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A PRELIMINARY INVESTIGATION OF DRIVER LEAN IN LATE MODEL VEHICLES WITH BENCH AND BUCKET SEATS

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A PRELIMINARY INVESTIGATION OF DRIVER LEAN IN LATE MODEL VEHICLES WITH BENCH AND BUCKET SEATS

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16. Abstract

Video films of targets placed on the back of subject's heads and shoulders were recorded for eighteen drivers in two Pontiac 6000 vehicles equipped with bench and bucket seats, respectively. Drivers were divided into three groups of six subjects by stature including females 5'1" or shorter, males and females between 5'4" and 5'8", and males 5'11" and taller. The driving route involved both local roads and highways for a total drive time of approximately 30 minutes. The video target images were digitized at one minute intervals when the head was facing forward and the lateral offset from centerline of occupant (i.e., centerline of seat) was compared for the two vehicles.

It had been hypothesized that the lateral offset and variability of lateral position (i.e., driver lean) would be greater in the vehicle with the bench seat. Under the driving conditions of this study, however, the data do not support this hypothesis. Subjects in both vehicles showed similar results for driver lateral offset which, for the center of the head, was just inboard of centerline of occupant. The results do suggest, however, that the current center of the eyellipses in SAE J941 is too far outboard for late model vehicles and actual driving conditions.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION AND OBJECTIVES

Driver eyellipses have been a valuable tool used by automotive designers for over twenty years. The first eyellipses data were collected in 1965 from 2300 drivers seated in three stationary vehicles equipped with bench seats without seat belts (Meldrum 1965). Data from this study formed the basis for the SAE J941 (SAE 1985). However, recent research results (Arnold et al. 1986, Yabuki et al. 1987) suggest the need for changes in eyellipses due to the different seat characteristics of contemporary passenger cars. Also, since the original eyellipses were based on the static situation, they do not represent changes in eye (i.e., head) positions during driving.

The purpose of this preliminary investigation was to study the lateral motion and position of drivers while driving two Pontiac 6000 vehicles with two different types of front seats -- bench and bucket. It was hypothesized that the more confining bucket seats would reduce driver lean and offset from the seat centerline and thereby reduce lateral variability in head and eye position. To investigate this hypothesis, driver head and shoulder positions relative to the centerline of occupant (i.e. the centerline of the seat and steering wheel) were monitored by video filming during normal highway and city driving conditions. The following tasks were accomplished in pursuit of the study goals:

1. Design and construct a video camera mount.

2. Develop a definition for lateral lean and develop a camera alignment/calibration protocol.

3. Develop a video digitizing system for analyzing recorded lateral lean data.

4. Recruit 18 test drivers representing small-, medium- and large-sized segments of the U.S. driver population.

5. Develop a test protocol to measure lateral lean of drivers.

6. Record video film data of test subjects driving each car for approximately 30 minutes on city roads and highways.

7. Analyze the data collected, test the hypothesis, and investigate other findings.

The 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 (now Health and Human Services) Policy 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.

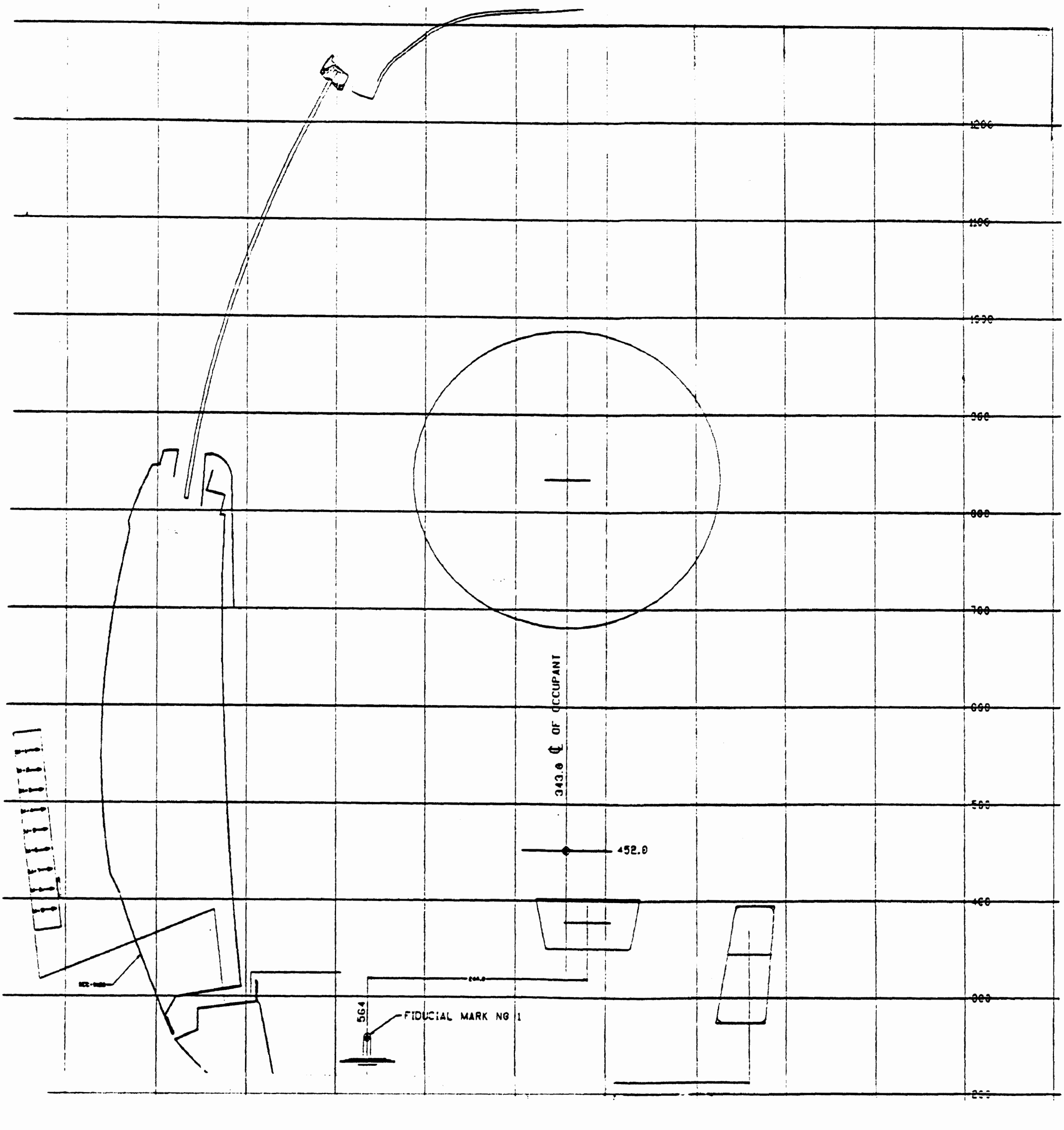


Figure 1. Rear package view illustrating the centerline of the occupant

II. METHODS AND PROCEDURES

A. DEVELOPMENT OF LATERAL MOTION MEASUREMENT SYSTEM

1. Definition of Lateral Lean

In this study, lateral lean was defined as the horizontal offset of both the center of the head and shoulders from the centerline of the occupant (as defined by the package drawing -- see Figure 1) during straight ahead driving. It should be noted that natural postures include leaning on the door sill or vehicle armrests, but that the offset is only defined by the targets when the driver is looking straight ahead. Under these conditions, it is also assumed that the measure of head center, which was taken at about eye level, can also be used as a measure of eye position.

2. Video Equipment and Alignment

In order to record lateral motions of drivers, two Panasonic Digital 5000 video cameras with 12x zoom lens were mounted on the rear shelves of two Pontiac 6000 vehicles as illustrated in Figure 2. A Panasonic AG-7400 video tape recorder was used to record video images and the output display of a digital timer was superimposed to provide a measure of driving time in each test. The optical centers of the video cameras were identified and each camera was aligned so that the centerline of occupant (343 mm outboard from the design centerline and at the same lateral position as the center of the steering wheel) coincided with the vertical centerline of the video frames. In order to facilitate this alignment procedure, targets were placed on the windshield, the dashboard, and the top of the seat back 343mm from vehicle centerline. Video camera alignments were checked before every test drive.

3. Description of Body Targets

Body targets were used both as a calibration scale and as tracking points for the centers of the head and torso (i.e., shoulders). The former was necessary since each subject selected his/her preferred seat detent and seat back angle which resulted in different distances among subjects from camera to targets.

Each target set positioned on the head and torso consisted of three contrast targets arranged in a straight line on a thin plastic strip. These targets were lightweight enough that subjects were not aware of their presence once they were in place. The head target consisted of three contrast dots spaced over a linear distance of three inches and was positioned on the back of the subject's head at approximately eye level. The torso or shoulder target consisted of three similar dots placed over a span of six inches and was positioned on the palpable surface of 7th cervical vertebrae (vertebra prominens). Figure 3 shows these head and torso targets attached to a subject.

4. Video Digitizing System

A video digitizing system was constructed to analyze recorded lateral motions of drivers. This system is composed of an IBM-PC/XT with PC Vision Plus frame grabber, a

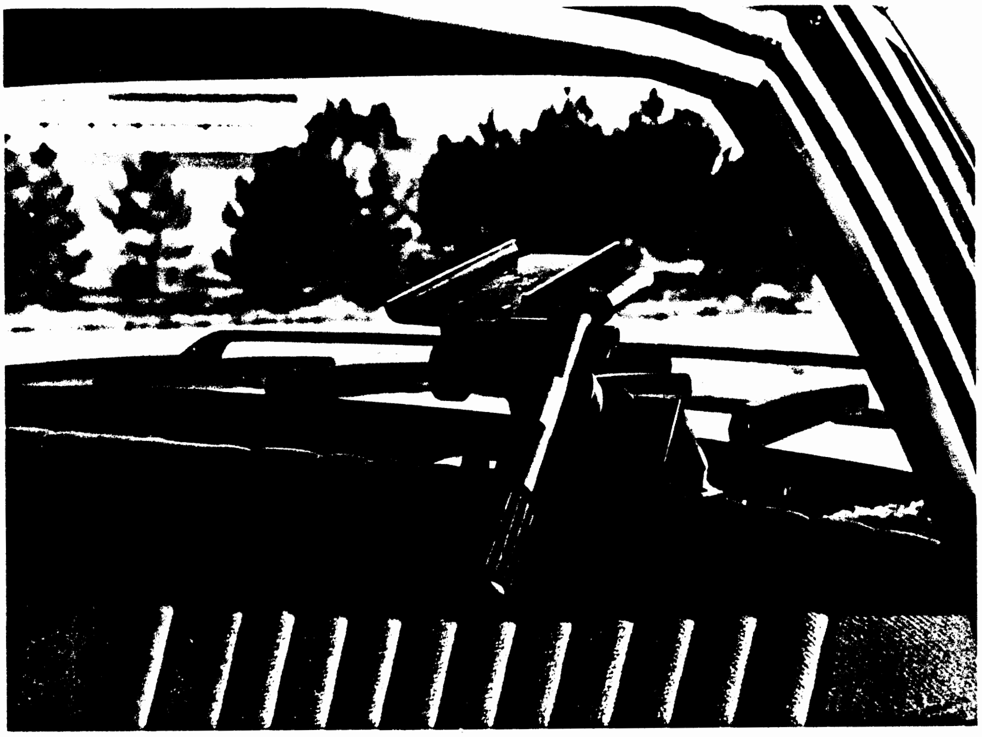


Figure 2a. Video camera mount attached to rear shelf of Pontiac 6000

Figure 2b. Rear view of Pontiac 6000 showing Panasonic video camera attached to rear shelf mount

Figure 3. Rear view of subject showing location of head and torso target

Figure 4. Video digitizing system

Microsoft Mouse, two video monitors, and digitization software. The frame grabber can capture thirty image frames per second with 640x480 pixel resolution. Microsoft Mouse was installed as a cursor positioning device. Figure 4 illustrates the system configuration. Data processing software includes calibration, digitization, and data storage routines. These were written and compiled in Microsoft FORTRAN using Halo 88 Graphics Kernel System subroutines.

B. SELECTION AND RECRUITMENT OF SUBJECTS

Eighteen male and female subjects were selected for the study to represent the short, average, and tall segments of the U.S. population by stature as indicated in Table 1. Six subjects were selected for each size group and each subject was assigned a four digit I.D. code of the form ###.#, where the first digit represents gender (1- male, 2- female), the second digit designates group number (1-small, 2-average, 3-tall), the third digit indicates the subject number within each group, and the last digit indicates the seat type (1-bucket, 2-bench).

Table 1.
Subject Group Description

Group	Stature	
Small	5' 1" or shorter	(154.9 cm)
Medium	Between 5' 4" and 5' 8"	(162.6 to 172.7 cm)
Large	5' 11" or taller	(180.3 cm)

C. MEASUREMENT PROTOCOL

1. Test Procedures

In order to ensure that the study results would be as representative of real-world driving conditions as possible, the subjects were not informed of the real purpose of the study. Rather, the need for the video cameras was explained by telling each subject that we were studying vehicle ride characteristics. The following steps were involved in conducting these tests:

1. After signing a consent form and filling out a health questionnaire, each subject was measured for height, weight, shoulder breadth, distance between the eyes, and eye-to-back-of-head distance.

2. Upon completion of these measurements and review of the health questionnaire, the subject was taken to the UMTRI parking lot where the two cars were

positioned and waiting with the seats in the rearmost positions, the seat back angles fully upright, and the steering wheel tilted to the highest position. The subject was instructed to sit in one of the vehicles and to make initial adjustments in the seat fore/aft location, the seat back angle, and the steering wheel tilt angle.

3. Head and shoulder targets were attached to the subject and the subject was instructed to fasten the seat belt and go out on a short drive in order to get acquainted with the vehicle and make further adjustments in the seat and steering wheel positions.

4. Upon his/her return, the subject was instructed to stay in the vehicle and to look straight ahead while the video equipment was turned on. These straight-ahead frames were later used to calibrate the lateral distance scale factor by using the known distances between targets attached to the subject.

5. The subject then drove the vehicle over a prescribed route involving both city and highway driving while the video camera recorded the subject position and motion.

6. Upon return from this drive, the subject was given a short rest before repeating the process in the second vehicle.

2. Test Driving Route

The testing route was selected to consist primarily of straight-ahead highway driving since this was of primary concern for defining head and eye position. This type of driving has the added advantage of limiting the amount and extent of head turning which facilitates the digitization and measurement process. Some city driving was also involved, however, as the subjects were required to drive to and from the UMTRI parking lot and the highway. Figure 5 shows the test driving route which involved about 25 miles and 30 to 40 minutes of driving time.

D. DATA ACQUISITION

1. Data Reduction Strategies

It was desired to digitize target positions only when the subject was not involved in any extra activities such as using the radio or other secondary controls, changing lanes, or turning corners. Also, for obvious reasons, it was necessary to collect position data only when the subject was looking straight ahead. It was subsequently determined that, in the straight-ahead position, the subject's eyes would appear in the rear view mirror in the video image and this could be used as a criteria for digitizing. Experimentation with digitizing of video frames taken at different time intervals indicated that one-minute intervals were sufficient (see section III.B.1). Whenever the subject's head was turned at the specific digitizing time, however, the closest frame following in which the head was straight ahead was selected.

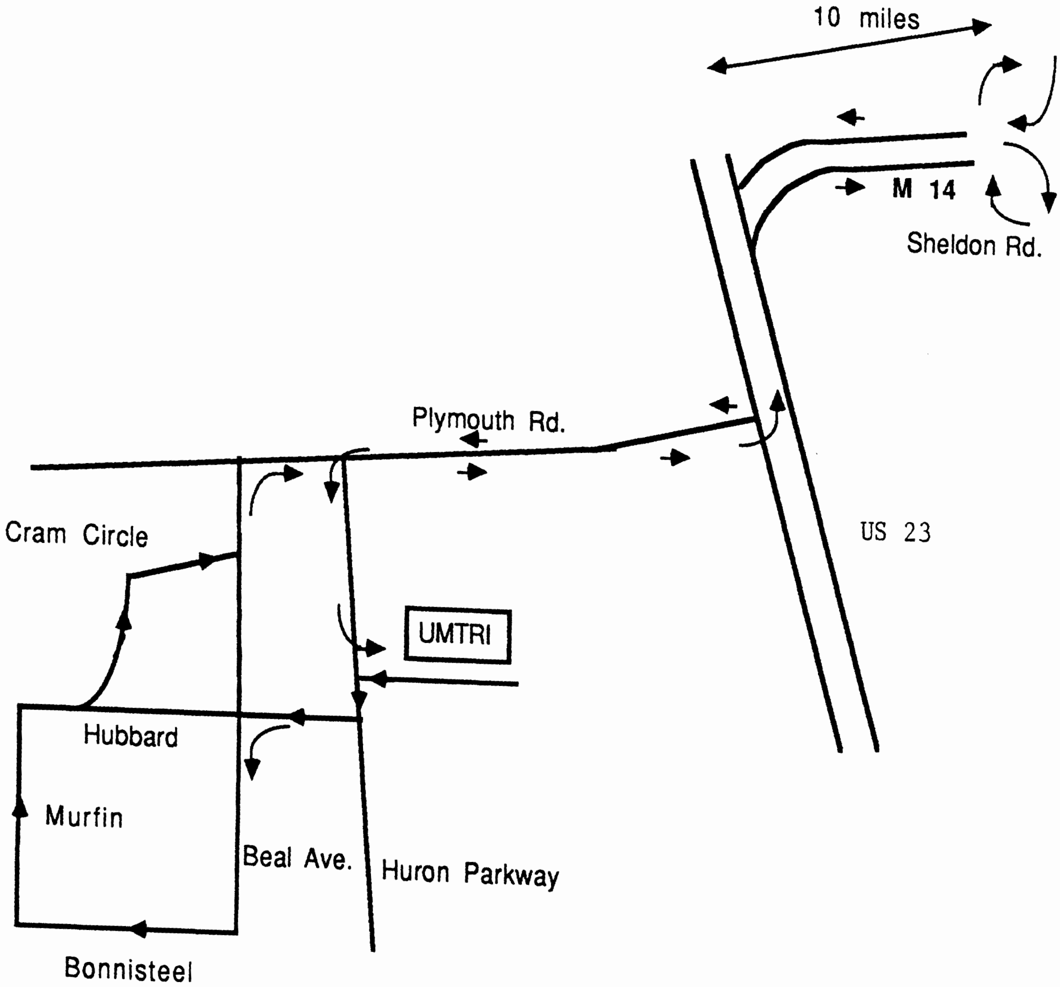


Figure 5. Test driving route

2. Calibration

Since each subject used different seat positions and seat back angles, the distance between the body targets and the camera varied. In order to measure distances precisely, each testing session was calibrated before digitization. Assuming no lens aberration error, measured distances in pixel values can be easily adjusted to actual distances using a simple scale factor:

$$\text{Scale factor (mm/pixel)} = \frac{\text{target size in mm}}{\text{target measured in pixel}}$$

As previously indicated, the set of shoulder targets had a distance of 152.4 mm (6") between the first and third targets and was used as a calibration reference. These targets were digitized in the pre-test video frame where the subject was known to be facing straight ahead.

3. Measures of Lateral Position

In order to quantify and compare the lateral motion characteristics of subjects sitting on the two different types of seats, specific measures of position and motion are required. As defined previously, lateral motions were considered as the deviations from the centerline of occupant. Thus, mean offset, standard deviation, and range of head and shoulder centers were used as measures representing the characteristics of lateral motions. Mean offset is a measure of the overall sitting position of the subject and involves both the offset in the initial seated position as well as any lean and movement from this position during the drive. Standard deviation represents the variability in lateral position over the time of the drive, and range indicates the maximum excursion of the lateral movements.

III. RESULTS

A. SUBJECT CHARACTERISTICS

Table 2 summarizes the anthropometric measurement results and Figure 6 shows a bivariate plot of stature and weight for the eighteen subjects.

Table 2.
Summary of Anthropometric Measurements

	Group I (Small)	Group II (Medium)	Group III (Large)	All
Stature				
Mean	155.48 (61.21)	169.08 (66.57)	184.17 (72.51)	169.58 (66.76)
S.D.	2.88 (1.13)	2.26 (0.89)	3.41 (1.34)	12.07 (4.75)
Weight				
Mean	50.06 (128.17)	69.12 (152.58)	80.63 (178.08)	69.28 (152.94)
S.D.	14.07 (31.08)	9.69 (21.38)	8.51 (18.78)	14.38 (31.74)
Eye to back-of-head distance				
Mean	16.97 (6.68)	17.00 (6.69)	19.17 (7.55)	17.71 (6.97)
S.D.	1.34 (0.53)	1.16 (0.46)	2.28 (0.90)	1.96 (0.77)
Distance between eyes				
Mean	6.08 (2.40)	5.88 (2.32)	6.37 (2.51)	6.11 (2.41)
S.D.	0.92 (0.36)	1.19 (0.47)	0.39 (0.15)	0.92 (0.36)
Shoulder breadth				
Mean	30.13 (11.86)	32.85 (12.93)	36.98 (14.56)	33.32 (13.12)
S.D.	3.00 (1.18)	2.38 (0.94)	2.19 (0.86)	3.80 (1.50)

Units: cm (inch), kg (lb.)

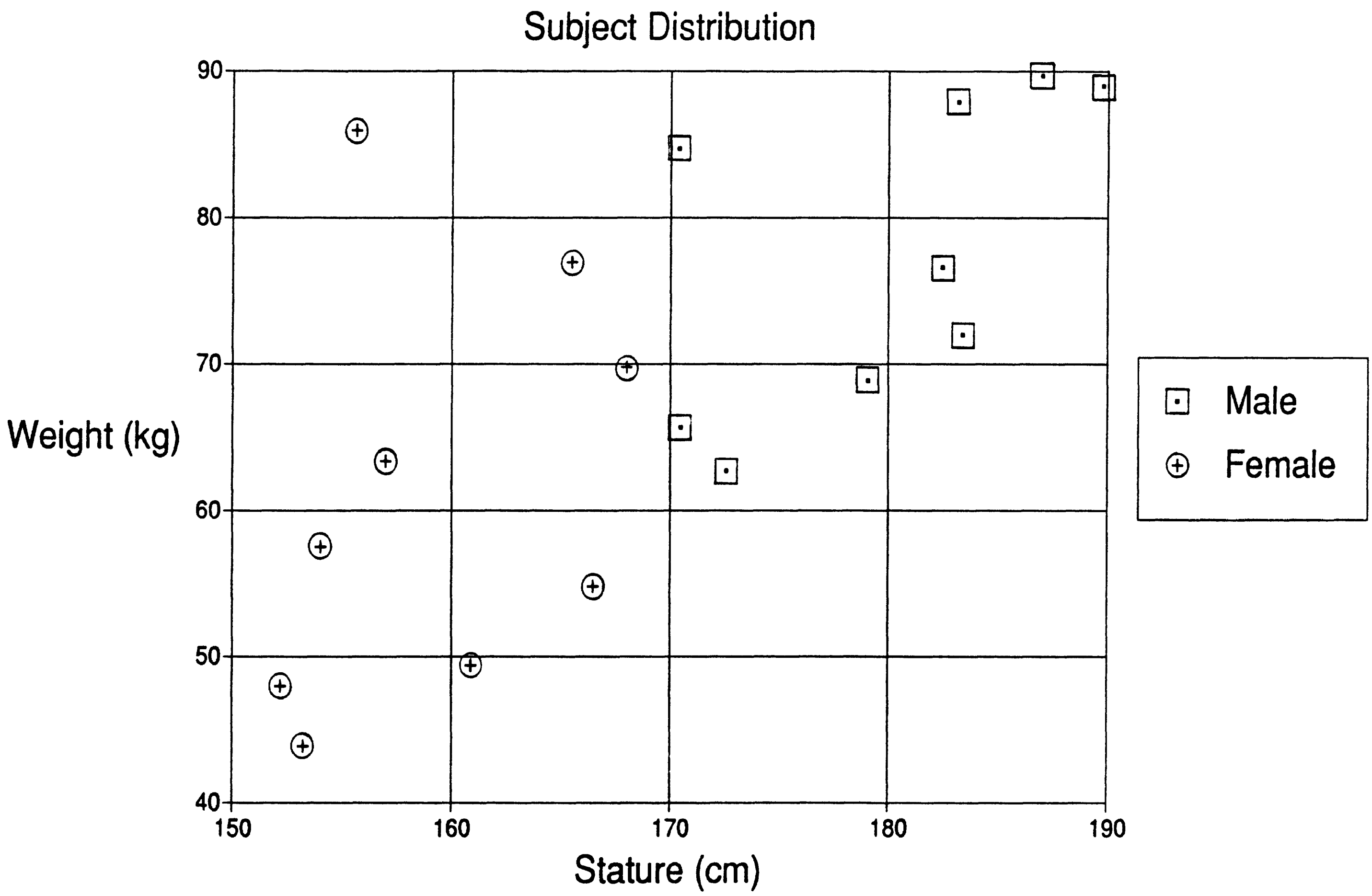


Figure 6. Stature-Weight distribution of subjects

Table 3 summarizes the preferred seat and steering wheel locations for the two test vehicles. There was no significant difference for steering wheel tilt usage ($t(16)=-1.0$, $p>0.33$) but there was a significant difference in seat position ($t(16)=-3.16$, $p<0.01$) whereby subjects tended to sit about one detent more rearward when using a bench seat. This may be due to the fixed seat back angle which requires drivers to sit further rearward to obtain their desired relationship to the steering wheel.

Table 3.
Seat and Wheel Tilt Data for Bucket and Bench Seat Conditions

Grp. #	Subj. #	Bucket Exp.*	Veh. Type**	Bucket Seat: Seat Detent	Bucket Seat: Seat Back Ang. Det.	Bucket Seat: Seat Back Ang. Deg.	Bucket Seat: Wheel Fitting Det.	Bucket Seat: Wheel Fitting Deg.	Bench Seat***: Seat Detent	Bench Seat***: Wheel Tilt Angle Det.	Bench Seat***: Wheel Tilt Angle Deg.
	211	X	I	2	2	22	2	58	2	2	58
	212	X	I	2	1	18	3	63	1	4	68
I	213	X	I	2	1	18	2	58	2	3	63
	214	X	D	2	1	18	4	68	3	4	68
	215	X	D	1	1	18	3	63	0	4	68
	216	X	D	1	2	22	3	63	3	3	63
	123		D	2	2	22	3	63	3	4	68
	124	X	D	5	2	22	4	68	6	4	68
II	125		D	4	2	22	4	68	7	4	68
	221	X	I	3	2	22	3	63	3	3	63
	222	X	I	3	2	22	3	63	6	3	63
	226	X	I	4	2	22	4	68	5	4	68
	131	X	D	8	2	22	4	68	9	4	68
	132	X	I		2	22	4	8	7	4	68
III	133	X	I	8	2	22	5	73	--	--	--
	134	X	D	8	1	18	4	68	8	2	58
	135	X	D	6	2	22	4	68	8	4	68
	136	X	D	7	2	22	3	63	9	4	68

* Bucket driving experience indicated by X
** Domestic (D)/Import (I) as usual vehicle driven
*** Seat Back Angle of bench seat is fixed at 26.5 degrees
Seat Back Angle degrees re vertical
Tilt Wheel Angle degrees re horizontal

B. VALIDATION OF DATA REDUCTION STRATEGY

1. Sampling Interval

The sampling interval can be an important aliasing factor of data reduction processes. Figure 7 illustrates the sensitivity of position data to different sampling frequencies while Table 4 shows the statistical results from these three sampling intervals. While the faster sampling rates indicate considerably more driver movement (i.e., lean), the overall statistics of the three rates are quite similar. As a result of these comparisons, a one-minute sampling interval was selected as a reasonable sampling frequency for this study.

Table 4.
Sampling Sensitivity

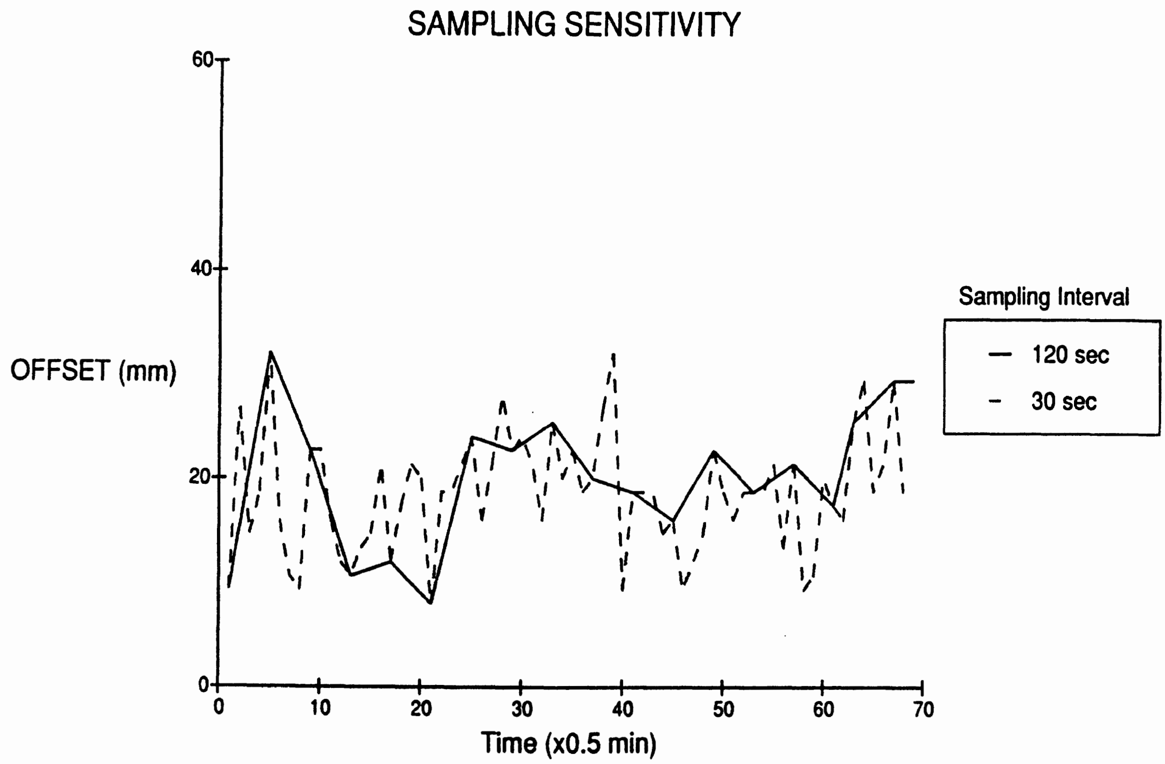
Sampling interval	30 sec	60 sec	120 sec
Number of samples	68	36	19
Mean	18.64	19.38	20.44
S.D.	5.66	6.20	6.88
Maximum	32.08	32.08	26.74
Minimum	8.02	8.02	8.02
Median	18.72	20.05	21.39

2. Repeatability of Digitized Data

Because of the need to select video frames when the driver was looking straight ahead, the same video tape segment will be processed somewhat differently by two investigators or even the same investigator on repeated digitizations. An investigation of the repeatability of digitizing was therefore made by having the same video tape data processed by two different investigators using the data reduction strategies described in section II.D.1. Table 5 compares the results. The high Pearson correlation coefficient between two different investigators (r=0.87 to 0.94) indicates good repeatability in data reduction.

Table 5.
Digitizing Repeatability

Video tape	#1		#2	
Experimenter	I	II	I	II
Mean	31.19	30.31	21.61	21.91
S.D.	9.86	9.47	21.72	22.77
Pearson r	0.8695		0.9363	



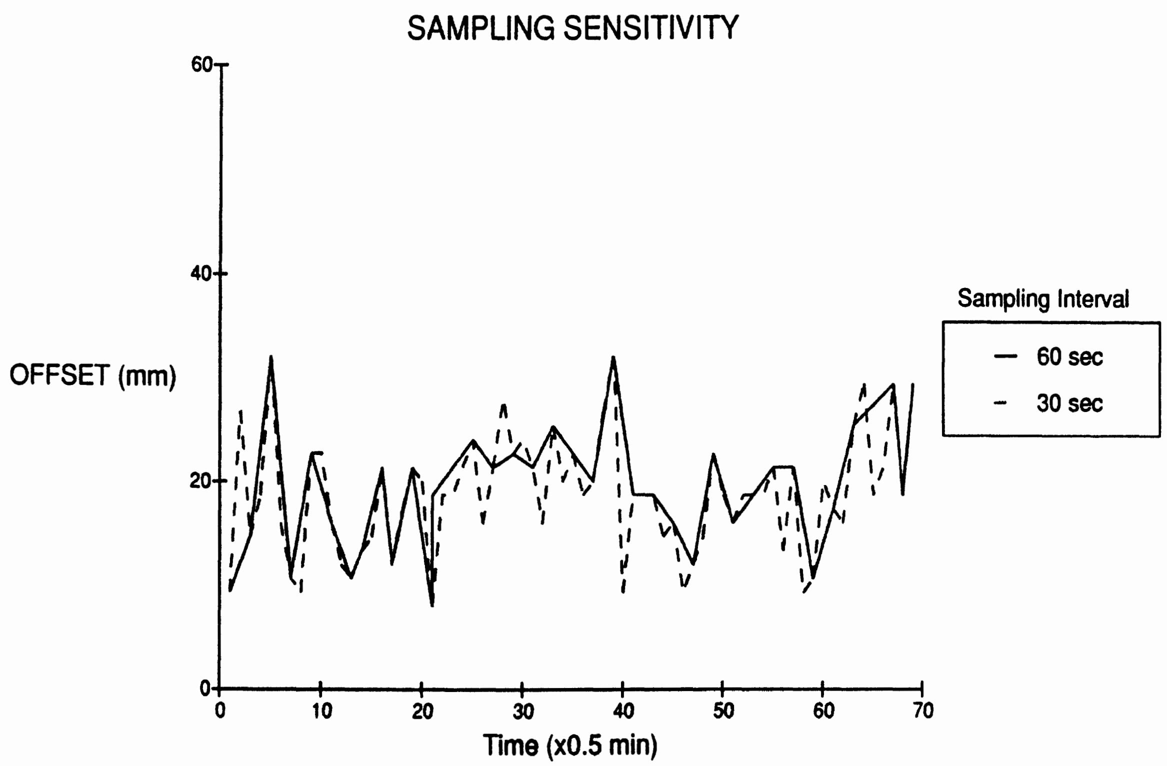


Figure 7. Digitized photo data at different sampling rates
(a) 30 sec vs. 120 sec sampling interval
(b) 30 sec vs. 60 sec sampling interval

C. COMPARISON OF LATERAL OFFSETS FOR BENCH AND BUCKET SEATS

1. Mean Offsets

Appendix I contains the one-minute time interval plots of digitized head and shoulder position for the eighteen subjects in the two Pontiac 6000s. For each seat condition, the mean value over time of lateral offset was computed from the digitized data. The lateral mean offset represents the average position of the digitized head or shoulder centers relative to the centerline of the occupant (i.e., the center of the steering wheel and, in the vehicle with bucket seat, the centerline of the seat). Because a driver may lean both to the left and to the right of the centerline, this mean offset is based on the average of both negative (i.e., left of center) and positive (right of center) values over time. The absolute mean offset, on the other hand, was computed by taking the average of the absolute values of lateral offset. In other words, the offset is considered positive whether the offset is to the left or the right. Absolute offset is, in effect, a measure of the overall off-centeredness of the driver over time without regard to direction of off-centeredness.

Figure 8 compares the mean offsets for the head and shoulder (i.e., torso) of the eighteen subjects for the bucket and bench seat conditions where the results are arranged by subject group. For the shoulders, it is interesting to note that all but two subjects had similar direction offsets (i.e., inboard or outboard) for both vehicles and only four subjects showed significant offsets in the outboard direction. For the head, all subjects have inboard or zero mean offsets with the bench seat and only a few subjects demonstrated small amounts of mean offset in the outboard direction with the bucket seat.

Table 6 summarizes the results for all subjects from which it is seen that there are no significant differences in mean offset of the head center ($t(17)= -0.92$, $p>0.37$) or mean offset of the shoulder center ($t(17)= -0.26$, $p>0.80$) between bench and bucket seats. Also, an analysis of variance for subject size versus seat type does not show any significant differences among groups ($F(2,30)=0.563$, $p>0.57$), between seat types ($F(1,30)=0.184$, $p>0.67$), or between interactions ($F(2,30)=0.418$, $p>0.662$). The larger mean head and shoulder offsets for Group 1 subjects in the bench seat are seen, from Figure 8, to be due to one subject who consistently demonstrated high offsets.

Figure 9 illustrates the absolute mean offsets for the eighteen subjects seated in bench and bucket seats. The results are arranged by subject group and the group and overall absolute mean offset values are given in Table 6. The somewhat smaller values for the head, which can also be appreciated by comparing the upper and lower histograms of Figure 9, may indicate that drivers tend to tilt their head back toward the center to compensate for body lean. This is also demonstrated in Figure 10 which shows scatter plots of head and shoulder average offsets for bucket and bench seat conditions. The larger number of points below the equivalent-offset line means a larger number of average shoulder offsets than average head offsets.

2. Standard Deviation and Range of Lateral Positions

The standard deviation and range of digitized lateral positions provide further information about the amount of variability in lateral position. Figures 11 and 12 plot these

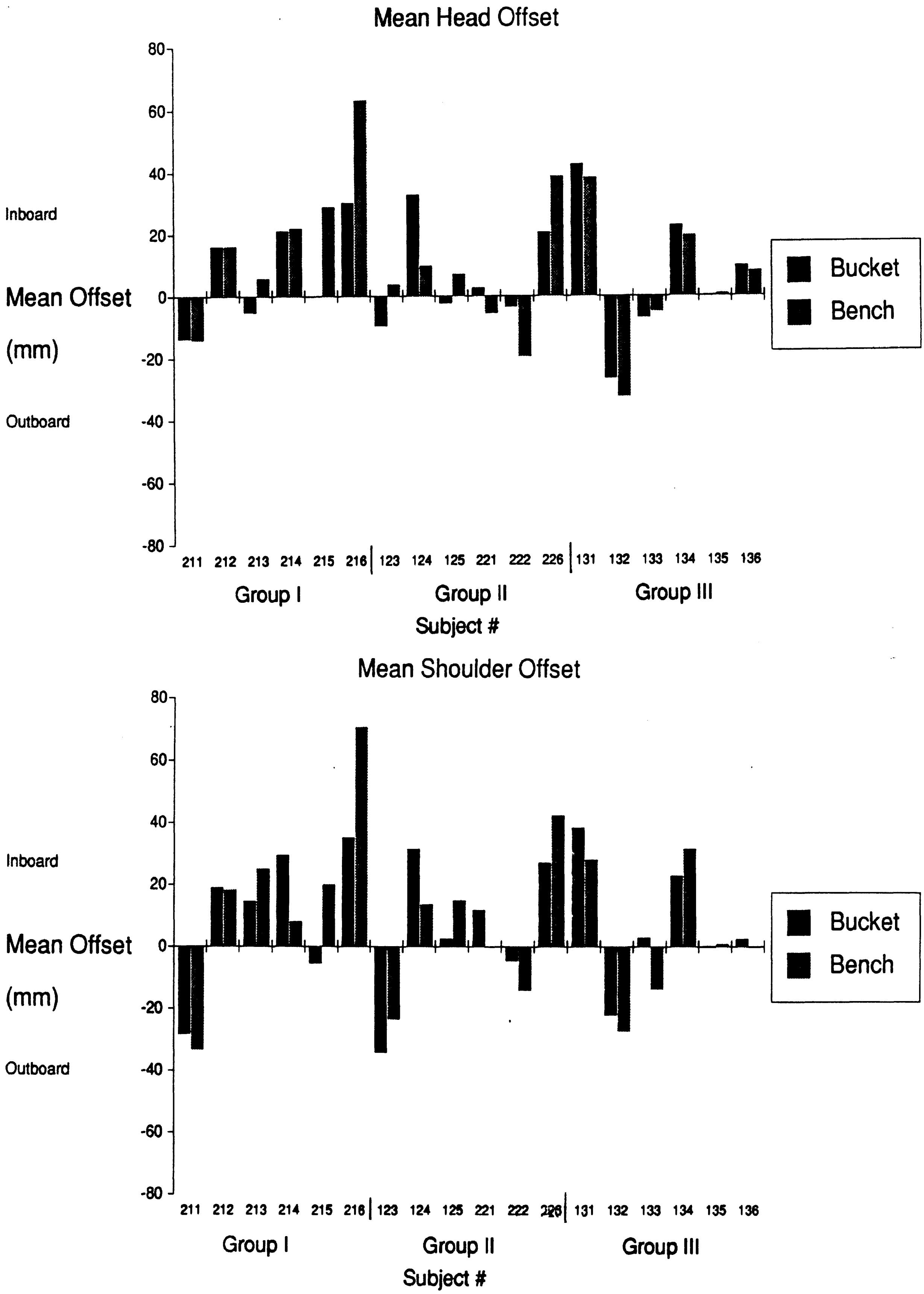


Figure 8. Mean offsets of the shoulder and head centers for bucket and bench seat driving

Table 6. Summary of Group and Overall Mean Offsets

(Units: mm)

		Group I (Small)	Group II (Medium)	Group III (Large)	Overall Mean	Overall Std.
Mean Offset (Head)	Bucket seat	8.33	6.95	6.37	7.17	23.34
	Bench seat	17.09	6.28	5.12	10.34	27.27
Mean Offset (Shoulder)	Bucket seat	11.06	6.08	7.64	8.06	23.72
	Bench seat	18.49	6.97	3.42	9.98	30.59
Absolute Mean Offset (Head)	Bucket seat	19.68	19.44	21.48	20.16	15.43
	Bench seat	24.62	20.81	17.32	20.99	17.76
Absolute Mean Offset (Shoulder)	Bucket seat	22.51	20.59	23.27	22.41	13.84
	Bench seat	33.86	21.26	21.14	26.41	17.91

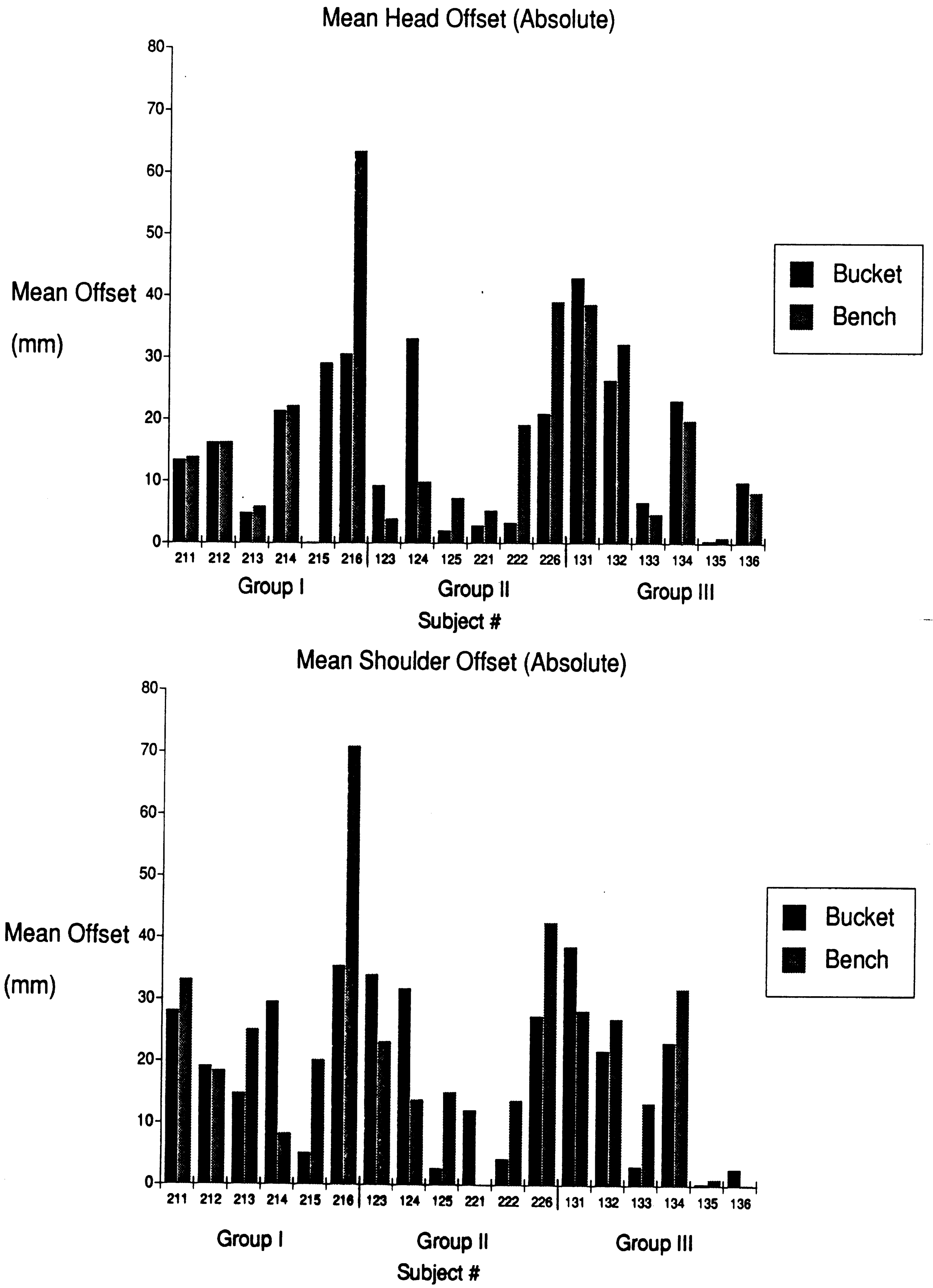


Figure 9. Mean absolute offsets of the shoulder and head centers for bucket and bench seat driving

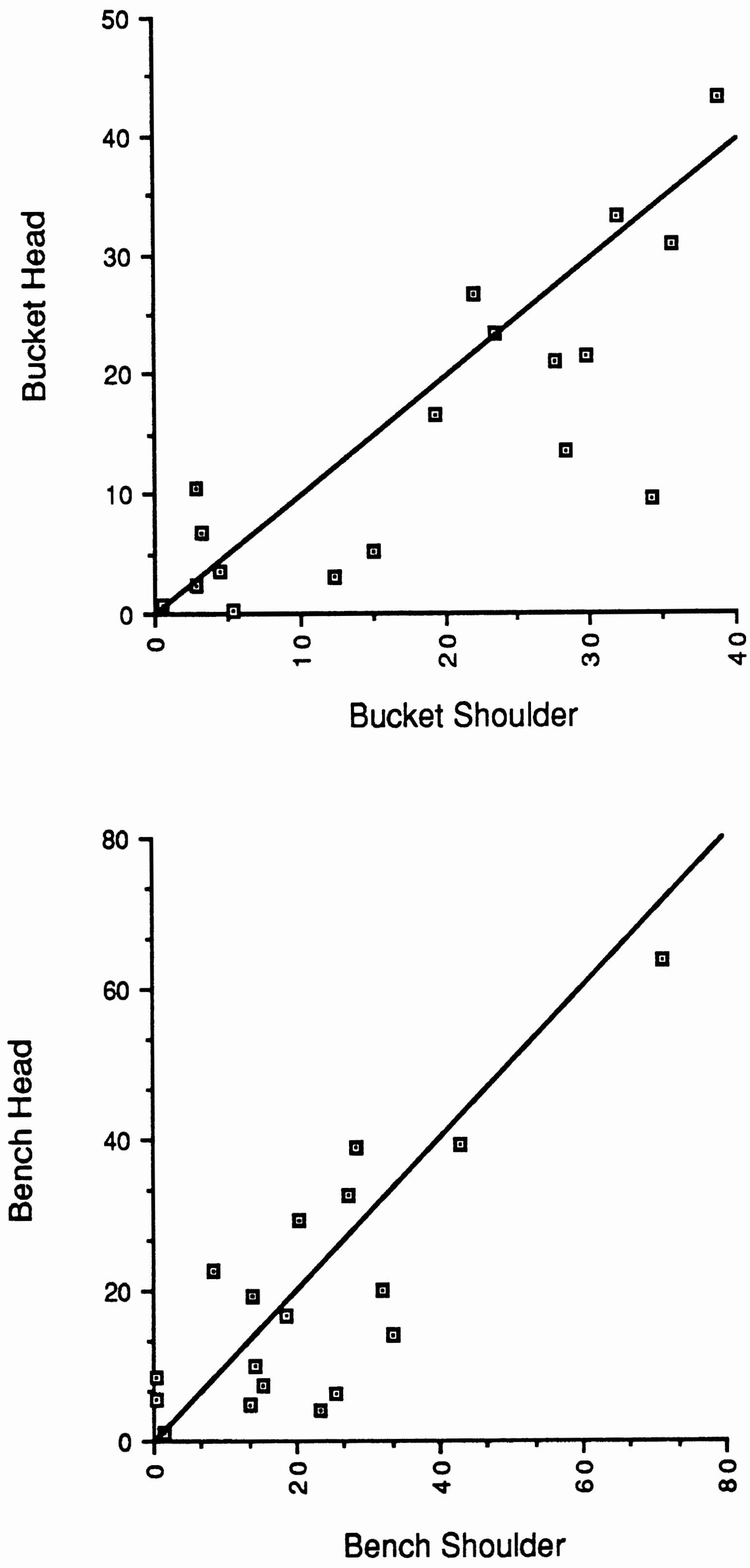


Figure 10. "Towards centerline" tendency of the head centers

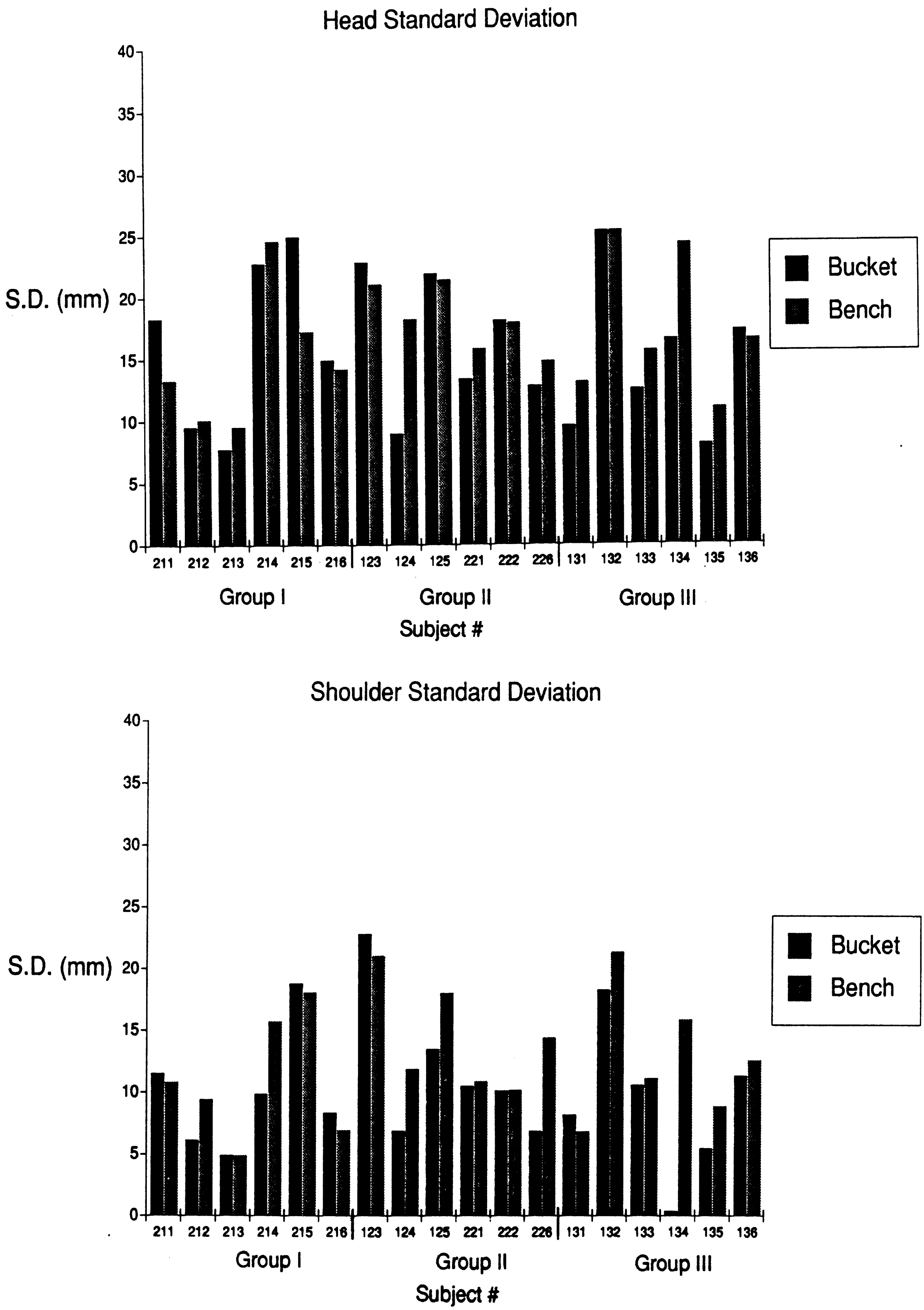
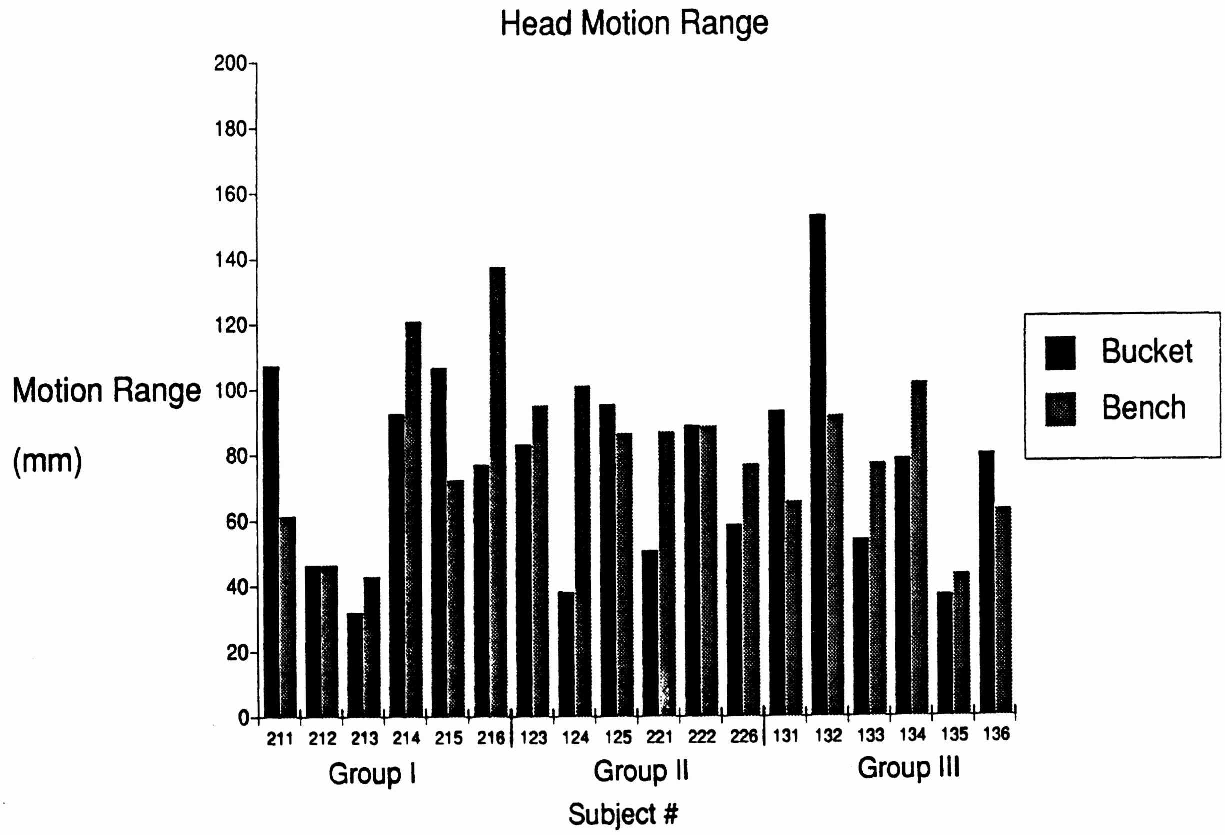


Figure 11. Standard deviations of the shoulder and head centers for bucket and bench seat driving



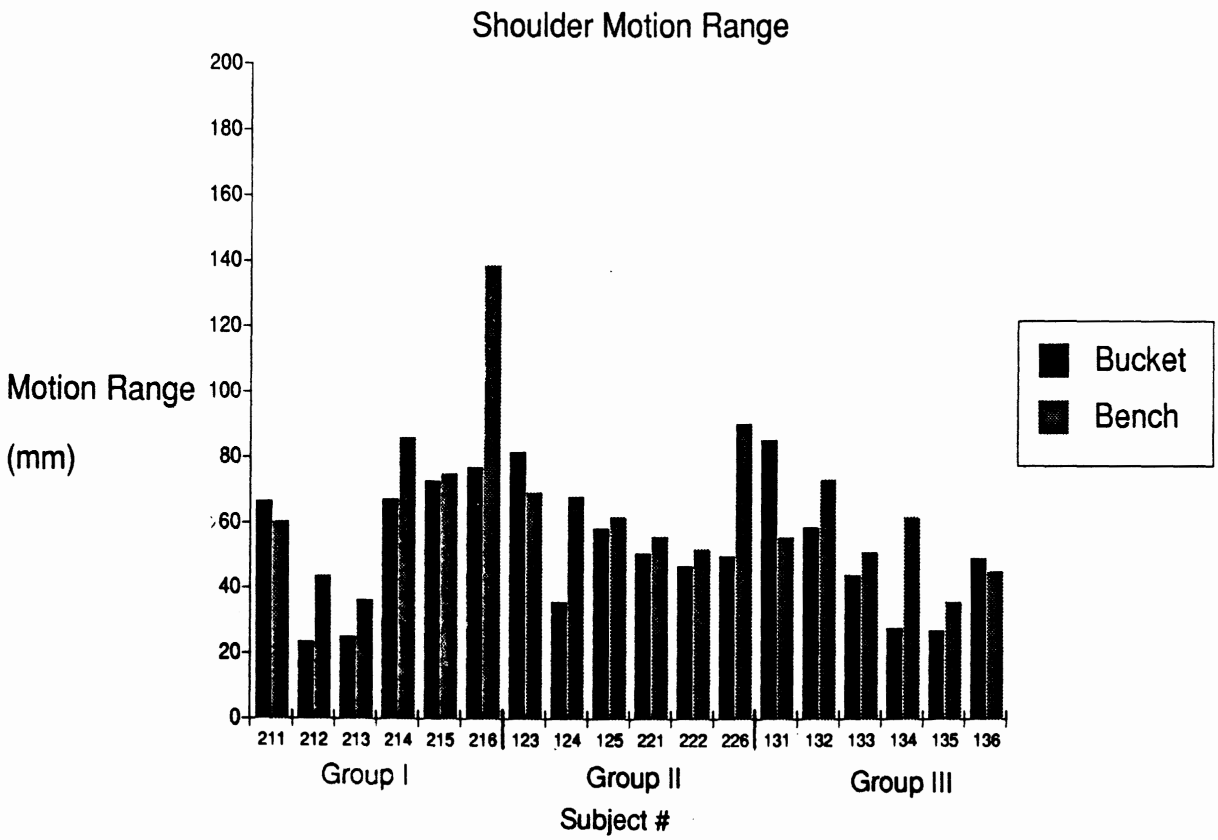


Figure 12. Range of lateral motion of the shoulder and the head centers for bucket and bench seat driving

two measures for the two seat conditions while Table 7 compares the overall numerical values. The range is computed as the difference between the maximum digitized offset to the right minus the maximum digitized offset to the left. As with the mean offsets, there are no consistent significant differences for the two seat conditions.

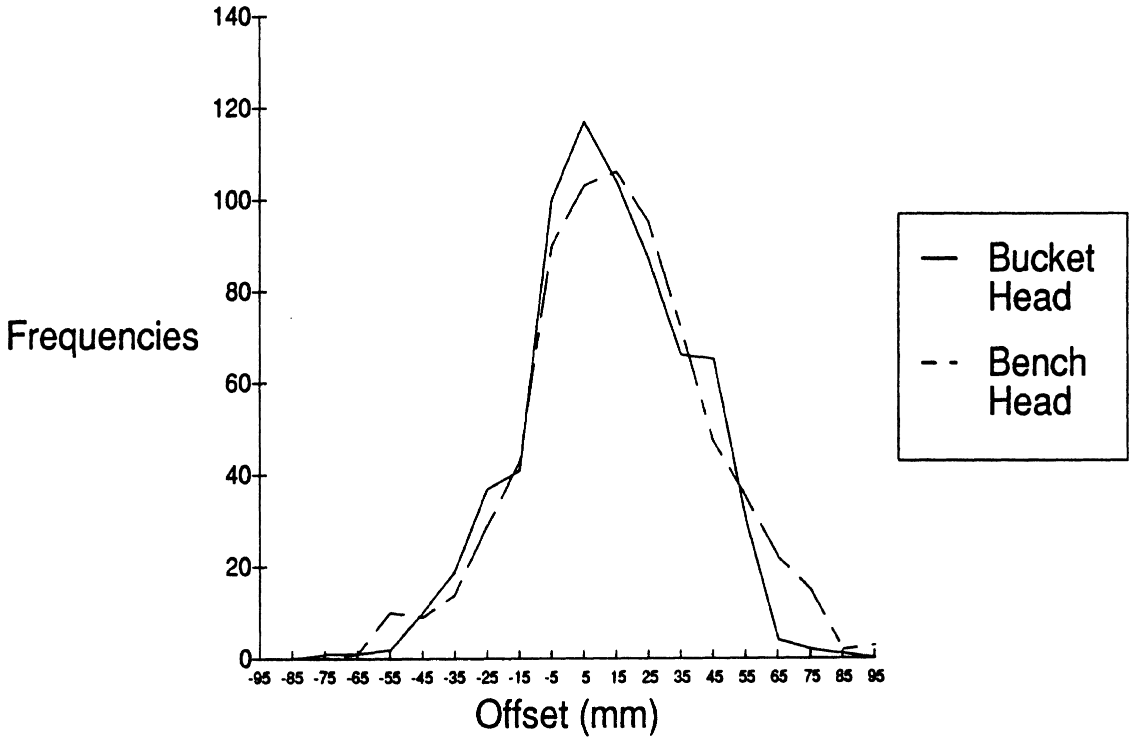
3. Frequency Distributions of the Shoulder and the Head Center

As indicated in Table 6, the overall mean offsets for the center of the head in the bucket and bench seats are approximately 7 and 10 mm inboard of centerline of occupant. Figure 13 shows the frequency distributions of lateral offset for the digitized data from all subjects combined from which the average values were obtained. As indicated, the positions are nearly normally distributed, although some skewness, especially for the shoulders, can be noted. The most common frequency for the shoulders lies between 15 and 25 mm inboard of the seat centerline, while the most common frequency for the head lies between -5 and 5 mm. If we assume that the location of the center of the head corresponds to the center of the eyellipses, the eyellipses center is located on or just inboard of the centerline of occupant.

Table 7.
Summary of S.D. and Range of Groups and Overall

(Units: mm)

		Group I (Small)	Group II (Medium)	Group III (Large)	Overall	
Standard Deviation (Head)	Bucket seat	23.43	22.57	27.06	24.34	
	Bench seat	25.89	25.38	28.79	27.27	
Standard Deviation (Shoulder)	Bucket seat	25.30	24.50	21.38	23.72	
	Bench seat	42.22	25.53	25.41	30.59	
					Mean	S.D.
Range (Head)	Bucket seat	77.46	69.64	83.19	76.76	30.04
	Bench seat	80.70	89.68	74.31	81.57	24.92
Range (Shoulder)	Bucket seat	55.9	54.35	49.18	53.15	19.28
	Bench seat	73.83	66.66	54.25	64.91	23.38



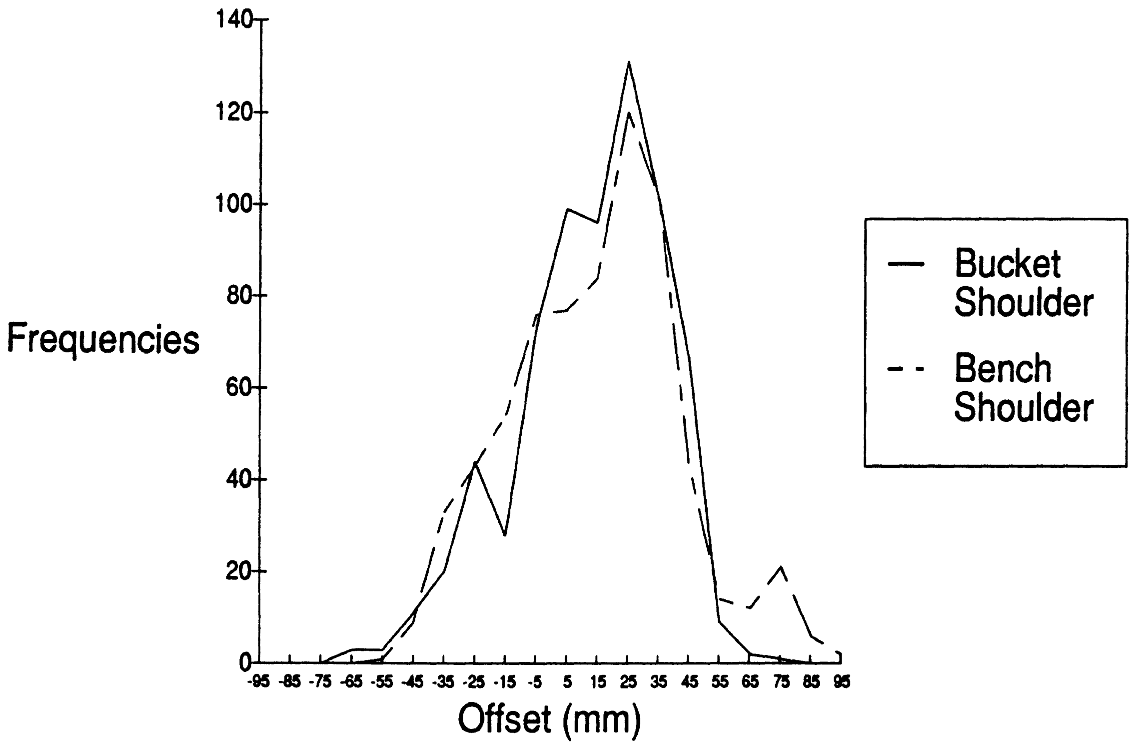


Figure 13. Frequency distributions of the head and shoulder centers

IV. DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

1. Inboard Characteristics of the Head Center

In this study, three groups of male and female subjects representing small-, medium-, and large-sized drivers were tested in two Pontiac 6000 vehicles equipped with bench and bucket seats respectively. In general, no significant differences for driver lateral offset relative to the centerline of occupant were found for the two seat conditions. However, the observed location of the head center, which overall is just to the right (i.e., inboard) of centerline is significantly different from the lateral location of the current eyellipses centroid. Figure 14 compares the distributions of head center data points for all subjects in bucket and bench seats, with the reconstructed distribution of the midpoint of the eyes based on the statistics of the current eyellipses. A relatively small percentage of head center data points fall on or near the mean value of the current center of eyellipses distribution.

The box and whisker plots in Figures 15 and 16 show the distribution patterns of the head and shoulder centers. The estimated center of the eyellipses from this study is just inboard of the centerline of occupant, which is 27.38 mm inboard from the current center of eyellipses (i.e., 370.38 mm on Y coordinate). The new preliminary data suggest that a considerable discrepancy may exist between currently used static eyellipses and the dynamic eye positions of drivers. The statistics from this study show that the mean head center is located 34.55 and 37.72 mm inboard from the current eyellipses center for bench and bucket seats respectively.

One possible explanation for the inboard characteristics of eye position in this study is the shoulder belt which was not used when the original eyellipses data were collected. It is likely that the presence of a shoulder belt, which was worn by all subjects in the study, will significantly affect the tendency to lean outboard and encourage the tendency to lean inboard. Table 8 shows the shoulder belt locations obtained from the video data by digitizing the inboard edge of the shoulder belt at the top of the shoulder. These locations are quite close to the current eyellipses center.

Table 8.
Shoulder Belt Locations

	Bucket Seat	Bench Seat
Average Shoulder Belt Position	431.96	412.76
Standard Deviation	15.80	19.84
Distance from current eyellipse center	61.58	42.38

(Unit: mm)

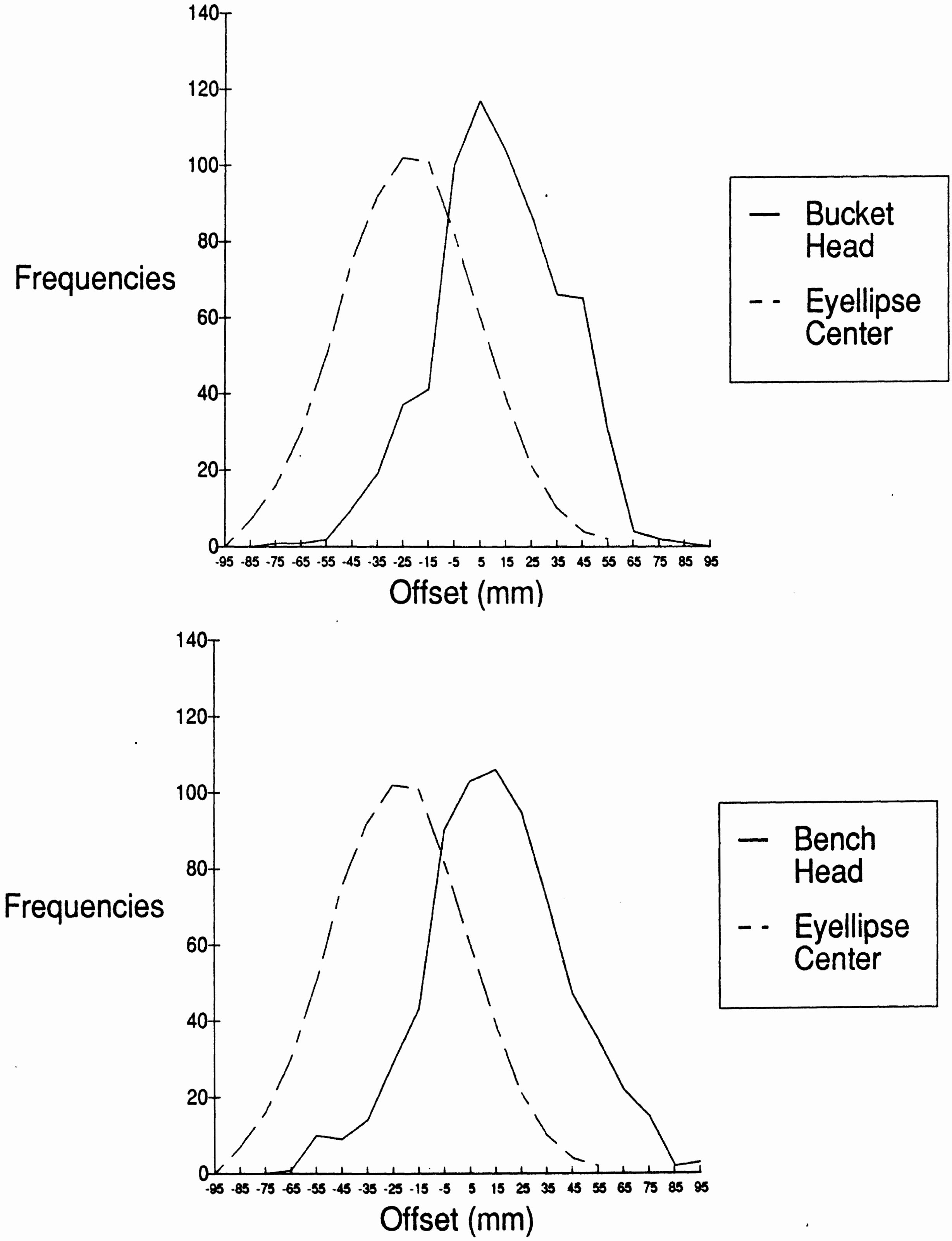
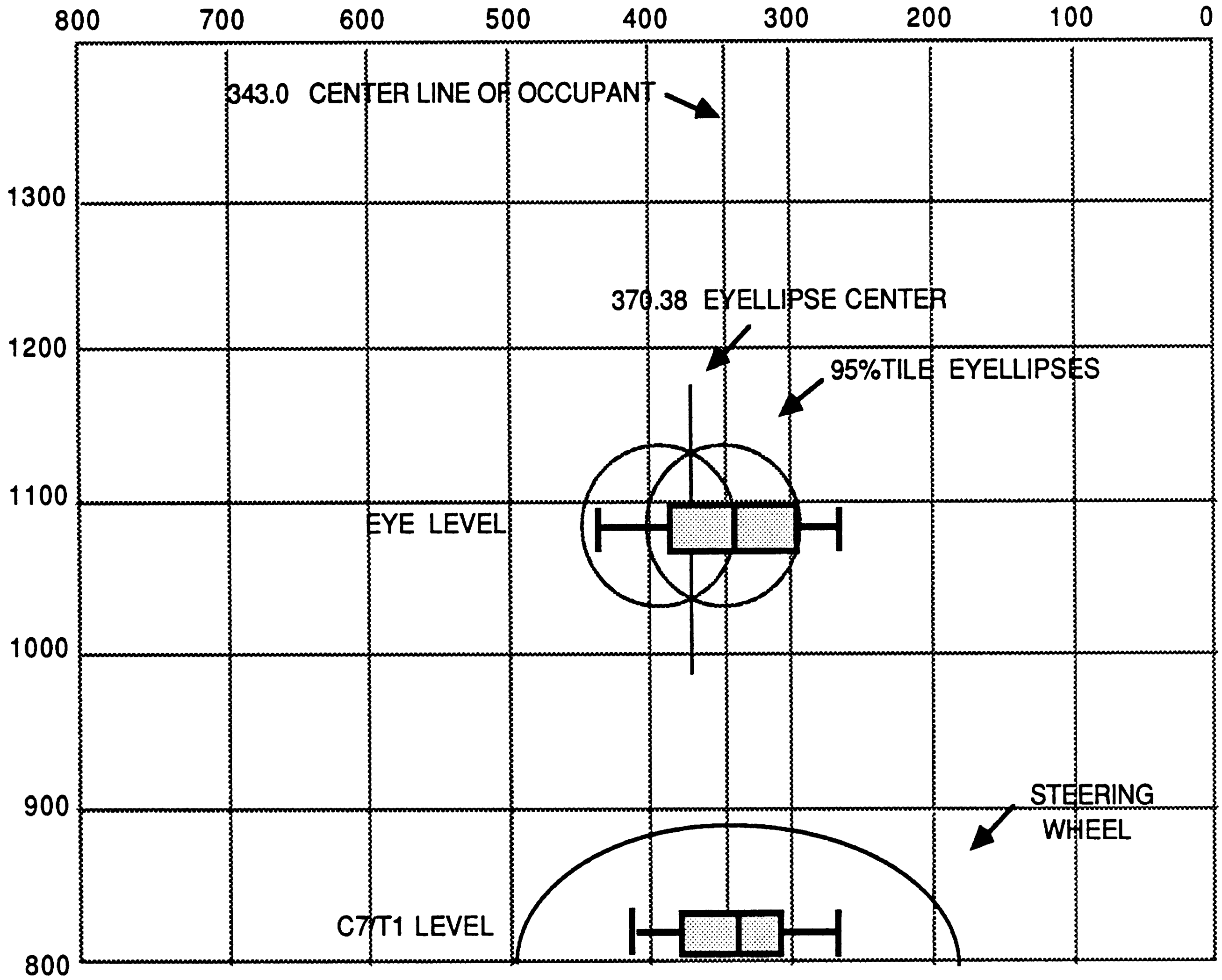


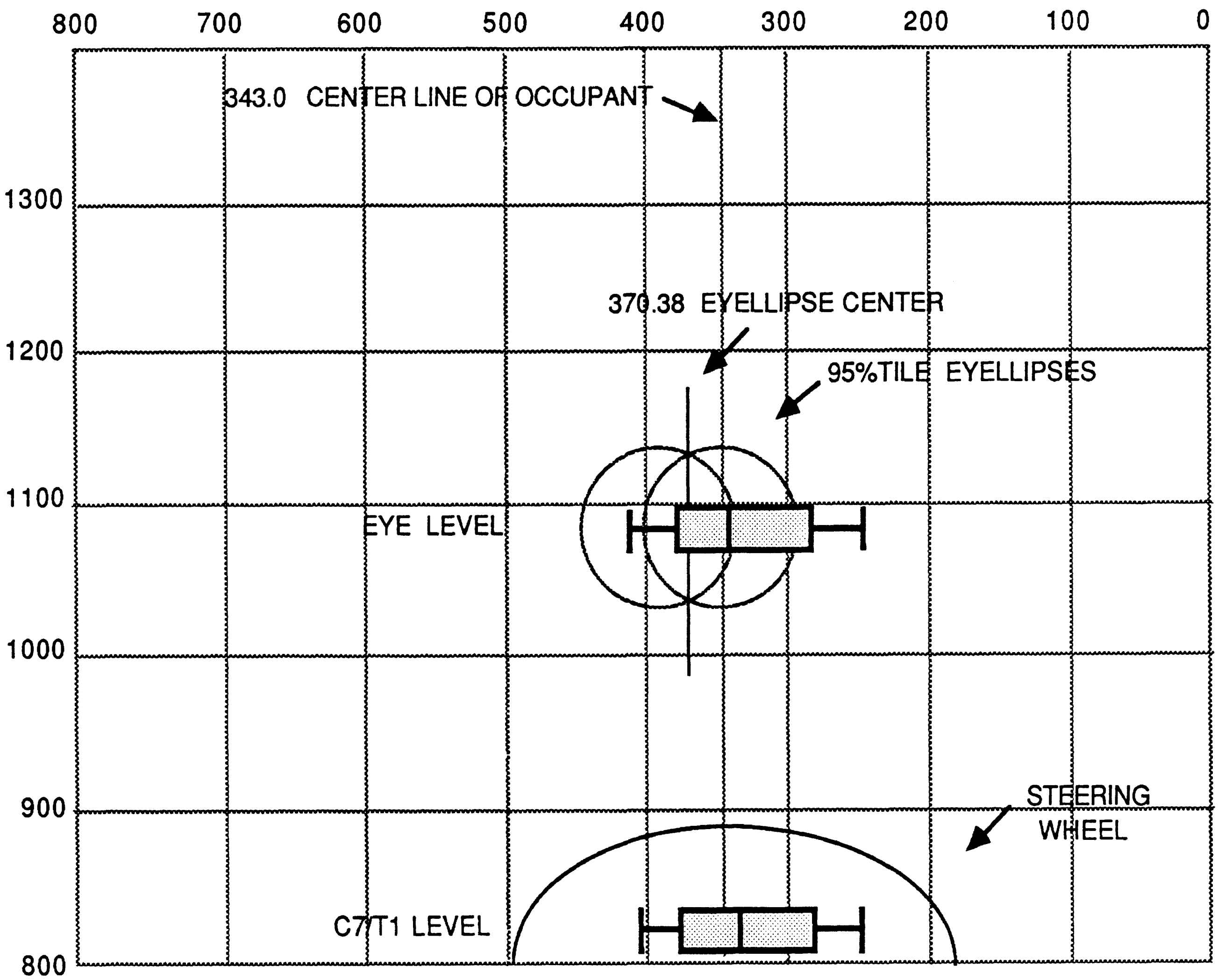
Figure 14. Comparison of frequency distributions of head centers from video data with reconstructed distribution of midpoint of eyes from current eye eyellipses center.



(Unit: mm)

	Max.	95%	Med.	5%	Min.	Mean	Std.
Head Center	427. 08	337.16	336.46	297.28	267.89	335.83	24.34
Shoulder Center	412.04	378.50	332.21	302.28	277.69	334.91	23.72

Figure 15. Box and whisker plot of head and shoulder center distributions for BUCKET seat driving



(Unit: mm)

	Max.	95%	Med.	5%	Min.	Mean	Std.
Head Center	412.80	377.90	335.24	284.98	242.99	332.66	27.27
Shoulder Center	407.02	379.91	332.61	282.36	256.08	333.02	30.59

Figure 16. Box and whisker plot of head and shoulder center distributions for BENCH seat driving

Other possible causes for the more inboard locations in the current study might be the narrower dimensions of late model vehicles, the presence of center armrests and consoles, and the fact that the current data were collected under actual driving conditions while the original eye ellipse data were collected for static vehicle conditions.

2. Summary and Conclusions

The original objective of this preliminary investigation was to compare the lateral positions and motions of drivers in bench and bucket seats. This was accomplished by recording and analyzing video tapes of drivers' lateral position relative to centerline of occupant under actual driving conditions. The results show that:

1. There were no significant differences between the lateral positions and motions for bench and bucket seats during straight ahead highway driving.

2. There were no significant differences between drivers of different size for mean lateral offset, standard deviation, or range of the lateral offsets

3. There is a significant difference between the current eyellipses centerline and the eyellipses centerline based on dynamic head position data collected in this preliminary study.

3. Recommendations for Further Research

The original eye position measurements (Meldrum, 1965) have been widely accepted for over 20 years and most subsequent efforts have concentrated on how to modify these original data for new vehicle design features such as the addition of seat back recliners. As a result, various geometric transformation methods have been developed (Roe, et al, 1972, 1975). However, contemporary vehicle models are quite different from 1963 model cars which were used in the original research. For example, the centerline of an occupant in a 1963 Ford is located at 400.05 mm but, in the 1988 Pontiac 6000, this line is located at 343 mm. This is due to both the different front seat configuration and different vehicle usage (i.e., three occupants in the front seat of older vehicles). Also, shoulder belts were not used in the original study. These differences may have resulted in a more outboard seated position as illustrated in Figure 17 which are taken from the original study by Meldrum.

Although this preliminary investigation did not measure the driver eye position directly, it suggests that a change in the lateral eyellipses location may be needed. At the most frequent head center position, only 38% of the new eyellipses area overlaps with the current 95 percentile eyellipses.

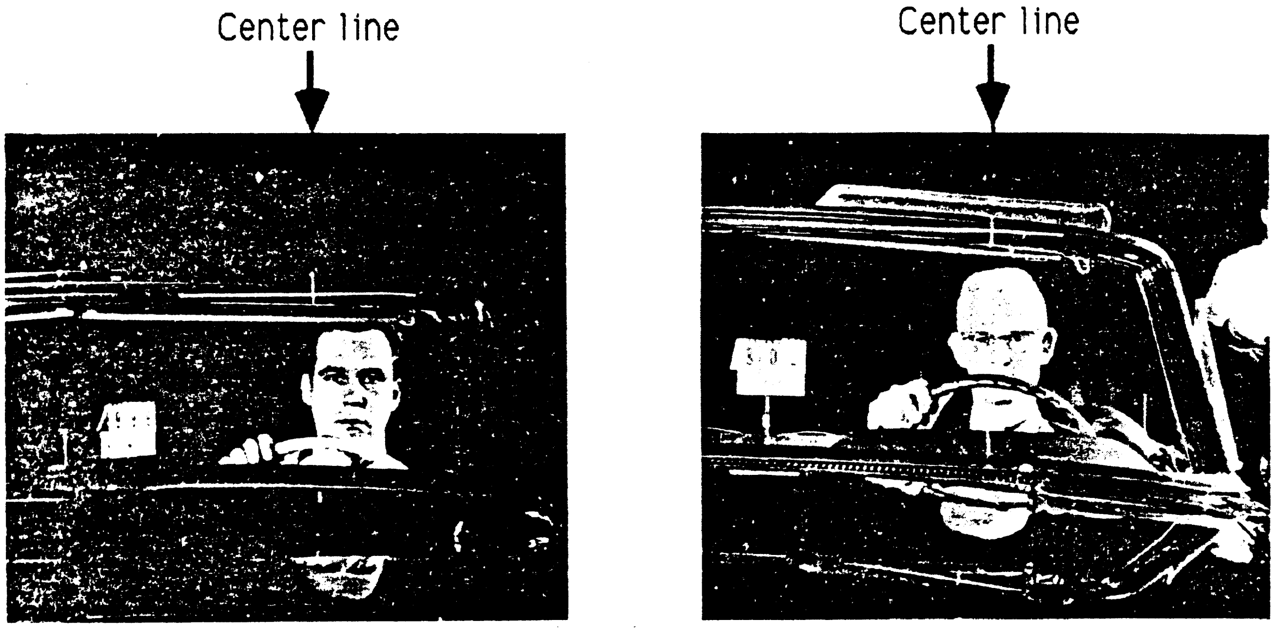


Figure 17. Front view of drivers sitting in 1963 model vehicles during original eyellipses study by Meldrum, 1965

V. REFERENCES

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Woodson, W.E. et al., Driver Eye Position and Control Reach Anthropometrics -- Vol II Dynamic Eye Position Study, Man Factors, Inc., 1971.

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Roe, R.W., Describing the Driver's Work Space: Eye, Head, Knee, and Seat Positions, SAE Paper 750365, 1975.

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Arnold, A.J., Ferrara R.A., and Kuechenmeister T., Effect of Alternate Population Mixes on Design Eye Locations in Vehicles, Paper presented at the Symposium on Visibility for Highway Guidance and Hazard Detection, 1986.

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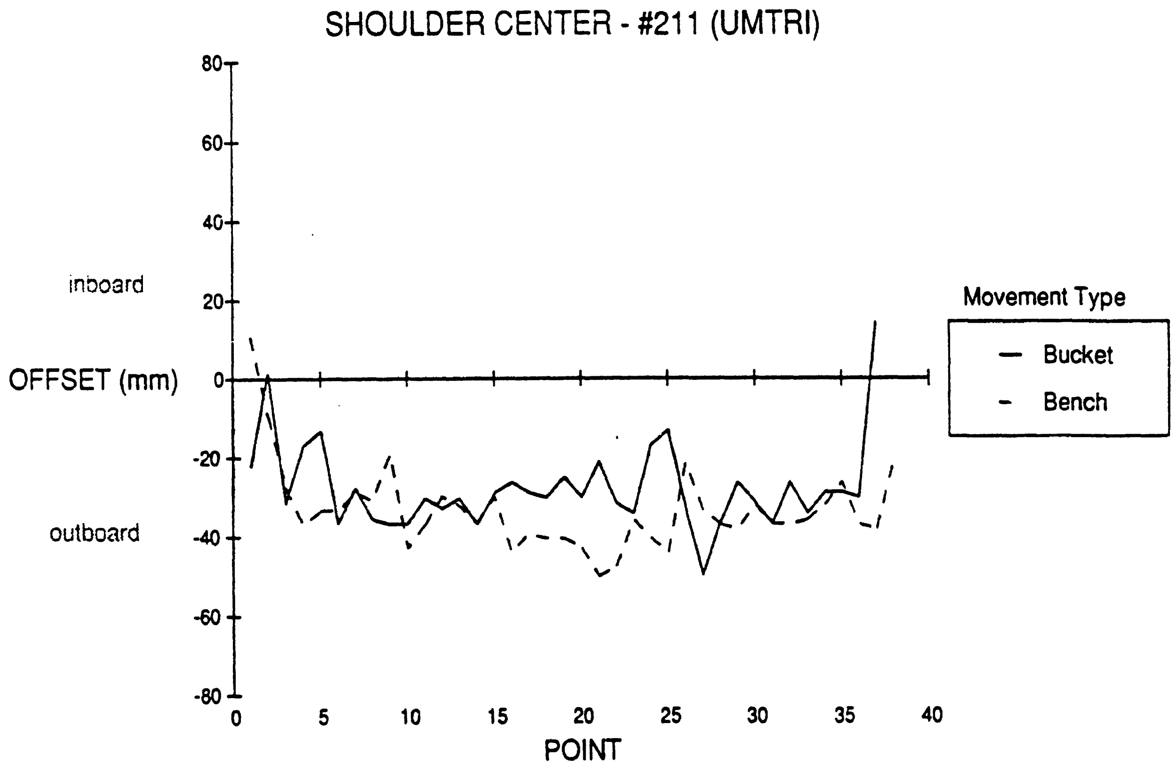
Appendix A

The Shoulder and the Head Center Movement Pattern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60
40
inboard
20
OFFSET (mm)
0
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outboard
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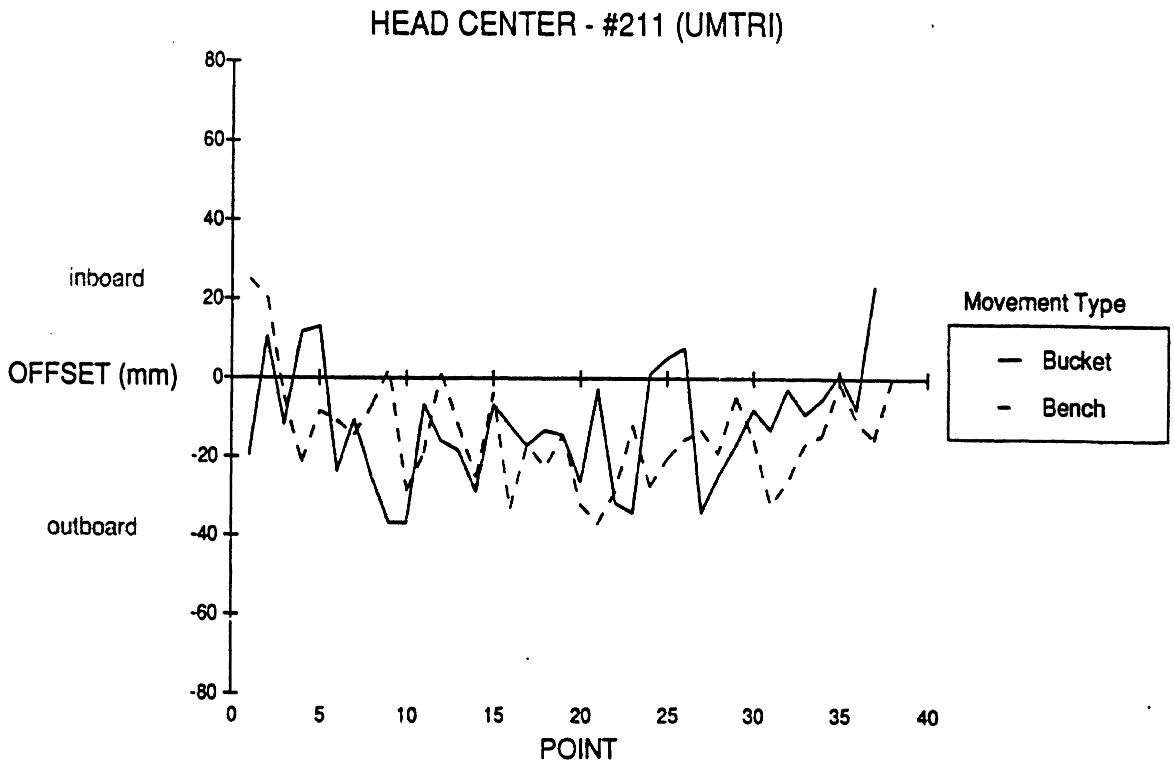
0
5
10
15
20
25
30
35
40
POINT
Movement Type
Bucket
Bench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inboard
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OFFSET (mm)
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5
10
15
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35
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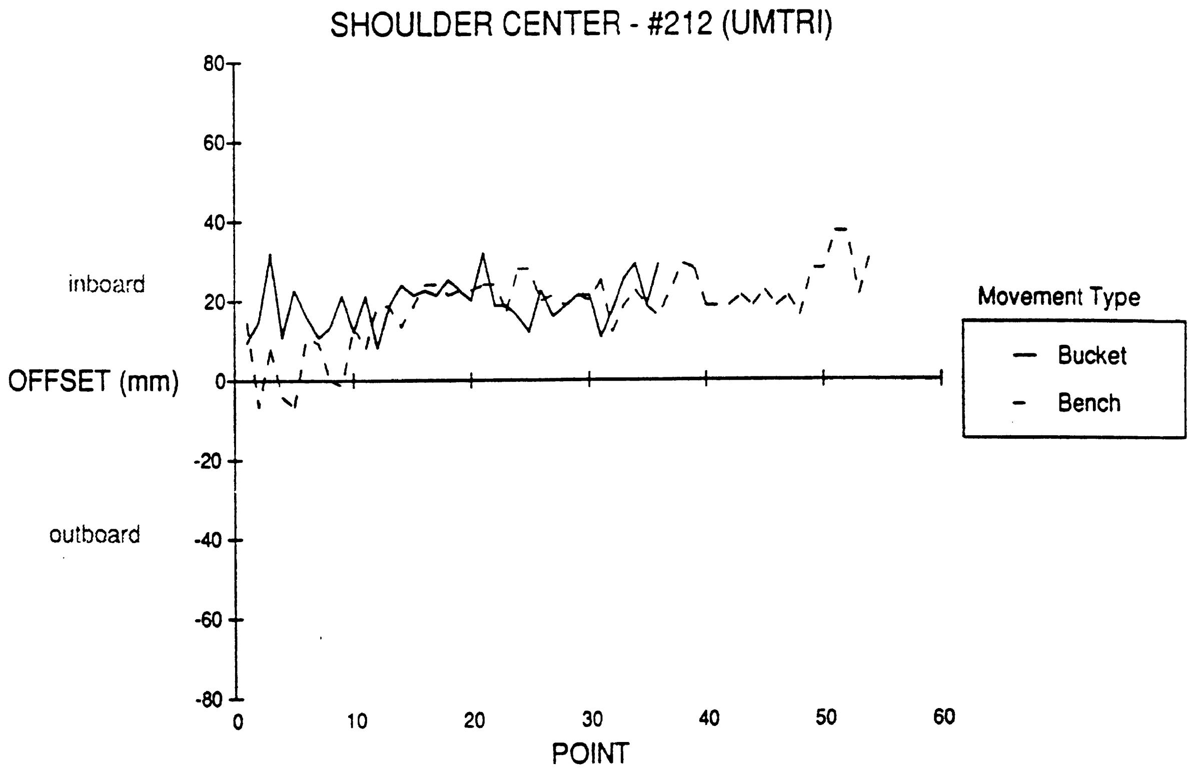
POINT
Movement Type
Bucket
Bench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OFFSET (mm)
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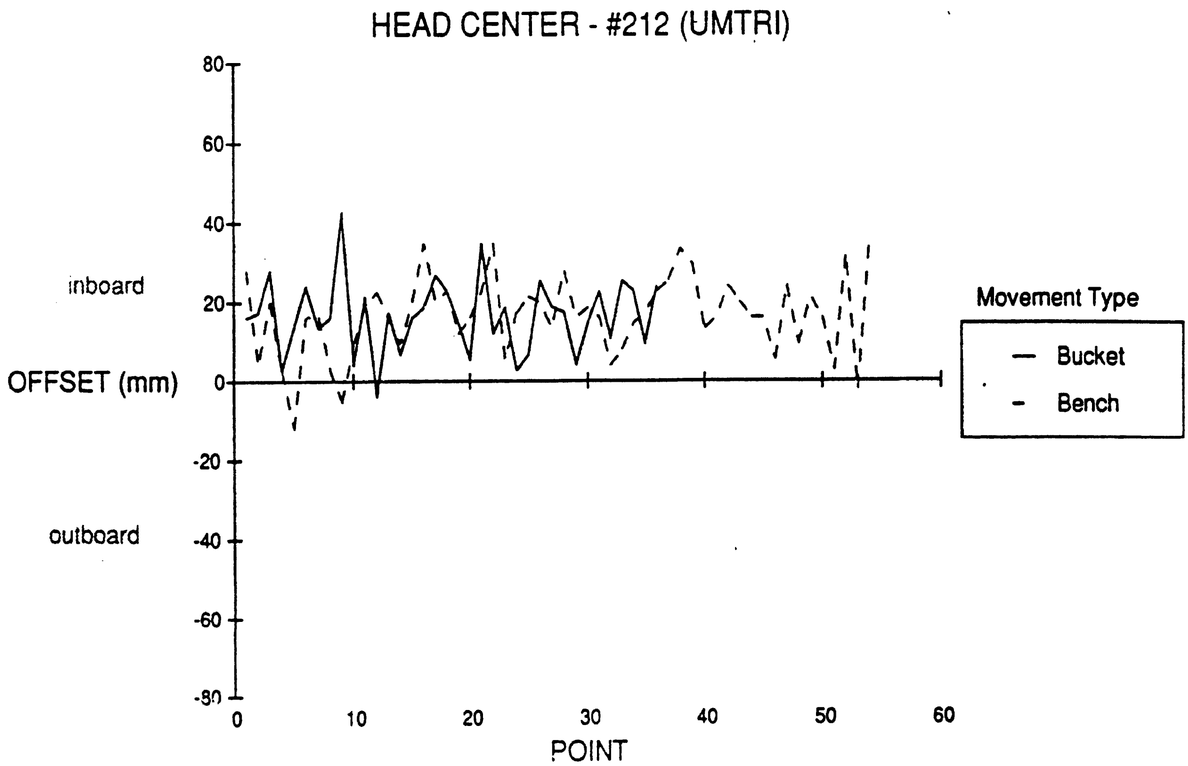
POINT
Movement Type
Bucket
Bench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outboard
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10
20
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50
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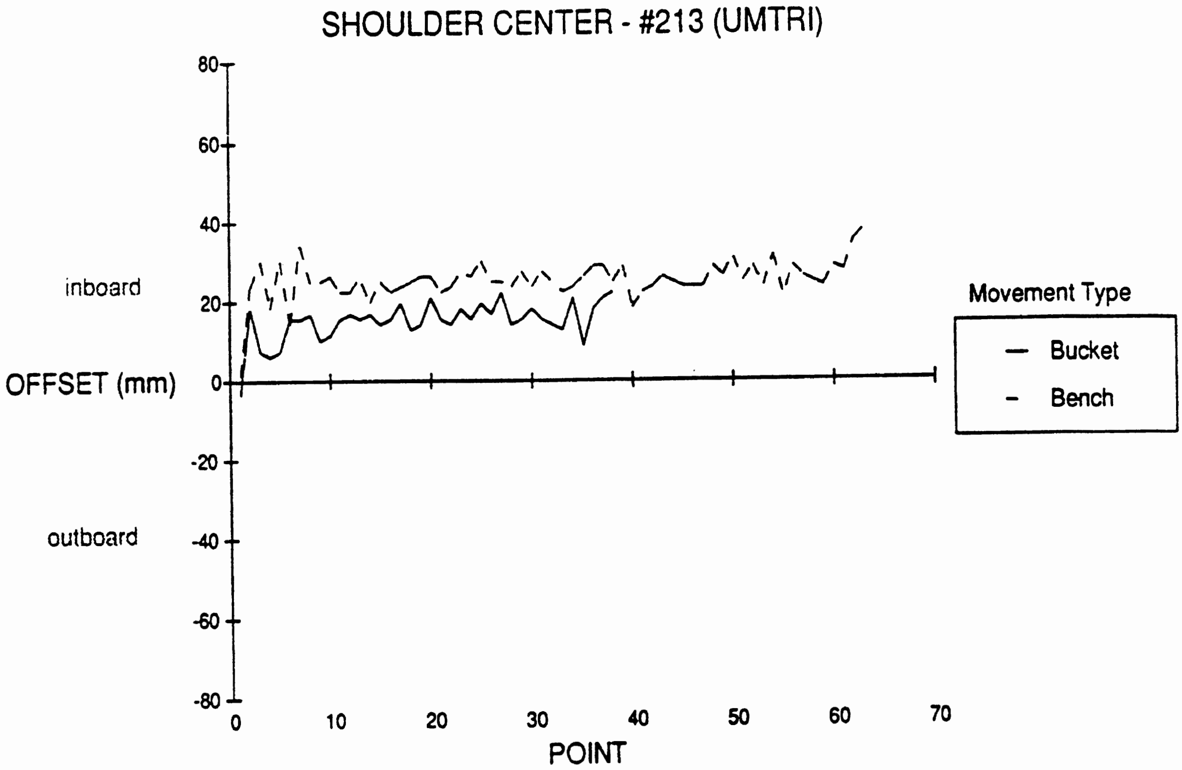
POINT
Movement Type
Bucket
Bench



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60
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20
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OFFSET (mm)
outboard
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10
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30
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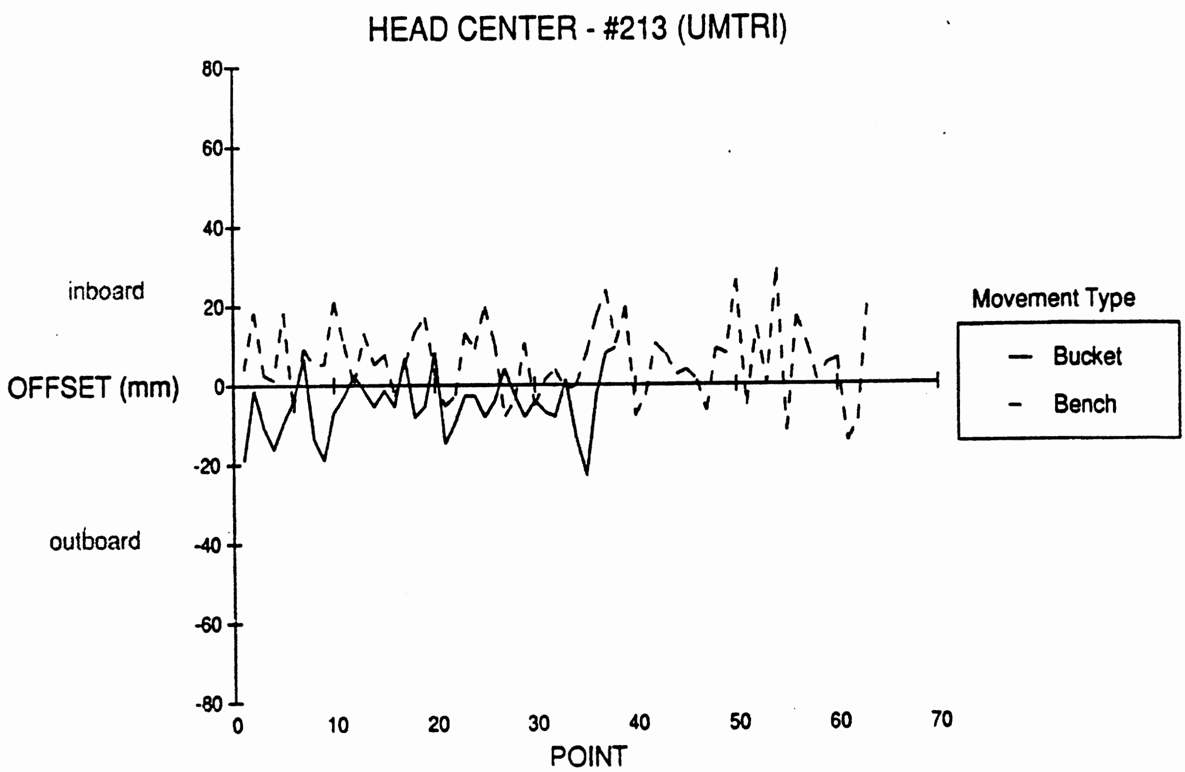
50
60
70
POINT
Movement Type
Bucket
Bench



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OFFSET (mm)
outboard
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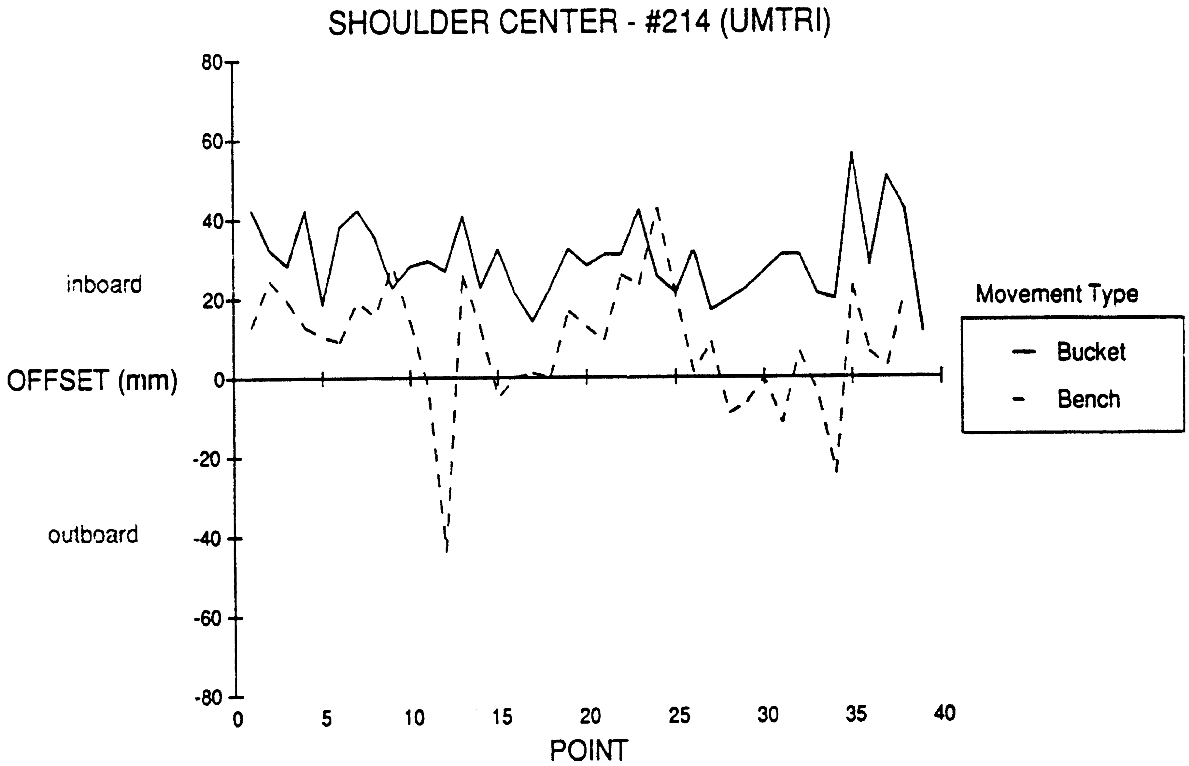
50
60
70
POINT
Movement Type
Bucket
Bench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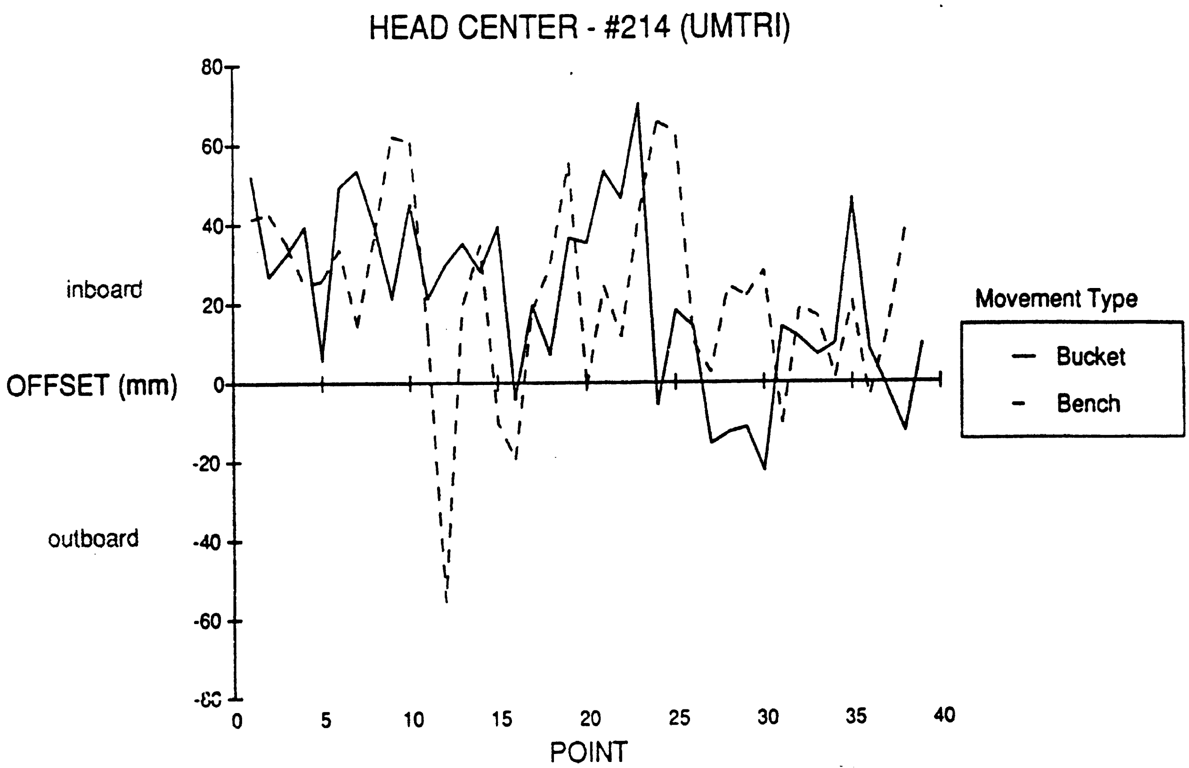
POINT
Movement Type
Bucket
Bench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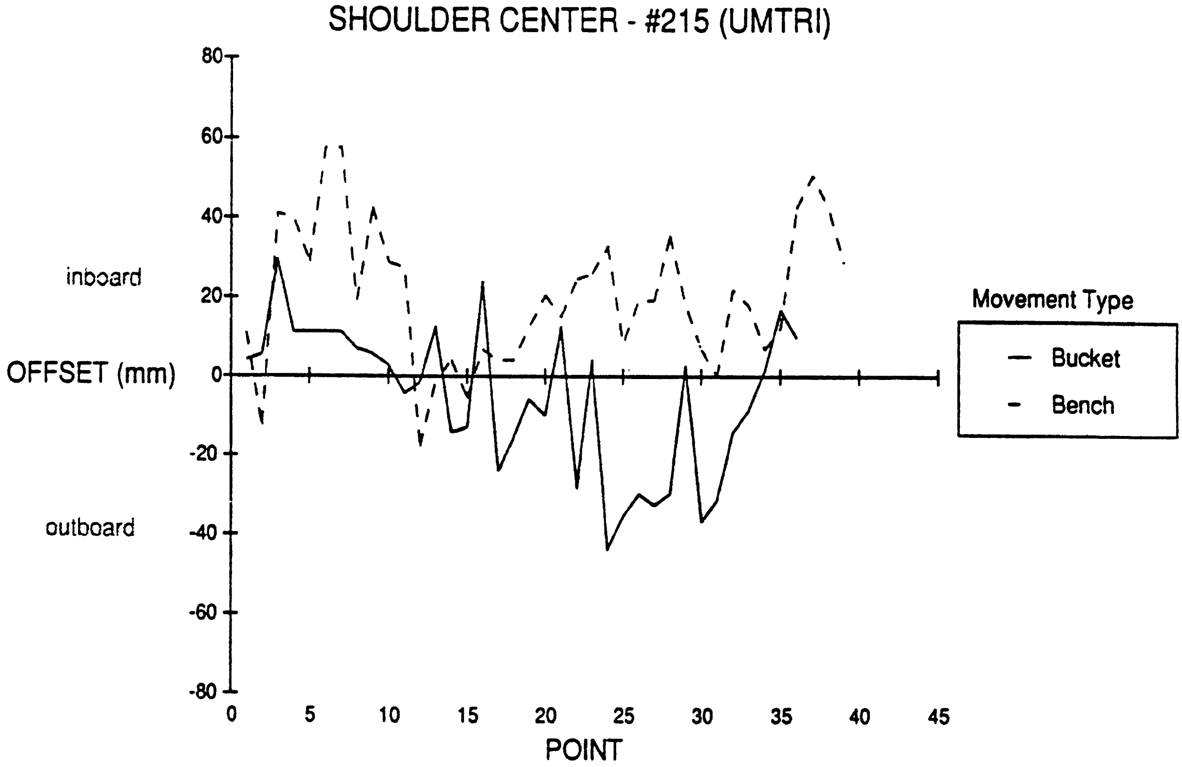
POINT
Movement Type
Bucket
Bench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outboard
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40
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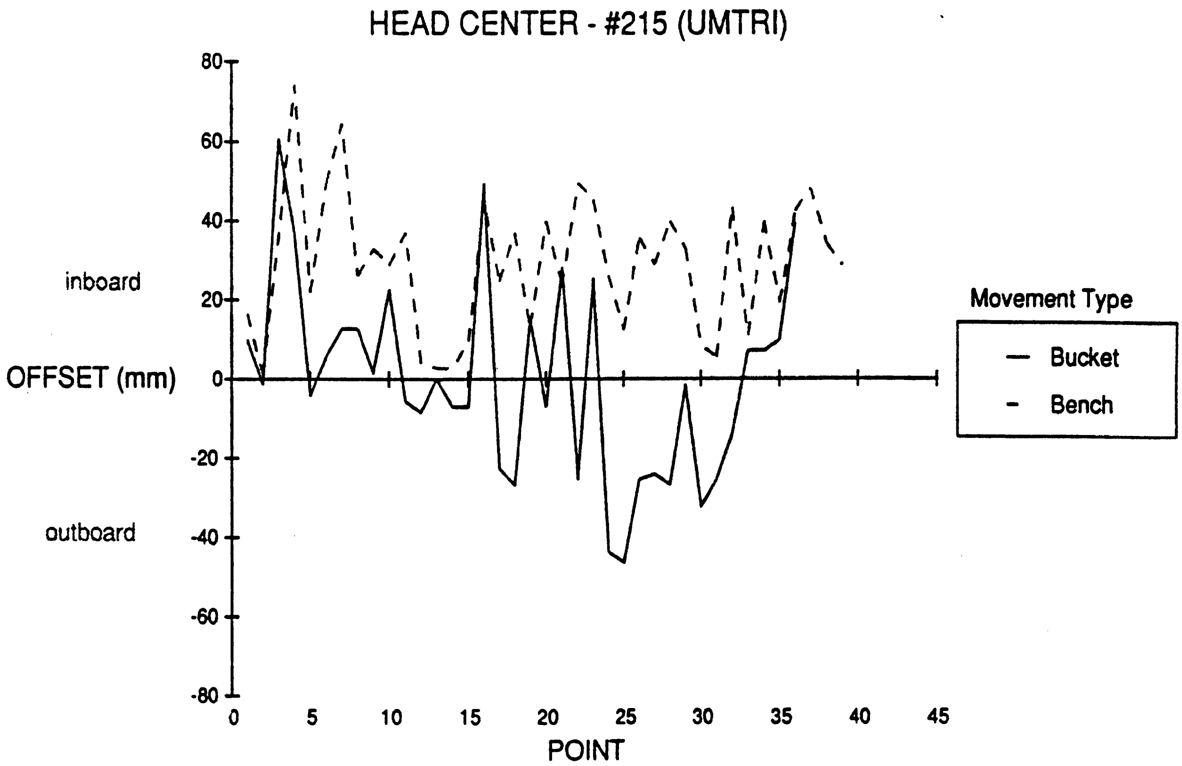
POINT
Movement Type
Bucket
Bench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outboard
OFFSET (mm)
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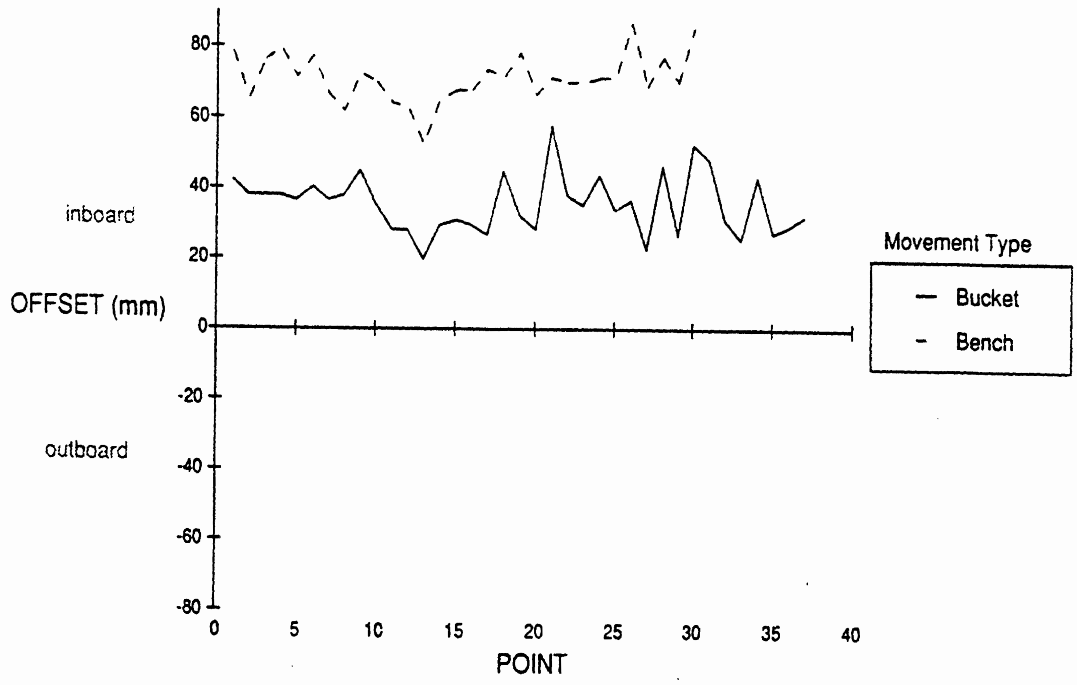
POINT
Movement Type
Bucket
Bench

SHOULDER - #216 (UMTRI)



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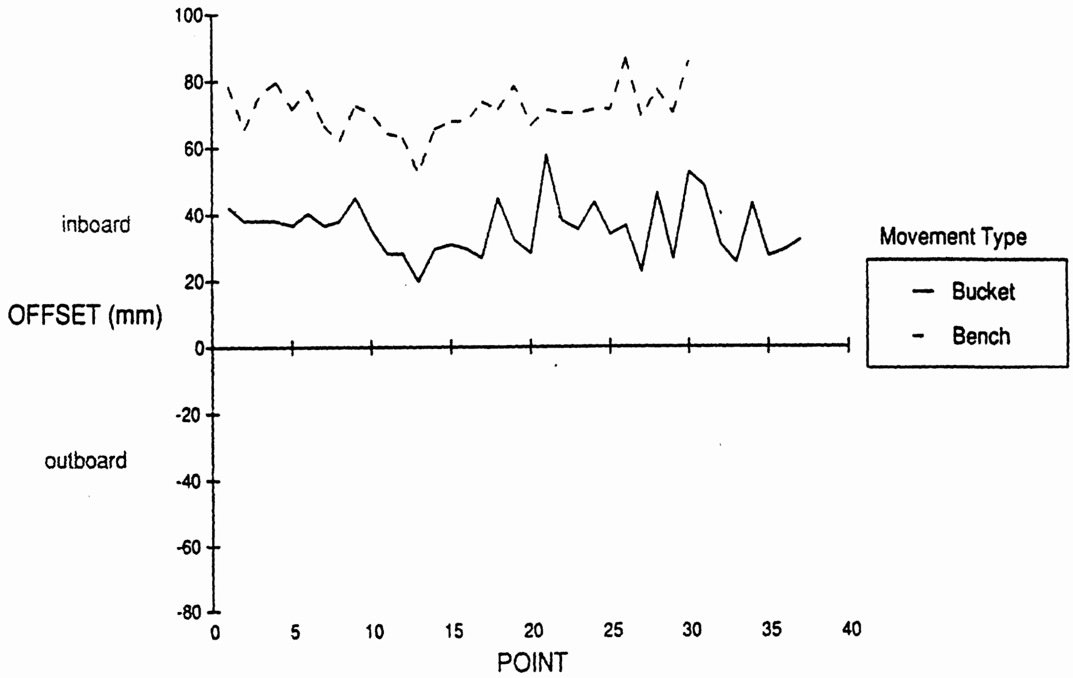

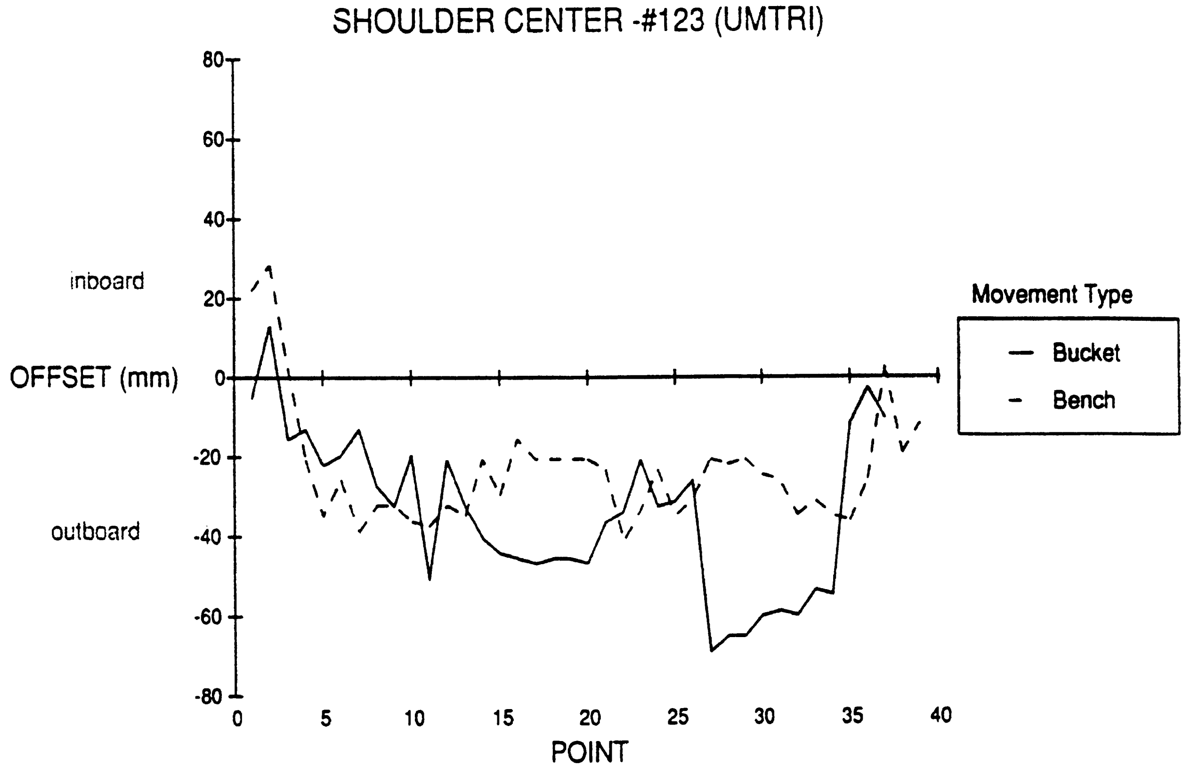
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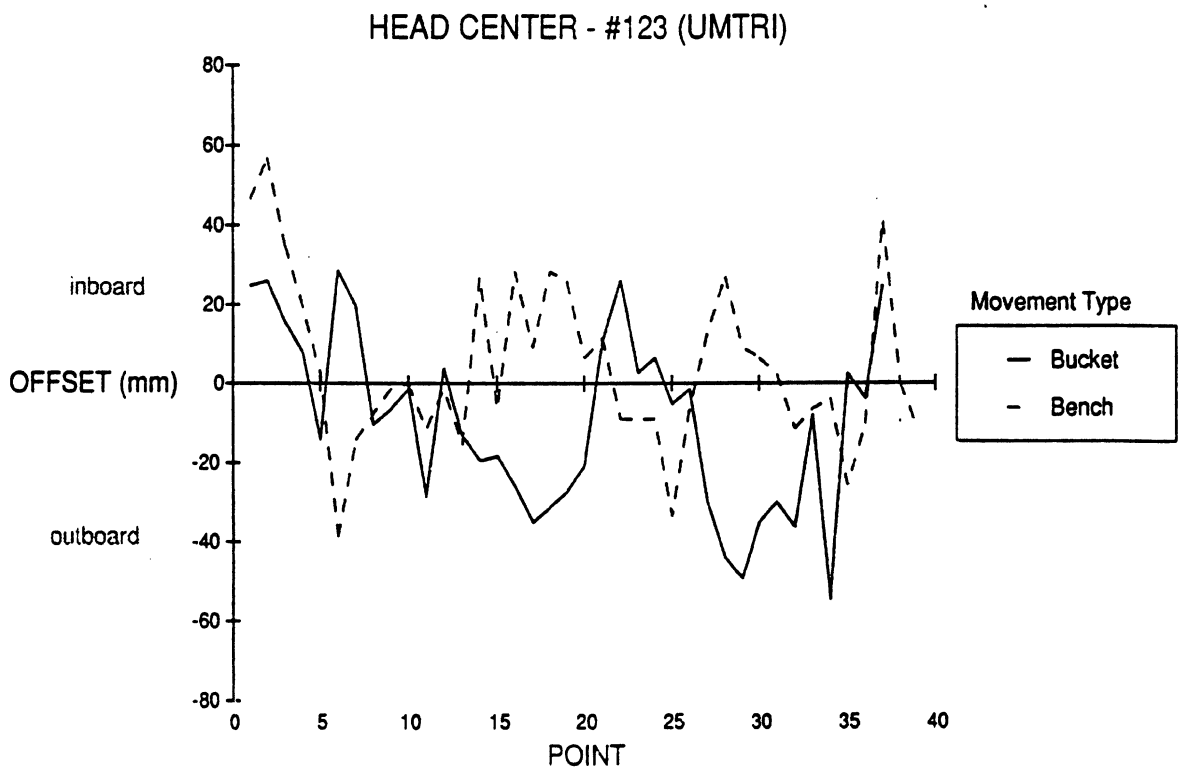
POINT
Movement Type
Bucket
Bench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OFFSET (mm)
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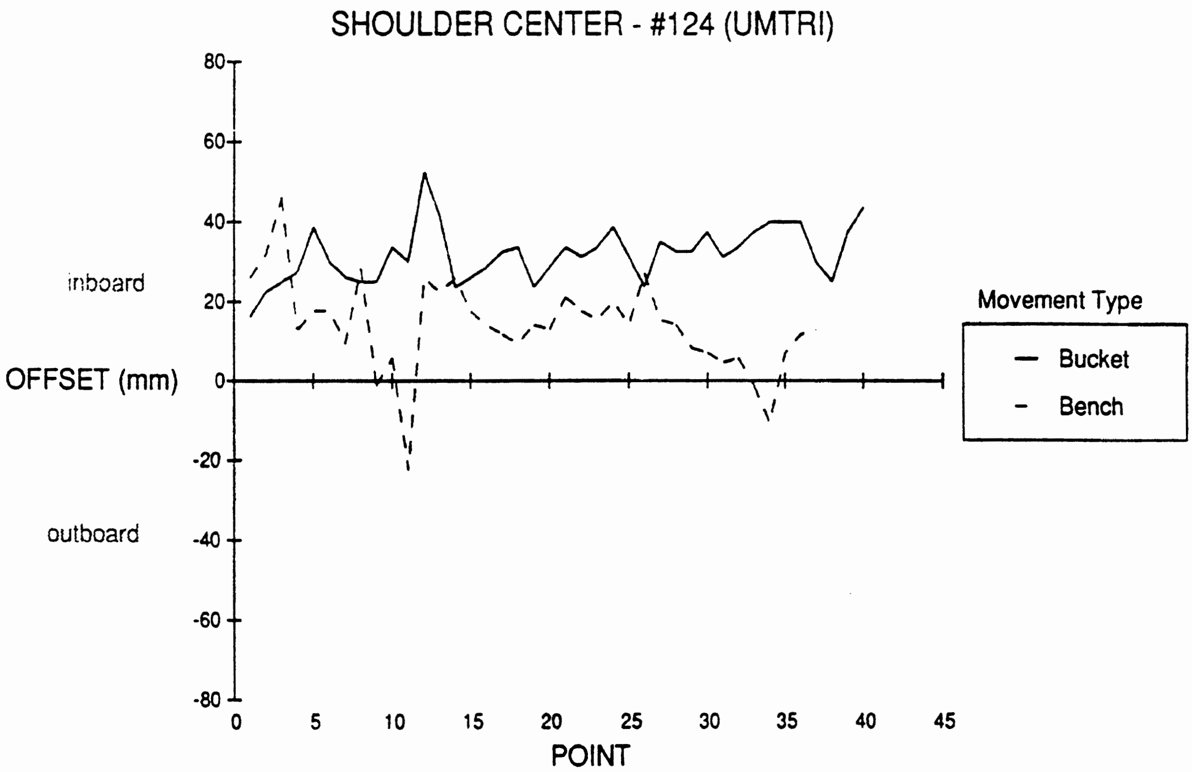
POINT
Movement Type
Bucket
Bench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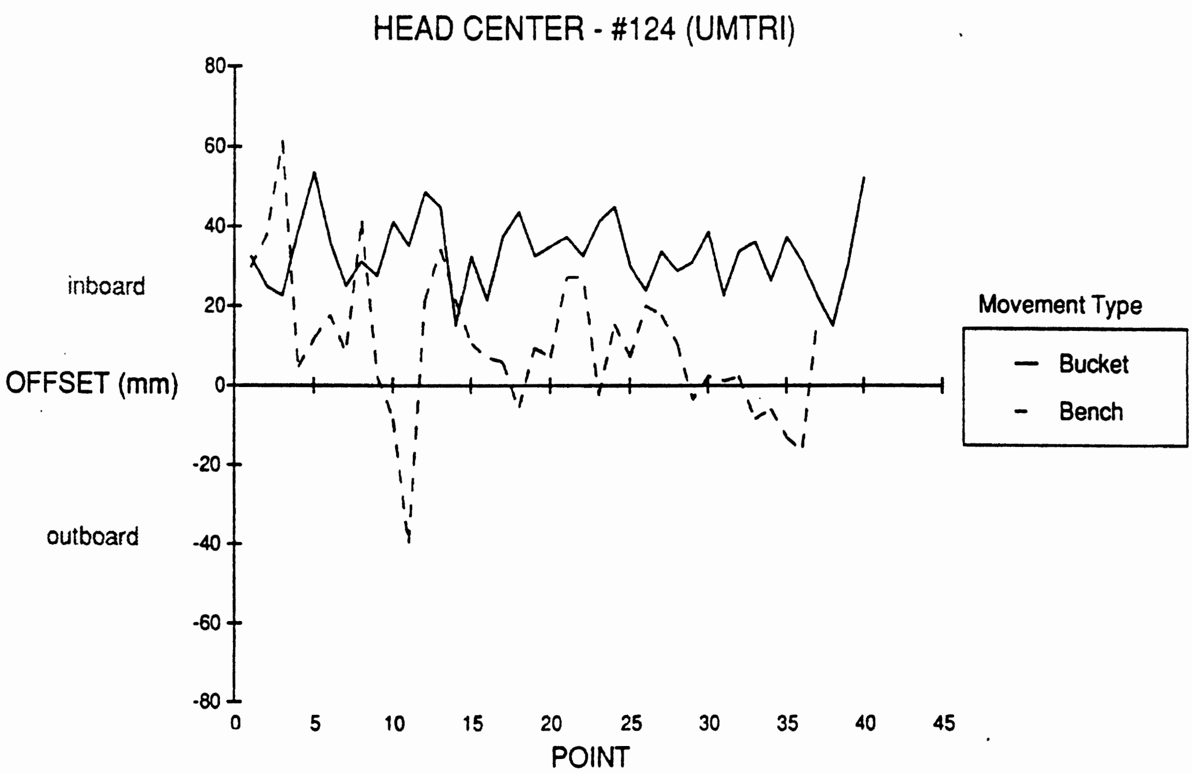
POINT
Movement Type
Bucket
Bench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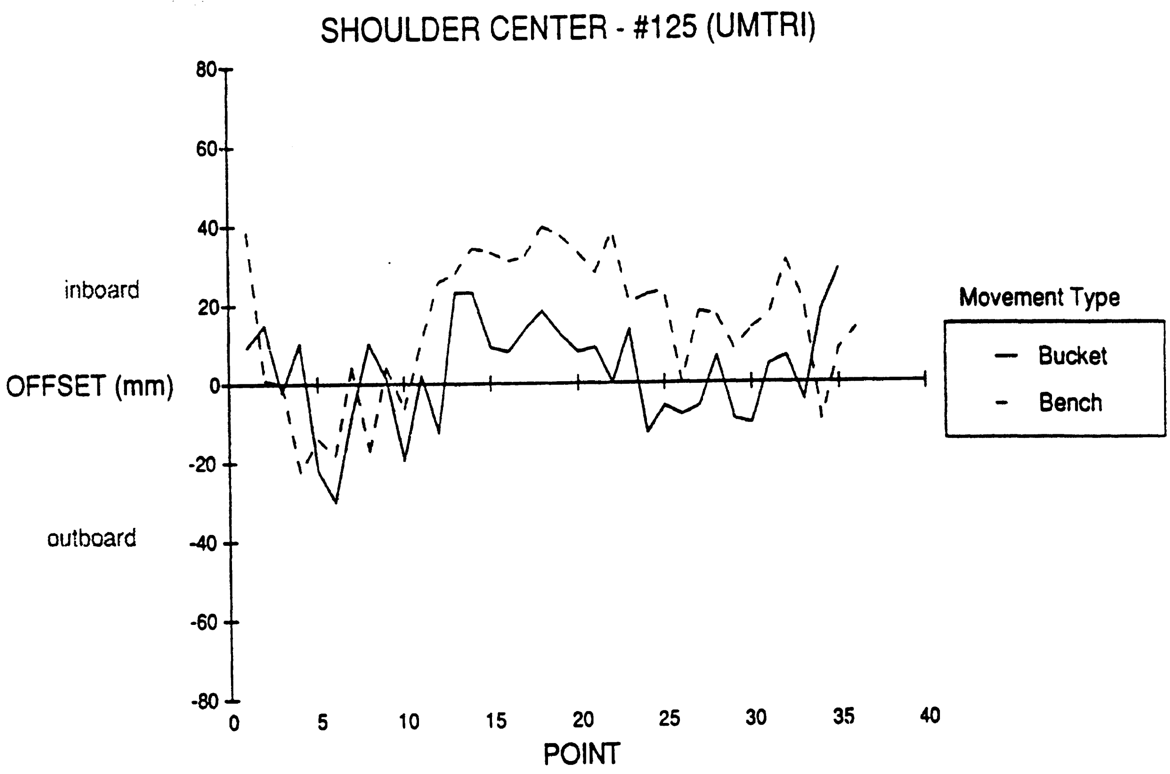
Movement Type
Bucket
Bench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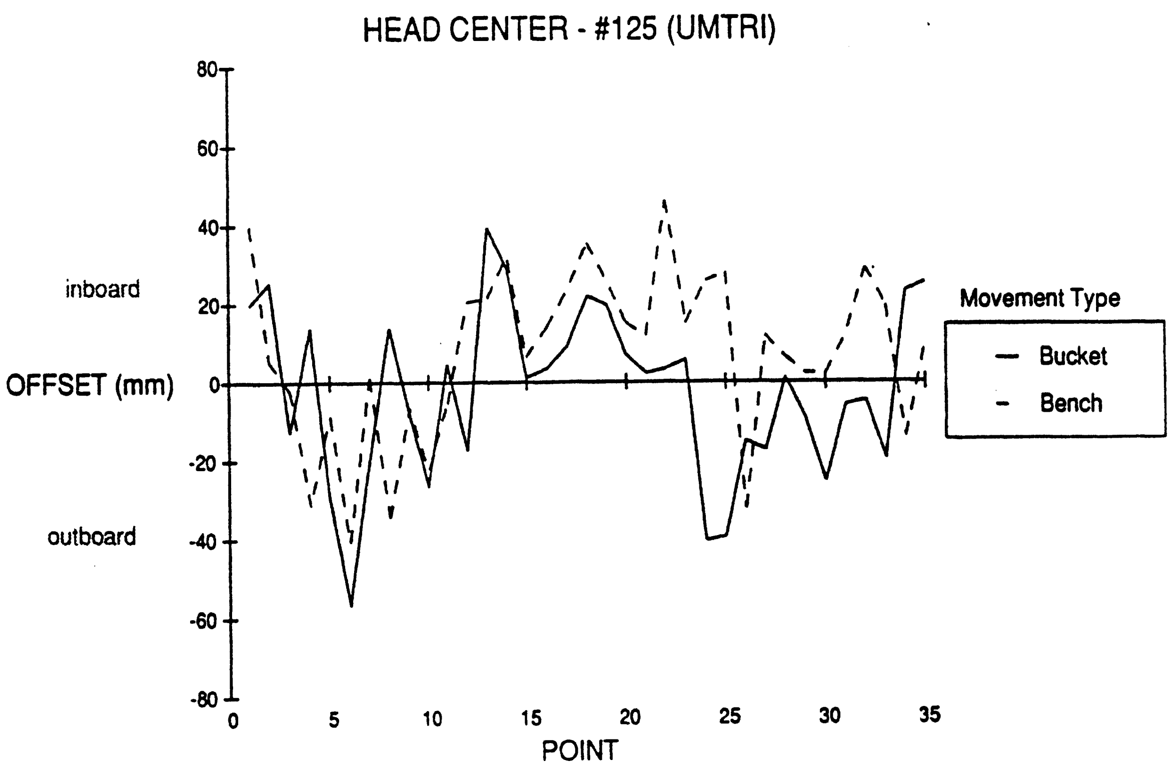
POINT
Movement Type
Bucket
Bench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OFFSET (mm)
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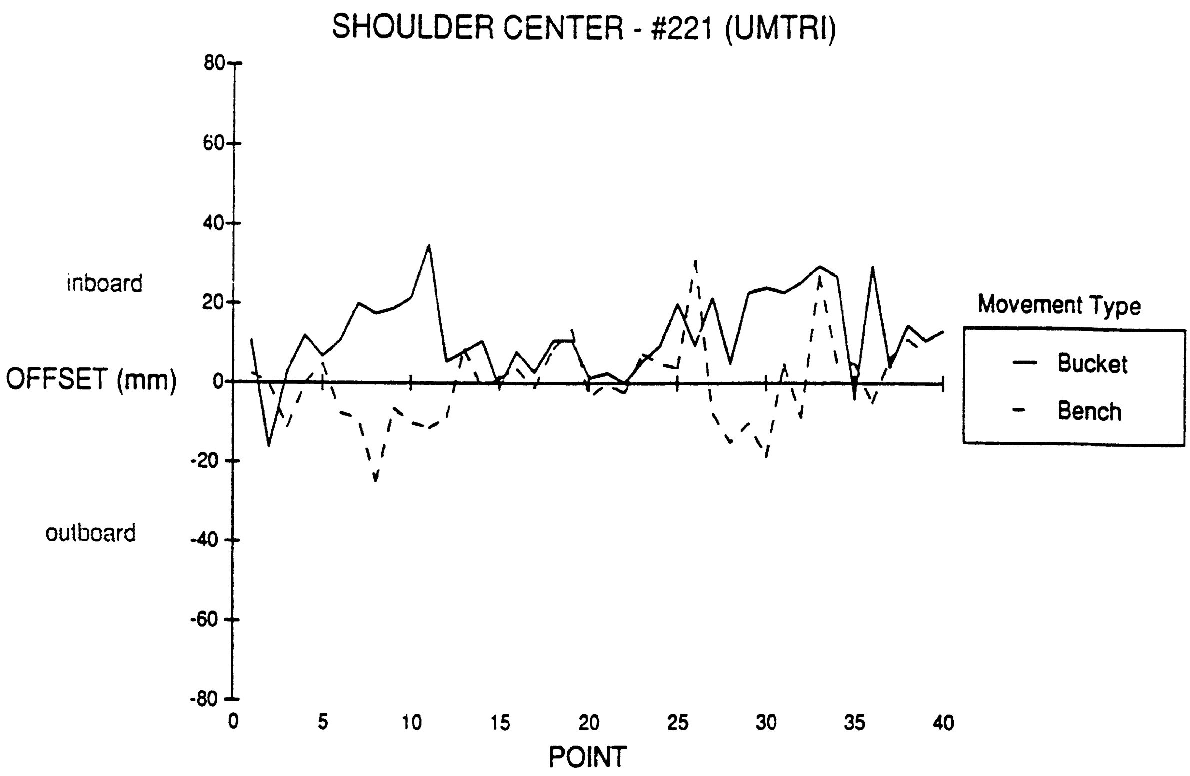
POINT
Movement Type
Bucket
Bench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Movement Type
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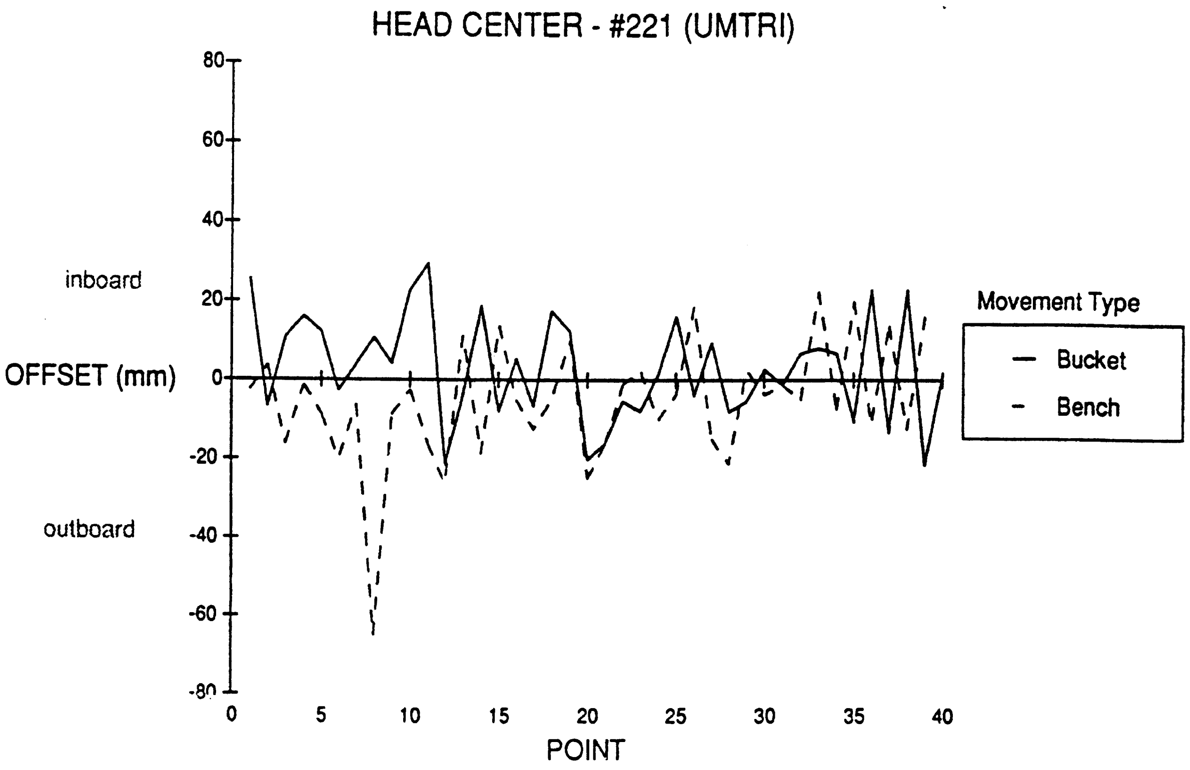
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Movement Type
Bucket
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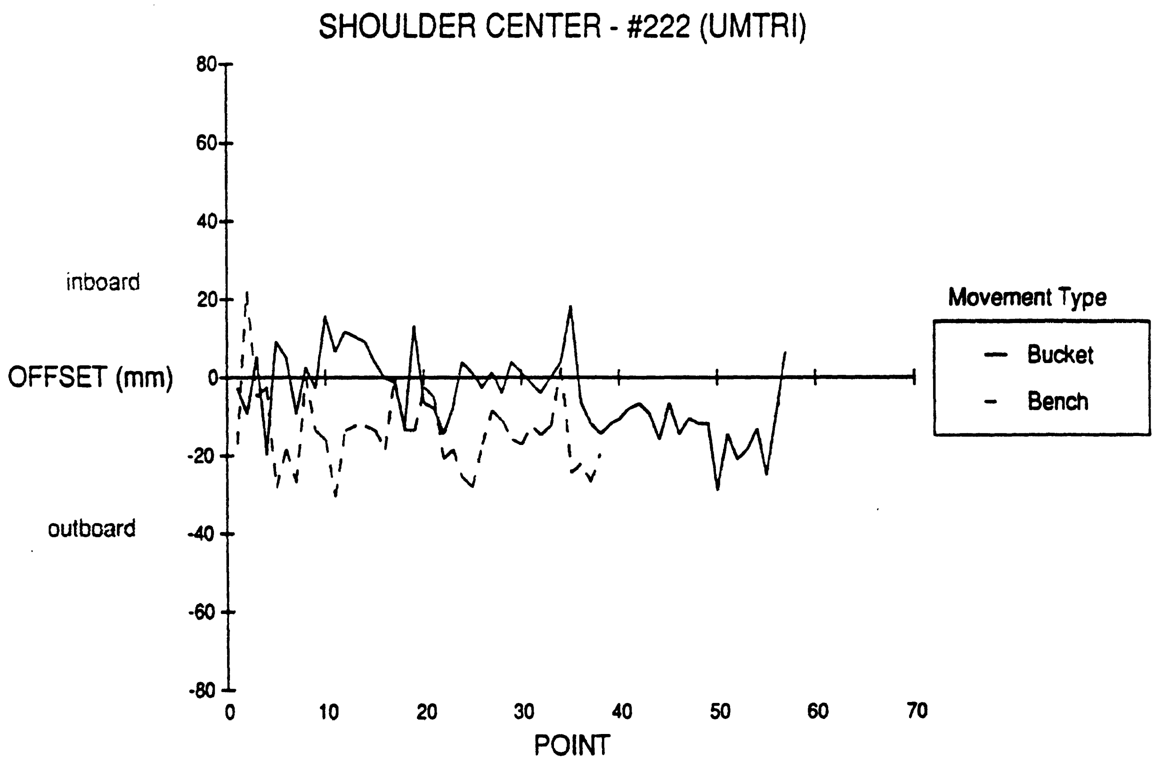
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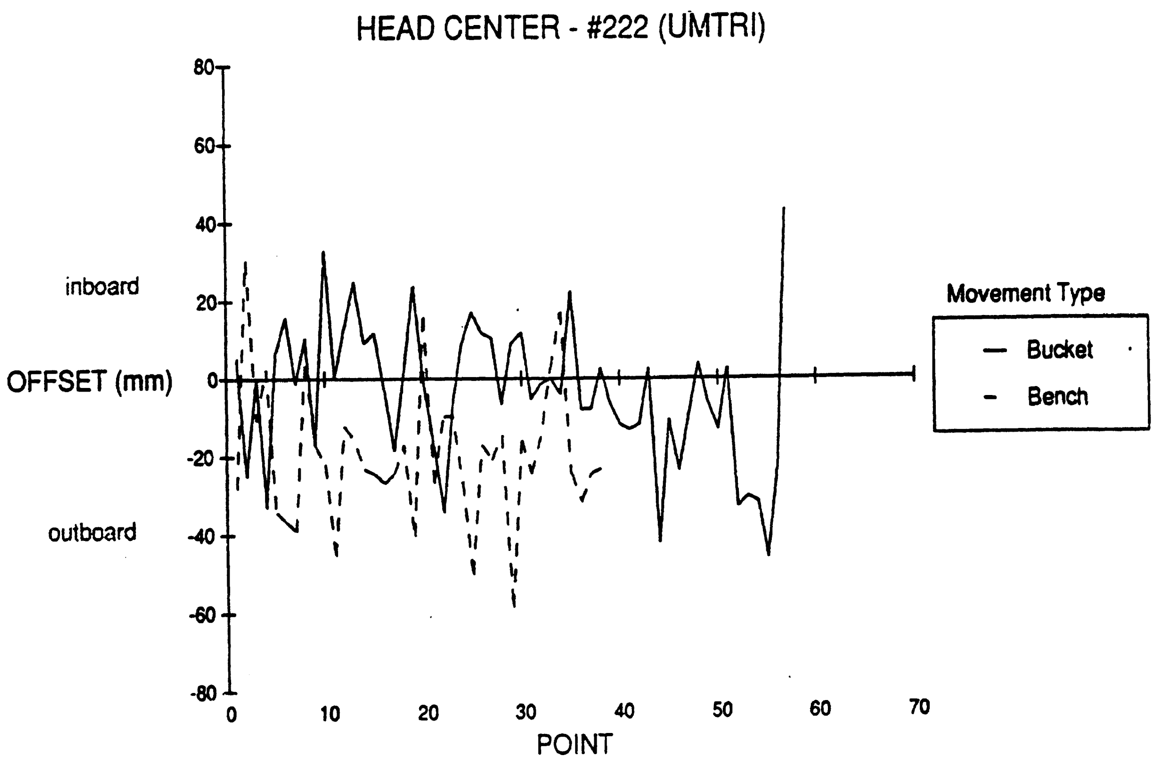
Movement Type
Bucket
Bench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POINT
Movement Type
Bucket
Bench

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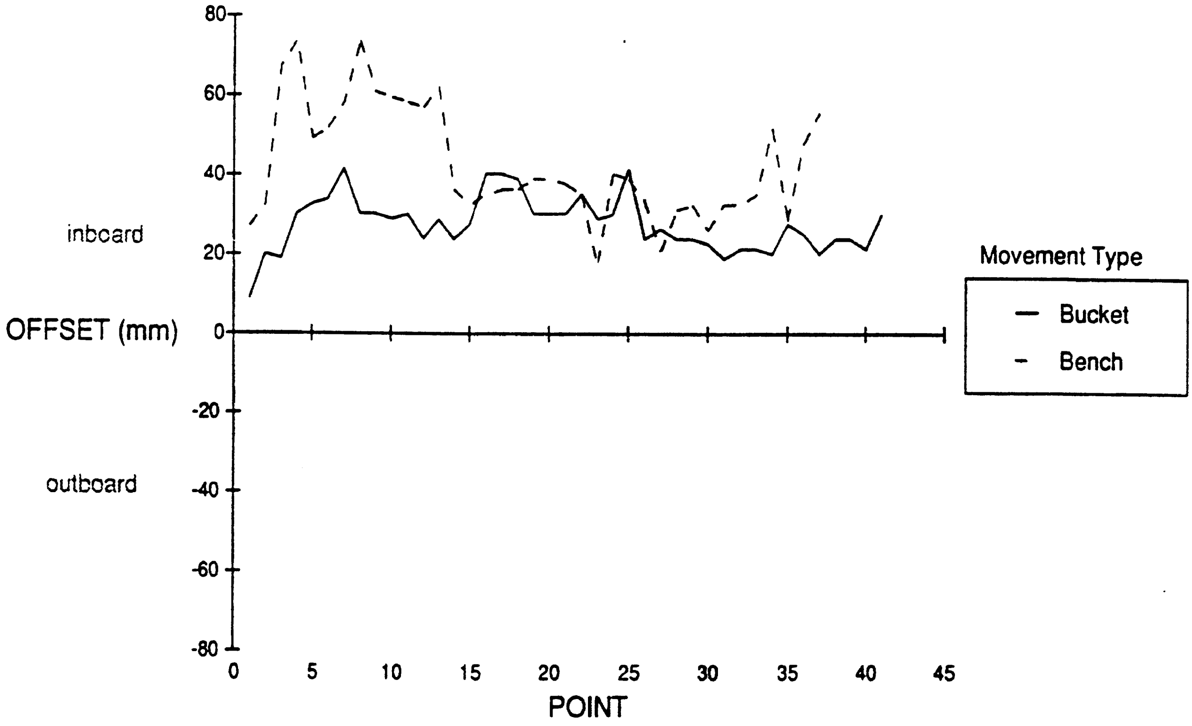

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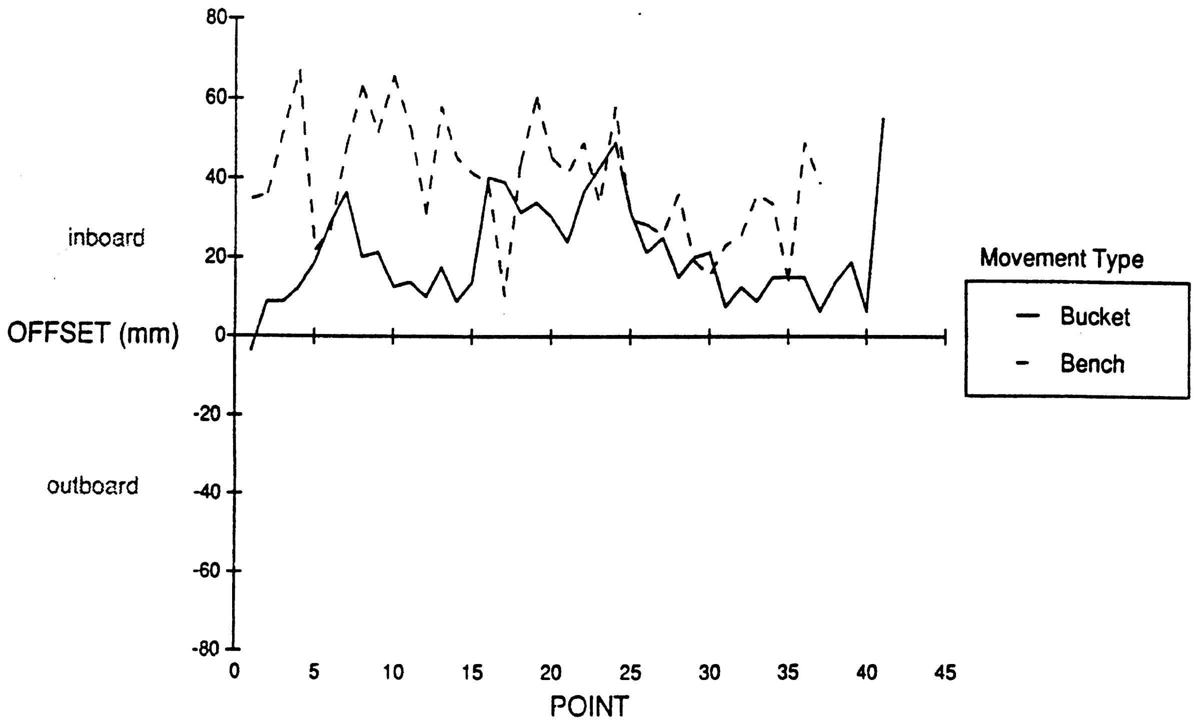

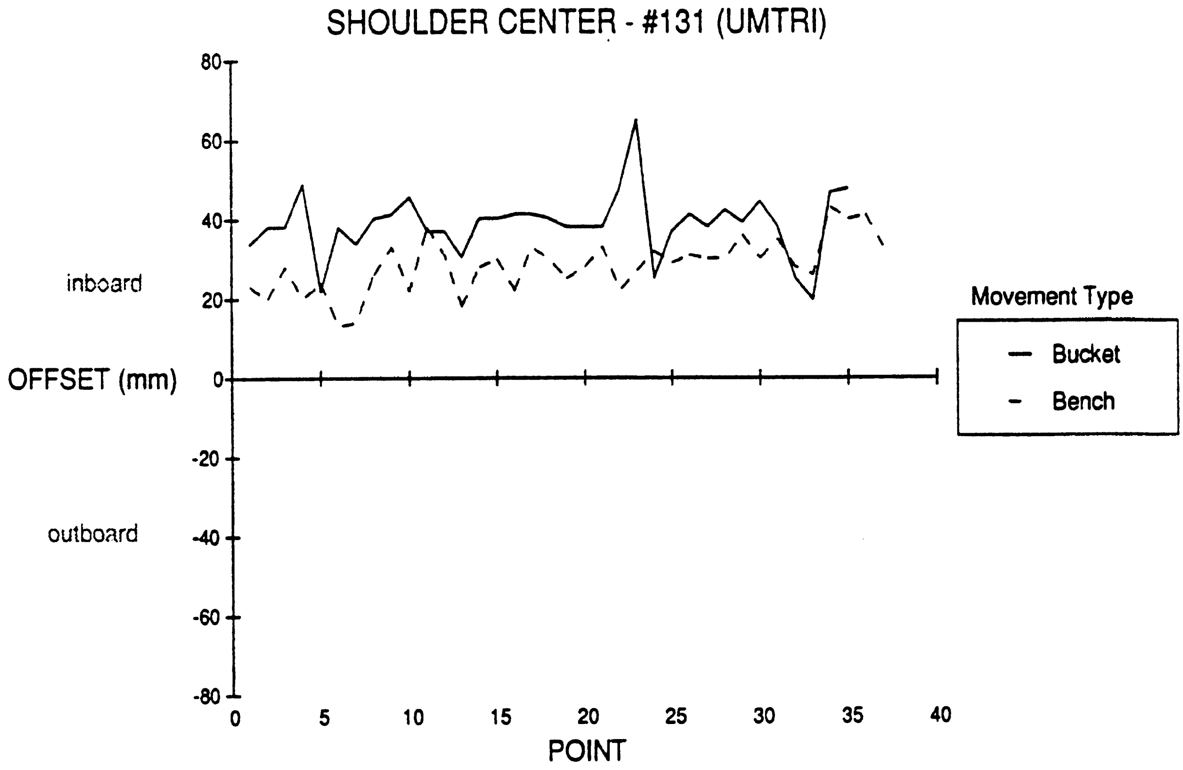
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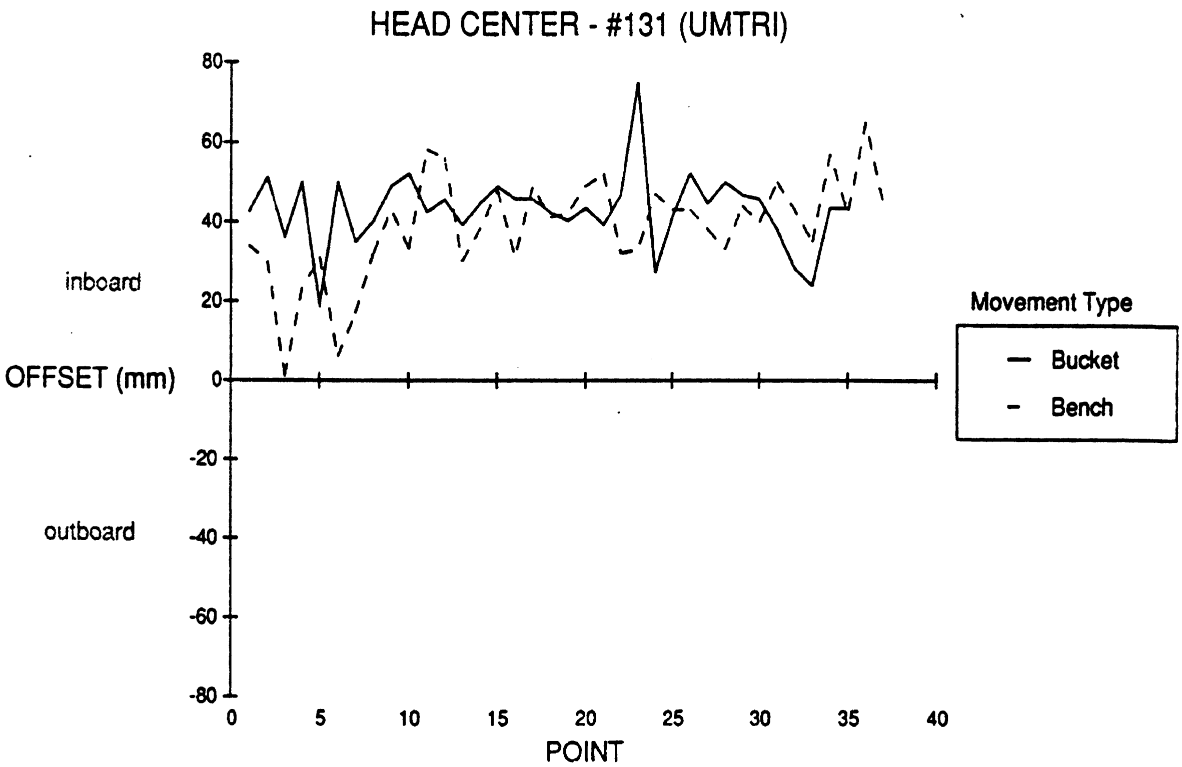
Movement Type
Bucket
Bench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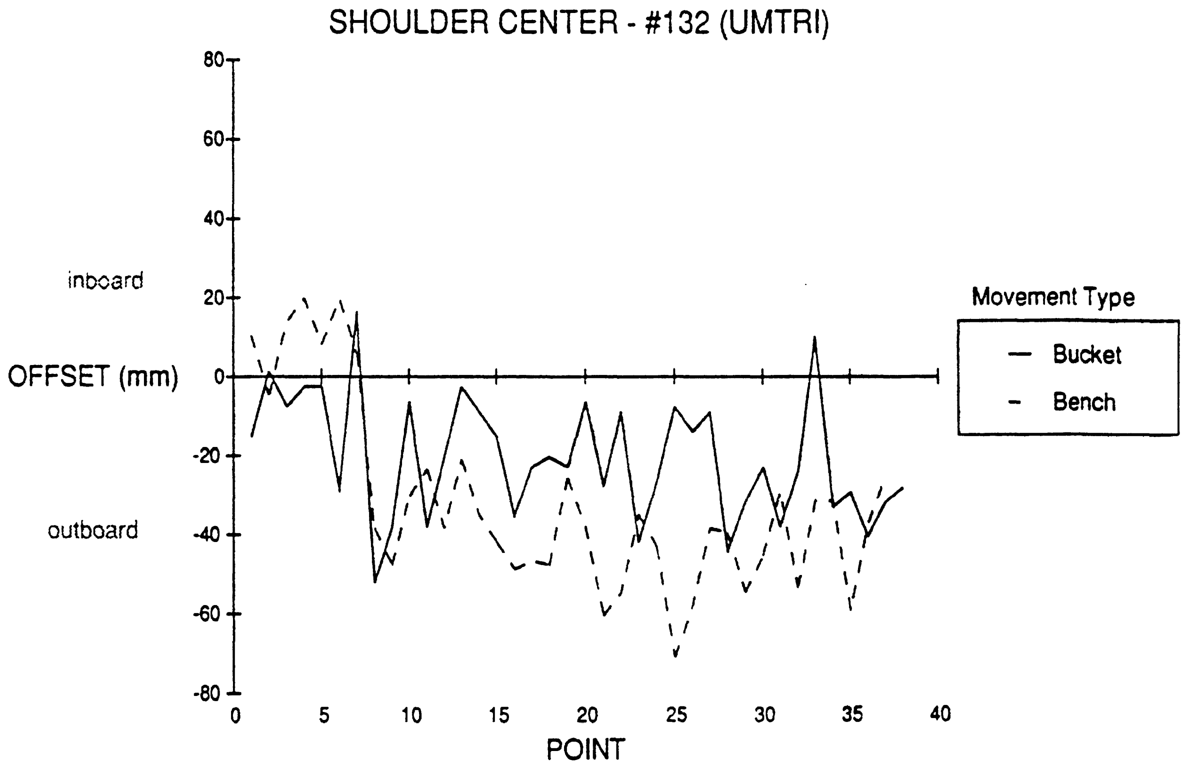
Movement Type
Bucket
Bench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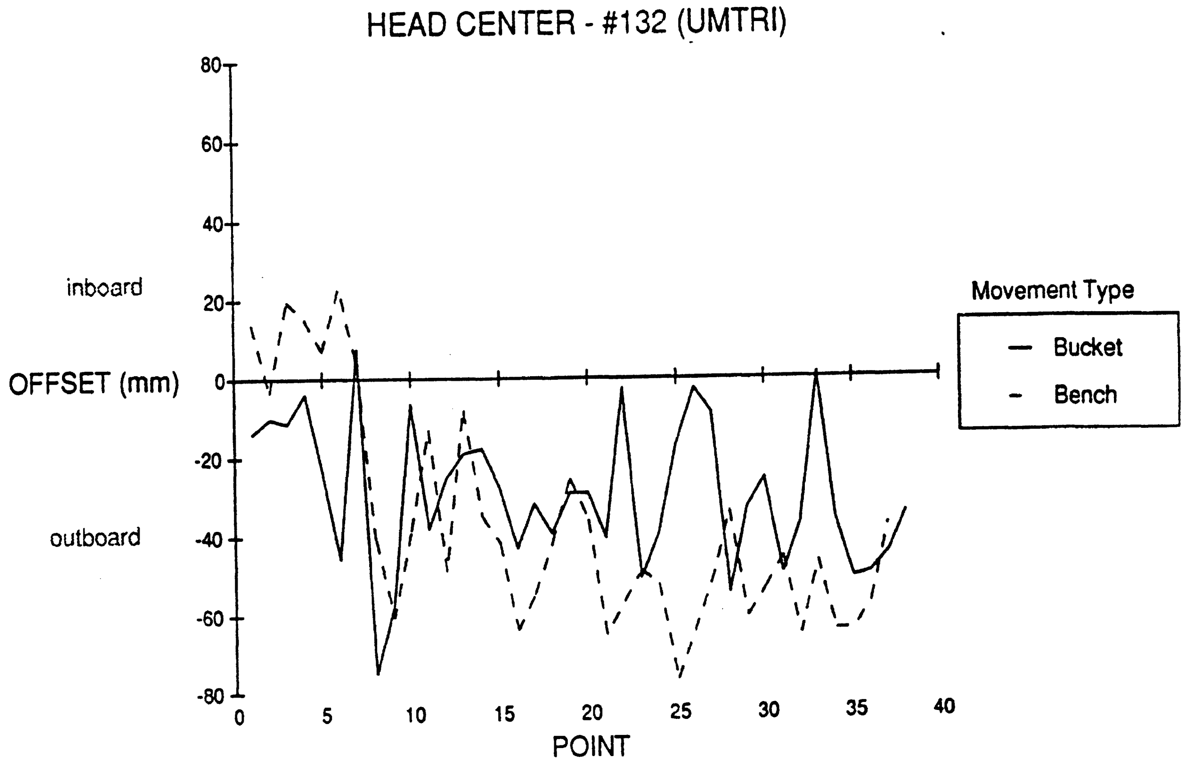
Movement Type
Bucket
Bench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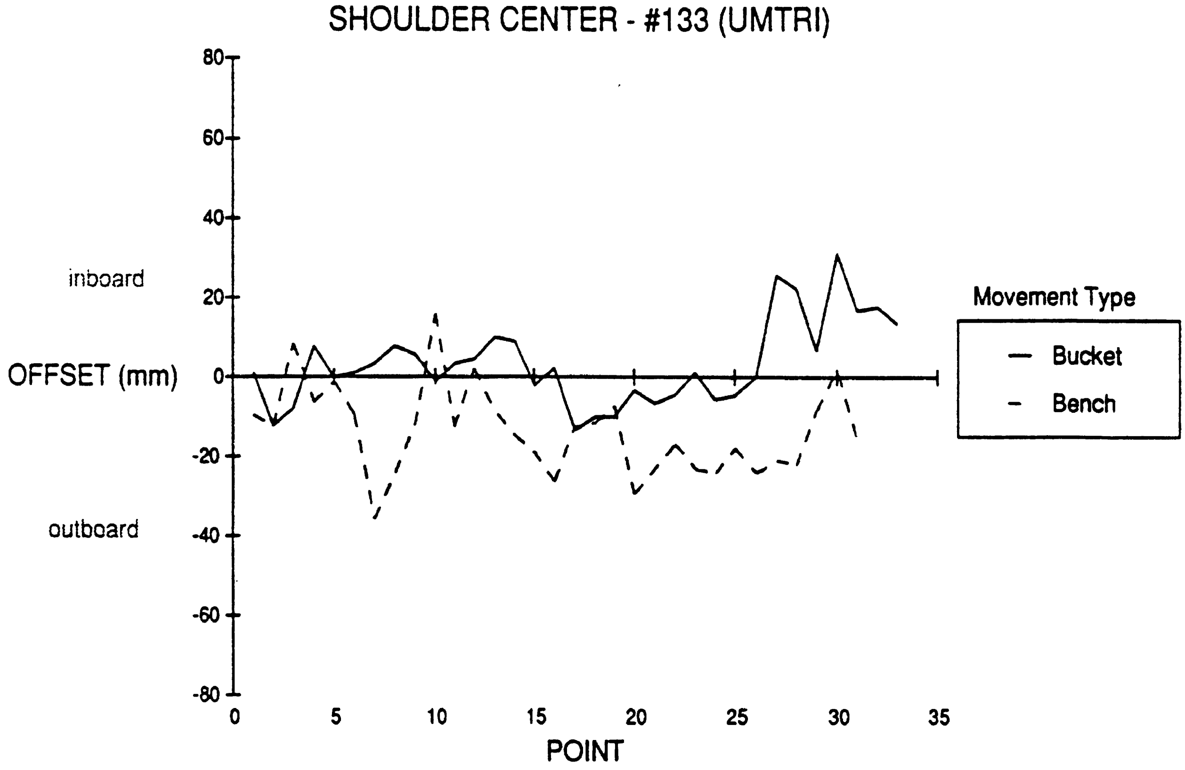
POINT
Movement Type
Bucket
Bench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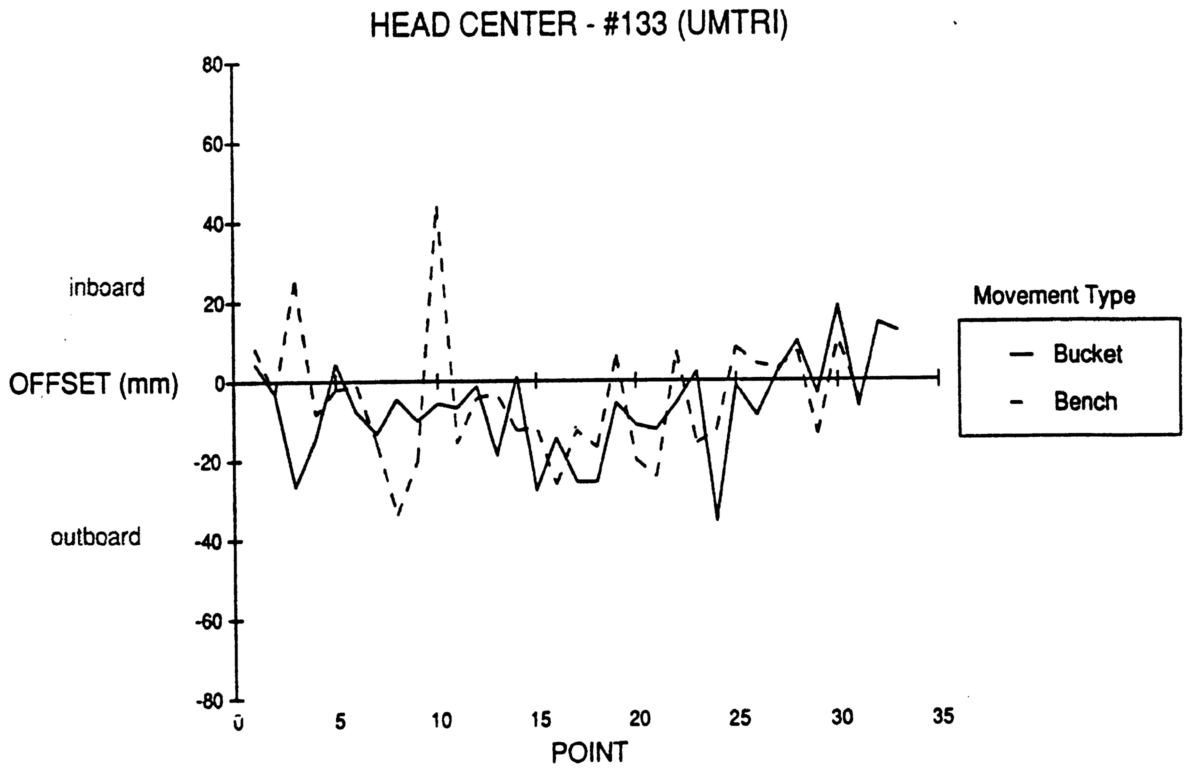
Movement Type
Bucket
Bench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OFFSET (mm)
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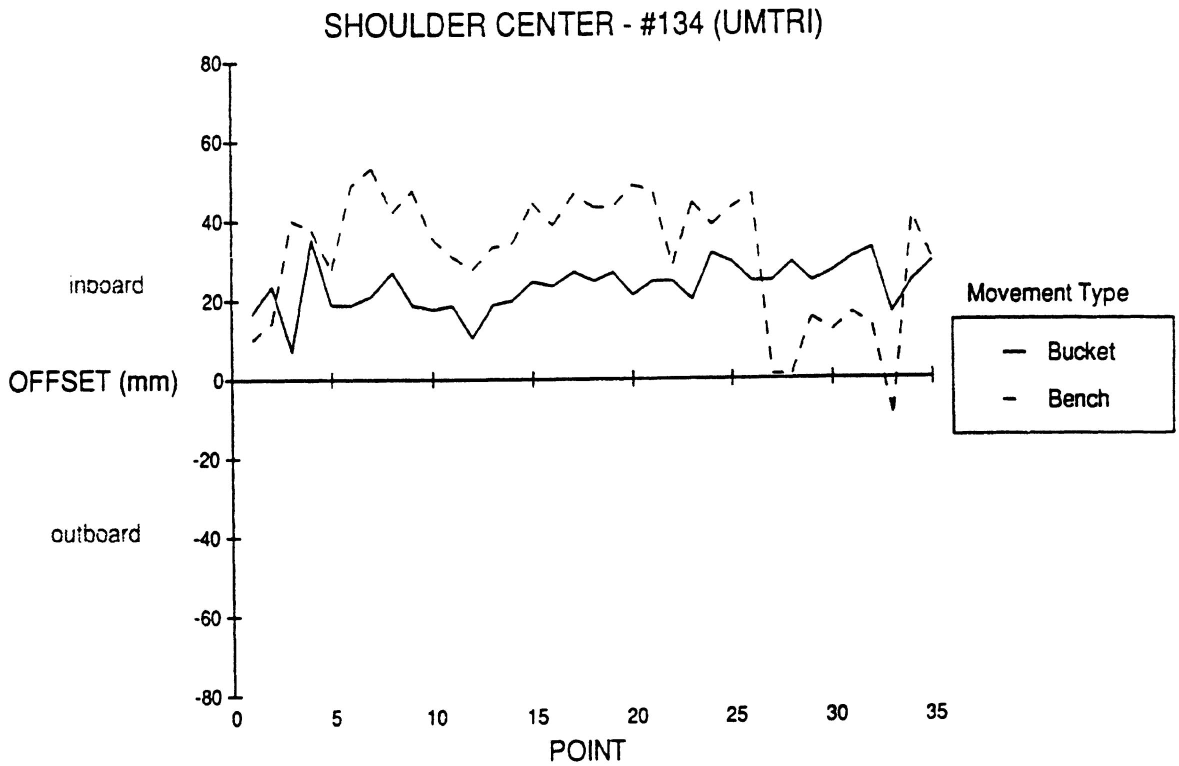
POINT
Movement Type
Bucket
Bench



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inboard
OFFSET (mm)
outboard
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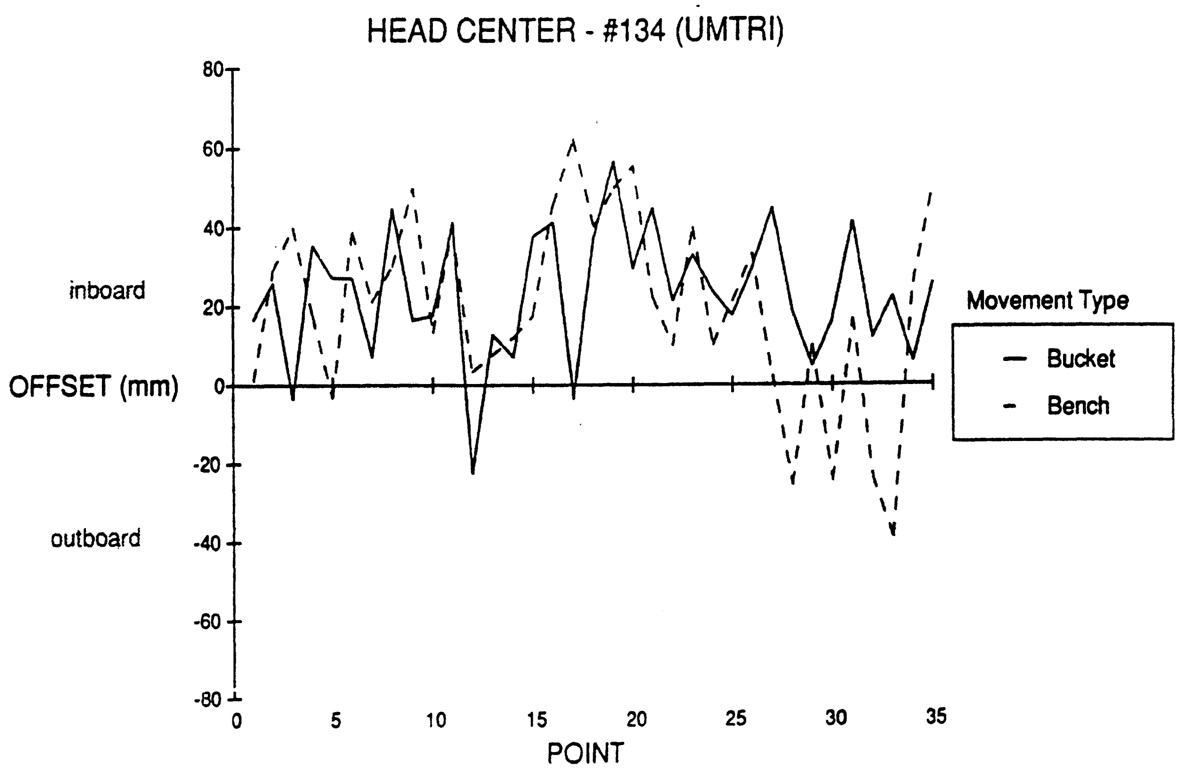
POINT
Movement Type
Bucket
Bench



HEAD CENTER - #134 (UMTRI)
inboard
OFFSET (mm)
outboard
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-80
0
5
10
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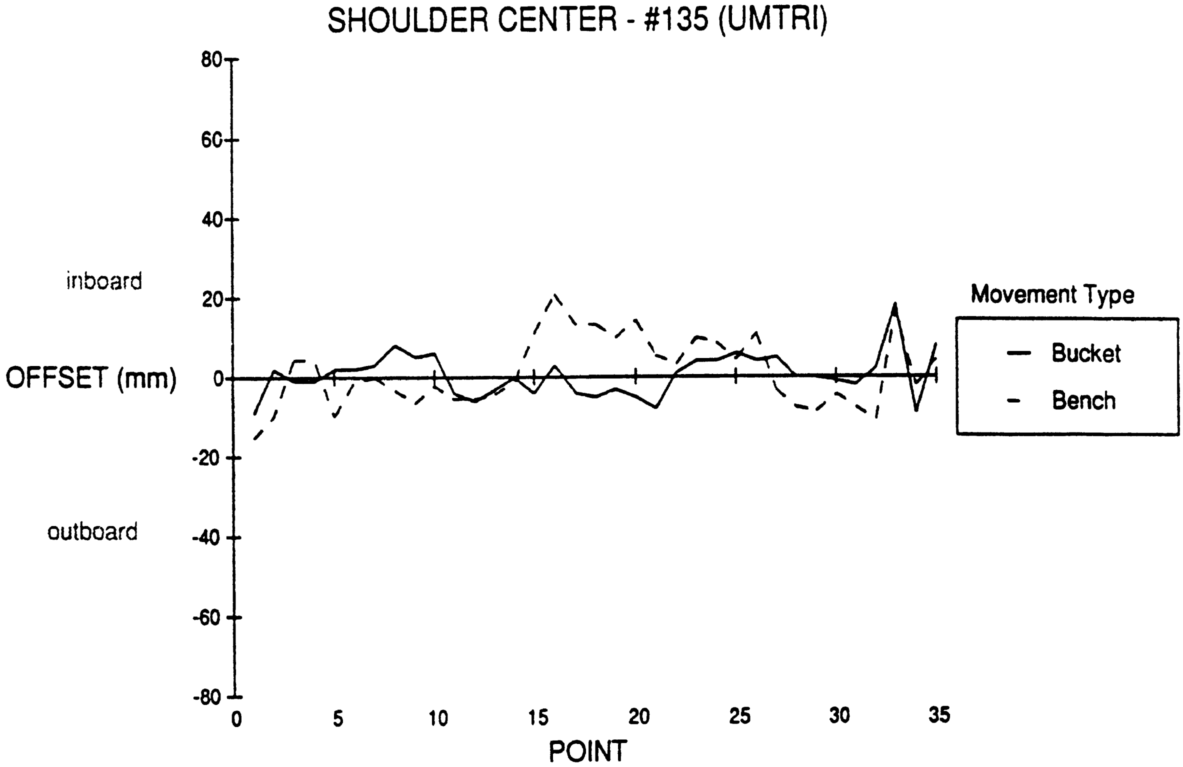
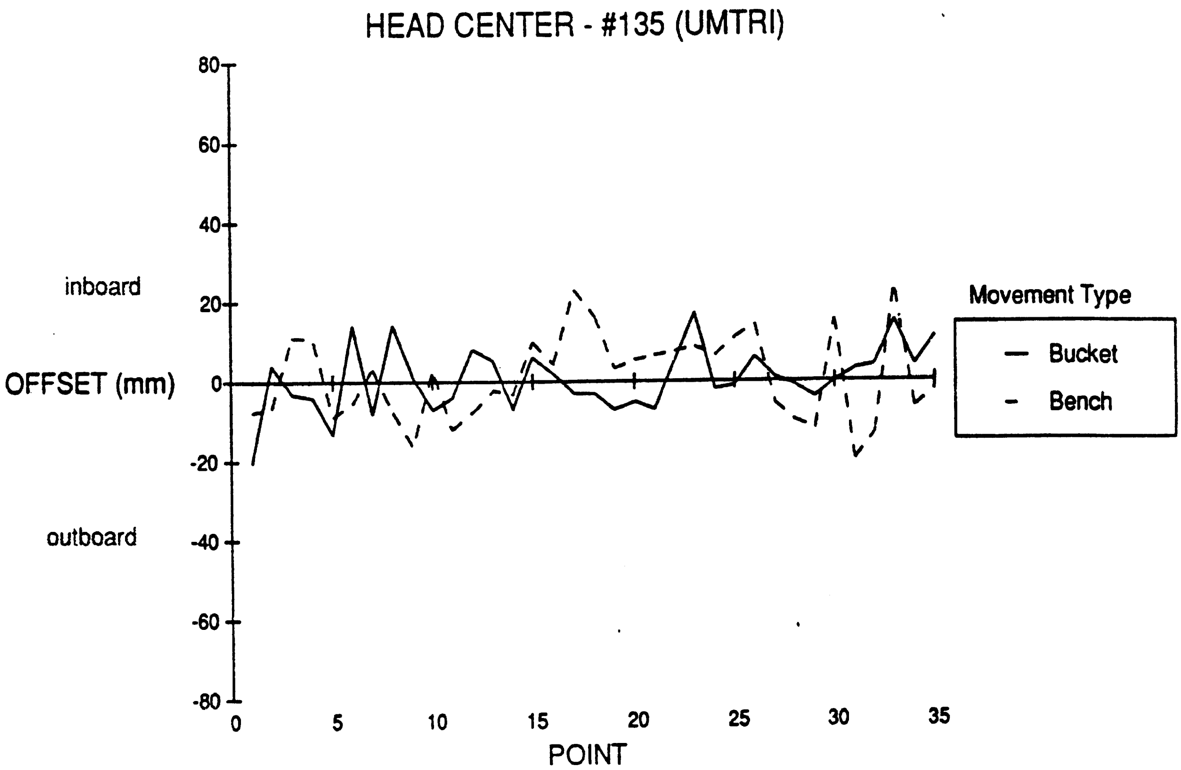
30
35
POINT
Movement Type
Bucket
Bench


SHOULDER CENTER - #135 (UMTRI)
inboard
outboard
OFFSET (mm)
80
60
40
20
0
-20
-40
-60
-80
0
5
10
15
20
25
30
35
POINT
Movement Type
Bucket
Bench


HEAD CENTER - #135 (UMTRI)
inboard
outboard
OFFSET (mm)
80
60
40
20
0
-20
-40
-60
-80
0
5
10
15
20
25
30
35
POINT
Movement Type
Bucket
Bench