	1	54	1698	173	53	21	3088
10709.2	1	7	9	2	37	1705	159	54	11	3039
10710.2	1	7	10	2	45	1703	184	56	11	3088
10804.2	1	8	4	2	38	1751	232	65	21	3112
10806.2	1	8	6	2	67	1743	174	59	16	3088
10807.2	1	8	7	2	49	1739	183	64	16	3137
10809.2	1	8	9	2	34	1734	148	53	26	3112
10810.1	1	8	10	1	33	1753	186	58	26	3063
10901.1	1	9	1	1	27	1800	217	66	21	3112
10902.1	1	9	2	1	25	1816	182	54	16	3112
10904.2	1	9	4	2	39	1795	204	62	26	3137
10905.2	1	9	5	2	21	1776	187	62	11	3161
10906.1	1	9	6	1	43	1808	217	74	21	3137
11001.1	1	10	1	1	33	1885	215	63	16	3161
11002.1	1	10	2	1	38	1889	196	9999	21	3161
11003.2	1	10	3	2	25	1874	198	62	16	3161
11004.2	1	10	4	2	26	1892	192	60	21	3137
11007.2	1	10	7	2	33	1862	187	61	21	3161

** 9999 denotes missing data

PONTIAC DYNAMIC EYE POSITION (file=pont2eye.dat)

<u>Variable</u>	<u>Description</u>
subject#	Subject identifying number
pont2x	Eye position X coordinate
pont2y	Eye position Y coordinate
pont2z	Eye position Z coordinate

PONTIAC DYNAMIC EYE POSITION DATA

subject#	pont2x	pont2y	pont2z
20102	3047	352	1040
20103	3070	344	1071
20104	3041	375	1064
20105	3040	353	1042
20106	3038	359	1076
20107	3047	368	1083
20202	3047	417	1109
20205	3095	325	1022
20208	3035	336	1071
20209	3034	353	1100
20210	3071	400	1088
20301	3154	344	1097
20302	3075	370	1058
20303	3146	353	1071
20304	3111	330	1094
20308	3083	364	1102
20404	3113	365	1069
20407	3125	364	1107
20408	3084	382	1136
20409	3070	363	1110
20410	3137	346	1078
20502	3151	362	1092
20504	3224	338	1094
20505	3209	363	1112
20508	3066	368	1108
20509	3185	377	1095
10602	3127	376	1108
10603	3135	365	1108
10605	3071	386	1099
10606	3109	380	1093
10607	3056	365	1070
10703	3127	370	1124
10704	3166	350	1088
10708	3150	445	1109
10709	3241	350	1112
10710	3143	358	1069
10804	3210	350	1138
10806	3131	390	1097
10807	3198	372	1109
10809	3195	351	1129
10810	3082	368	1130
10901	3202	355	1126
10902	3198	321	1135
10904	3228	385	1122
10905	3283	384	1096
10906	3163	387	1146
11001	3235	355	1133
11002	3183	399	1144
11003	3241	354	1117
11004	3289	337	1139
11007	3265	402	1106

