WEIGHT DISTRIBUTION PATTERNS AMONG GOLFERS OF DIFFERENT SKILL LEVELS

by

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ABSTRACT

The purpose of the study was to determine whether a significant relationship existed between the skill level of golfers and the weight distribution patterns exhibited during the putting stroke. A differential research design was utilized to place thirty six male subjects into groups of low (0-5), medium (6-14), and high (15-25) handicap (hdp) levels. Subjects performed ten trials over ten and fifteen foot putting distances. A 3 X 2 (groups by distances) analysis of variance with repeated measures on the second factor was used to determine whether kinetic measures and total putting accuracy scores were different across groups. The normalized vertical force $\underline{F}(1,33)=9.03$, $p=.005$, and the final ball position (degrees) were found to be significantly different for each putting distance, $\underline{F}(1,33)=27.31$, $p<.001$. The effect of skill level on the final ball position (degrees) was dependent upon the distance of the putt, $\underline{F}(2,33)=6.83$, $p=.003$. The low and medium hdp groups were successful with a significantly greater number of putts than the high hdp group, $\underline{F}(2,33)=6.67$, $p=.004$. All groups made more putts from the ten foot distance than the fifteen foot distance, $\underline{F}(1,33)=67.94$, $p<.001$. No significant relation existed between the total excursion, $\underline{r}=.005$, and the normalized vertical force, $\underline{r}=-.022$ with the putting accuracy scores. Similarly, there was no significant relation between the total excursion, $\underline{r}=.004$, and the normalized vertical force, $\underline{r}=.096$ with the skill level of subjects. A stepwise multiple regression analysis determined that no dependent measure was a significant predictor of skill level at

a critical level of .05. The hdp groups were significantly different with regard to the age at which they started playing golf, $\underline{F}(2,33)=5.723$, $p=.007$, the average number of three putt greens per game, $\underline{F}(2,33)=3.488$, $p=.042$, and the number of tournaments entered each year, $\underline{F}(2,33)=4.318$, $p=.022$. All other kinetic measures were nonsignificant.

CHAPTER 1

Purpose

The purpose of this study was to determine whether a significant relation exists between the skill level of golfers and the kinetic weight distribution patterns exhibited during the putting stroke. These relationships were related to putting accuracy by the use of independent kinetic measures.

Significance

Golf's popularity, since its advent in North America in 1873 at the Royal Montreal Golf Club, has unquestionably increased at a fantastic rate. The popularity of golf can easily be substantiated by the large volumes of written instruction, the steady increase in the number of golfers, and golf course developments that have evolved over the years. Books on golf outsell books on all other sports combined (Price, 1990). Unfortunately, many textbooks are written in the absence of substantiated scientific evidence to support the contentions made by the authors. As a result, much of the textbook content is of a subjective nature and is a reflection of what has worked for the authors. The findings of this study may or may not substantiate present literature for the biomechanics of putting and may also serve to support current golf coaching methodologies.

Specific putting literature using weight force measures is limited. In a review of force plate literature, Schieb (1985) states, "for several sports, only one or two force plate articles were found; thus indicating a need for additional kinetic research". A review of the literature substantiates that studies investigating the ground reaction forces involved in the golf swing are limited especially for putting.

A major objective of this study was to expand the body of available literature, perhaps provide guidance for further related research, provide practical results for teachers, and instructors of the putting stroke. Findings may assist instructional personnel in highlighting major faults within the many and varied number of putting styles. Presently, there are no standardized guidelines for teaching the putting stroke (Pelz, 1989). From personal experience, teaching professionals often demonstrate and instruct a variety of conflicting approaches and techniques and there was no definitive teaching methodology regarding the putting stroke. If common kinetic tendencies were displayed by successful putters, we can infer that these tendencies should be seriously considered by all instructors, with some flexibility for individual differences. An additional objective for conducting this study was based on perfecting a personal putting style in an attempt to improve my own game.

Putting contributed to a significant portion (43%) of the game of golf and therefore, any improvement could translate into improved overall performance (Figure 1.1) (Pelz, 1989). The importance of putting in the game of golf cannot be denied

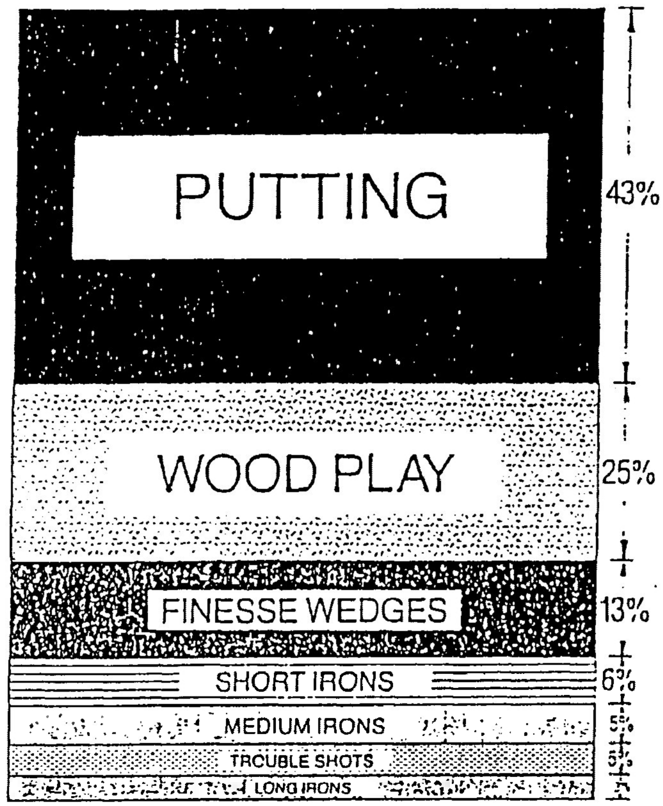


Figure 1.1. Contributions to the game of golf (Pelz, 1989)

(Mahoney, 1982). A common axiom in golfing circles states, "you drive for show and putt for dough" (Gott & McGown, 1988); and in order to score well you must become a "consistently" good putter (Nance & Davies, 1985). Comments such as these served to highlight the importance of putting in golf and perhaps it was time we direct our attention to what constituted the largest percentage of golf shots: the putting stroke.

Limitations

A major physical limitation to the study was the location of the testing apparatus, a force platform mounted in a gymnasium floor surface. All subjects were tested indoors on an artificial putting surface. The "artificial" laboratory setting may have had an influence on the performance of the subjects, however, fifteen practice putts minimized the effects of the unfamiliar putting surface. Due to the width of the subjects stance and the limiting size of the force plate only the subjects target/front foot was in contact with the force platform. Based upon the kinetic information collected on the target foot, inferences regarding the kinetics of the foot not on the force platform were made.

Although the validity of the testing instrument was high, the application of the force information had not previously been applied to this type of analysis and its suitability had been judged solely on its application for gait analysis. Practice or playing frequency during the week of testing may also effect the performance outcome of the subjects. This information was collected using a questionnaire (Appendix C). The subject population, due to availability, were comprised primarily of golfers from Thunder Bay, Ontario or the surrounding area. The sample may have restricted the generalizability of the findings to the golfing population. The reliability of the subjects' handicaps, although attested by the hdp chairman of their respective golf clubs, were also accepted to be accurate indicators of the subjects abilities.

Definitions

(1) Force Platform - is a biomechanical research tool capable of detecting ground reaction forces of a subject in contact with the platform (Schieb, 1985).

(2) Centre of Pressure - projection on the ground plane of the centroid of the vertical force distribution. In effect, the centre of pressure is the point where the resultant force vector would act if it could be considered to have a single point of application (Cavanaugh, 1978).

(3) Kinetics - the study of forces which influence the movement of the body (Krieghbaum and Barthels, 1985).

(4) Excursion - the distance covered by the track of the centre of pressure along the designated coordinate axis (American Mechanical Technology Inc. (A.M.T.I.) Data-Acquisition and Analysis Software Operating Manual, 1988).

CHAPTER 2

REVIEW OF LITERATURE

The literature review includes both qualitative instructional sources and available quantitative measurement of the putting stroke in golf. The review demonstrates a noticeable lack of objective quantifiable research on the putting stroke.

A Qualitative Analysis of the Golf Putting Stroke

The golf putting stroke is a highly individualized skill, and demonstrates a range of weight distributions over the left foot and right foot (Cheatum, 1975). In general, the ball was played from a point opposite the inside of the left heel to a point opposite the centre of the stance. "If the ball is played toward the left side, more weight may be carried on the left foot" (Nance & Davies, 1985). Similarly, Owens (1984) states, "the ball is placed in the stance from a midpoint between the foot to a position as far forward as a position off the target foot". Cheatum (1975), recommended that the ball should be opposite the large toe of the left foot and a stance taken so that the eyes were directly over the ball. Some players preferred to have the weight mainly on their target foot with the ball played off a position in front of the target toe. Others placed the weight equally on each foot, well-balanced between the heels and toes. It would appear that the ball position relative to the stance at the address position may be an indicator of weight distribution. Conflicting opinions existed in this regard. Moody and Van Kampen (1990) promoted keeping the weight distributed evenly between both feet even though the ball was played toward the front foot, while Irwin (1990) emphasized more weight on the ball of the left foot despite playing the ball in a similar position (Figure 2.1). To complicate matters even

Moody and Van Kampen (1990)

Irwin (1990)

Figure 2.1. Various weight distributions with ball played from a similar position.

more, Knox and Yocom (1990) played the ball more toward the middle of the stance with sixty percent of their weight concentrated on the left leg and foot (Figure 2.2). This discrepancy served to

Figure 2.2. Weight towards the front foot and ball played towards midline. (Knox and Yocum, 1990)

highlight the subjective and personalized viewpoints of the authors. According to the Encyclopedia of Golf (1973), "a really good putting stance is one that is comfortable, yet permits proper balance and to achieve this, most good putters keep their feet close together and their weight evenly distributed back on the heels of both feet". Due to the individual nature of the skill, both the width of the stance and the placement of the weight may vary greatly among players. "An important objective is that the body is in good balance with enough stability to keep motionless during the stroke" (Owens, 1984). "The key change I made in my putting setup was to spread my feet very wide - outside my shoulders. This new stance lowers my centre of gravity and provides a more stable foundation" (Stewart and Van Kampen, 1990). "Too many moving parts are bad enough in a full swing, but in putting they spell disaster" (Ballesteros, 1990). According to Owens (1984), there was no weight shift and the head and body remain steady during a putt. Similarly, the Encyclopedia of Golf (1973) states, "during the entire putt, hold your body and head steady. By doing this you will restrict body movement to a minimum".

A comparison of handicap levels would provide a possible measure of performance in terms of weight transfer. Once established, these skill level performances may provide meaningful comparisons so that instructors might recognize and correct weight shift tendencies.

A Quantitative Analysis of the Golf Putting Stroke

As previously mentioned, the weight distribution patterns of golfers performing the putting stroke was not evident in the research literature. Although the weight distribution patterns during the full swing have been investigated, the number of studies in this regard were somewhat limited. The development and application of an effective measurement instrument was probably the reason for the lack of specific research on the topic.

"While there has been a preponderance of force plate (FP) analyses of walking, running and jumping, twenty different sports have been analyzed by biomechanics researchers utilizing a FP for study of various reaction force parameters" (Schieb, 1985). Adapting the FP ground reaction instrument for applications other than locomotory purposes had permitted a much more detailed analysis of kinetic movement in a variety of sports, however, the number of studies conducted in the golf area were limited. The FP had been utilized by researchers such as Williams and Cavanaugh (1983) to investigate the mechanics of the foot action during the golf swing and various implications for shoe design. Results indicated that peak vertical forces occurred under the left foot just before impact with a normalized value of 1.6 Newtons. The pattern of force production for each club used (3-iron, 7-iron, and driver) were similar, however, the peak forces for the more lofted clubs were generally smaller.

Cooper, Bates, Bedi and Scheuchenzuber (1974) used the FP to conduct a kinematic and kinetic analysis of the golf swing. Subjects in that study utilized the same three clubs as in the Williams and Cavanaugh (1983) study. Findings indicated that there was approximately a 25 percent force shift towards the front foot as impact was reached. The weight at impact was distributed approximately 75 percent on the front foot and the remainder on the rear foot. After impact, the force distribution remained the same for the seven iron (75 percent on the front foot and 25 percent on the rear foot); however, it returned to a more balanced position when the driver was used (50 percent on the front and rear foot). This would seem to indicate that a more stable position was gained when using a less lofted club. Another interesting finding concerned the maximal force shift to the front foot. For the three and seven irons, this shift occurred after impact, however, for the driver it occurred prior to the point of impact. In all instances, the total vertical force decreased during the impact phase of the swing.

Richards, Farrell, Kent and Kraft (1985) used the FP to study the weight transfer patterns during the golf swing. Only a 5-iron was utilized for analysis in this study. Results indicated a tendency for the skilled golfers (handicap <10) to place their weight closer to their heels at ball contact as compared to the lesser skilled golfers (handicap >20) who transferred most of their vertical force onto their toes at contact. The transfer of vertical force from the rear foot to the target foot appeared to be strongly influenced by skill level as the highly skilled group allowed the force to transfer farther forward onto the target foot than did the high handicap group. Conclusions drawn from this indicated a difference in the weight transfer patterns in the follow through motion of both groups. The more skilled golfers allowed the force to be transferred to the lateral edge of the target foot following ball contact. The overall group variability was less for the skilled group as compared to the lesser skilled group.

More recently, Johnson and Schiffman (1992) completed a study concerning foot pressure during the full swing of a driver. A thin electronic material was fitted inside the players shoe and wired to a computer capable of providing foot pressure data. High speed video analysis was utilized to synchronize the swings with the foot pressure data. More than 100 golfers were tested and it was found that the higher handicap golfers displayed a wide variation in the left foot pressure when comparing the address and impact positions. The more skilled golfers left foot pressure was virtually the same at both the address and impact positions.

A review of the literature demonstrated a trend for analysis of the full golf swing with limited attention given to the putting stroke. Based on the literature available, the availability of FP kinetic data for putting measures was extremely limited. Hopefully this study will provide a basis for further investigation.

CHAPTER 3

METHODS AND PROCEDURES

Subjects

A cluster sampling procedure was used to place the subjects into their respective handicap (hdp) groups (0-5, 6-14, and 15-25). The objective was to maximize the number of subjects in each group to include fifteen and this varied due to availability. The majority of the subjects resided in Thunder Bay, Ontario or the immediate surrounding area. The intention was to divide the subjects into groups of low, moderate, and high skill level. The hdp of the subjects, attested by the hdp chairman of the golf club, were used to quantify the groups so that they were indeed different. It was assumed that the hdps were indicative of the level of performance expected from each group.

Apparatus

A force platform system was utilized to record the percentage of body weight transferred onto the front foot during the putting stroke. An A.M.T.I. force platform and amplifier was utilized with the accompanying Biomechanics Data-Acquisition and Analysis Software (BEDAS-2). A Mikadon computer and keyboard along with a TTX monitor constituted the display hardware (Figure 3.1). The force platform was covered with an indoor putting surface providing a consistent and reasonably realistic putting surface for the subjects. The platform was calibrated (vertical forces) with the

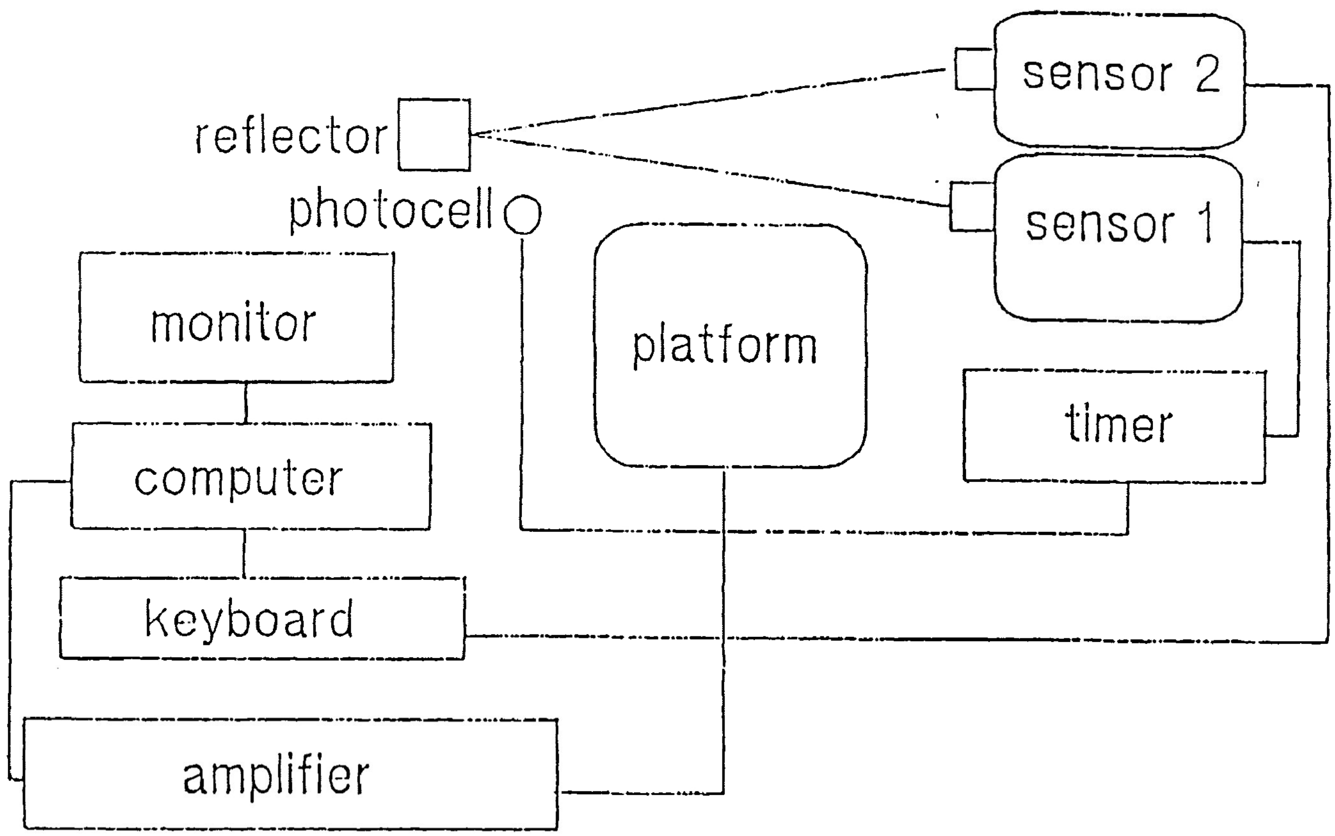


Figure 3.1. Force platform system

putting surface in place using a known weight. This allowed normalized (relative to body weight) vertical force comparisons between the subjects and skill levels.

Timing and Synchronization

Two light sensors (sensor 1 and 2) served to start the force platform and a timer (Figure 3.1). The sensors were aligned on top of each other thus ensuring that the timer (sensor 1) and force platform (sensor 2) started simultaneously. The sensors were positioned as far from the subject as possible to maintain the integrity of the putting stroke and were triggered as the club was swung back to interrupt the beam emitted by the sensors. Sensor 2 served as the trigger method for the force platform and was electronically connected to the keyboard to initiate data collection. The timer, started by sensor 1 on the backswing, was stopped as the ball was struck by the putter allowing light to enter the photoresistor under the ball. As soon as the ball was displaced the photoresistor was energized by the light, thereby, closing a switch and stopping the timer. The photoresistor also ensured that the ball was placed in exactly the same starting position on successive trials. The timer displayed the time from the initiation of data collection on the force platform to the point of ball contact. Times were displayed accurate to two decimal places allowing the point of ball contact to be plotted on the force data time axis (Figure 3.2).

Measurement Validity

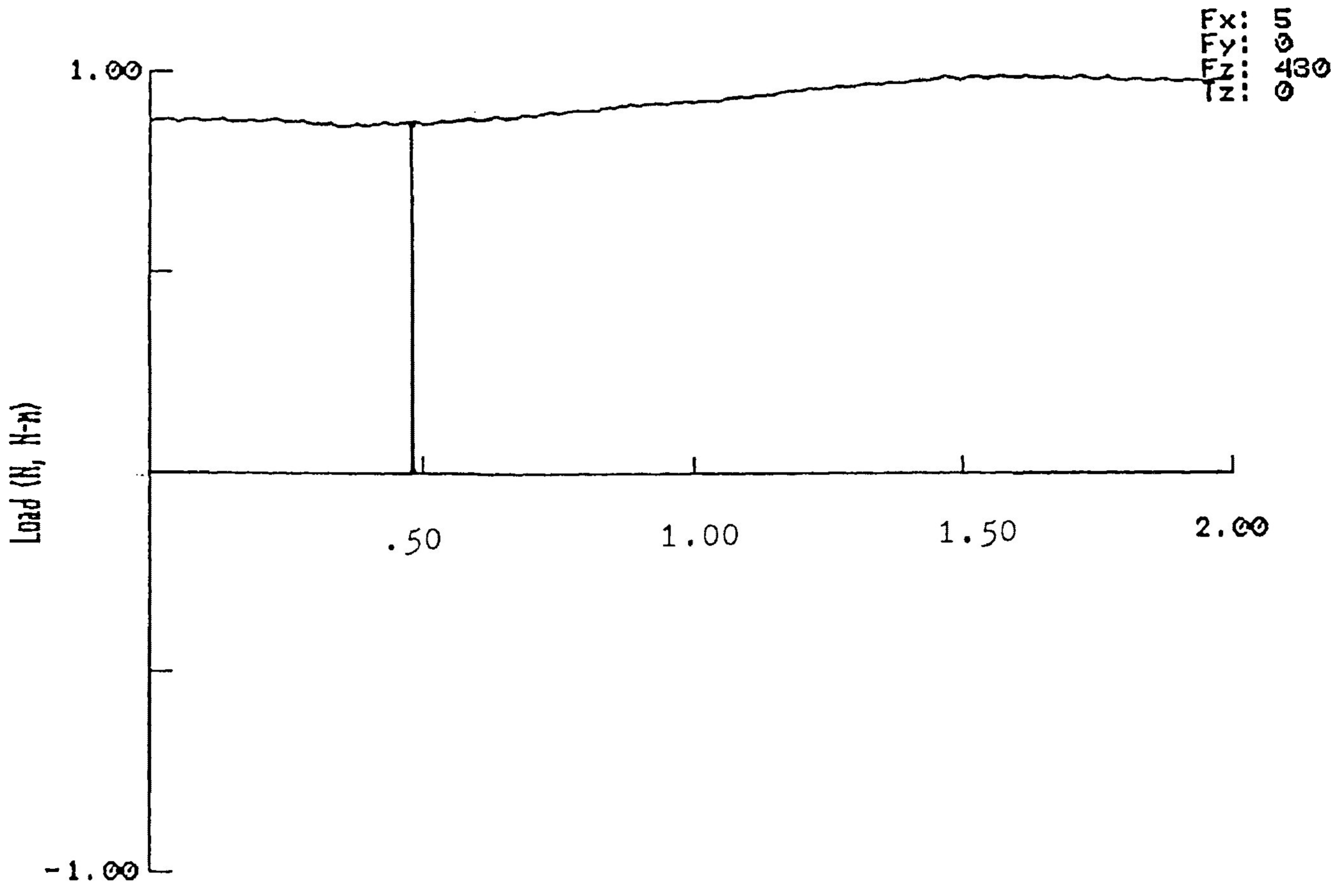
The reliability of the force platform was ensured through manufacturer calibration procedures prior to installation. In addition, the X, Y, and Z planes (channels 1, 2, and 3) were manually adjusted to balance the bridge circuits before each test session. Each subjects body weight was recorded on the platform prior to the testing session in accordance with the testing protocol.

The reliability of the timing system was measured by swinging

DON PUTTER11 L6 — 10-22-90
LEFT LEG ON PLATE — 236782

.48 - Time of Ball Contact

Platform: 1



Time (sec)

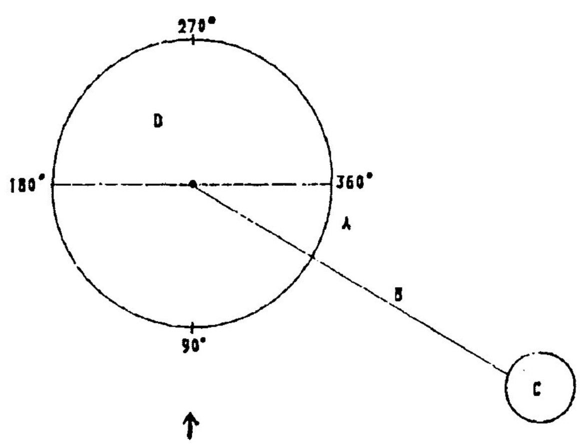
Vertical Force VS. Time

Figure 3.2. Time of ball contact.

a pendulum weight from a fixed height through the sensor beam. It was determined that the timer was extremely reliable to the first two digits of the readout. The time data was recorded to two decimal places.

Putting Accuracy Measurement

The final ball position relative to the centre of the hole was measured. A protractor (360 degrees), oriented with 90 degrees facing the subject, was placed over the hole after each putt. A string was stretched to the centre of the ball with the ball position in degrees recorded. The distance from the centre of the hole was also measured in centimetres (Figure 3.3). The objective was to provide a more accurate assessment of putting ability as opposed to counting the number of putts made.



A=Angle in Degrees

B=Distance in cms

C=Ball

D=Hole

Putting Direction

Figure 3.3. Final ball position measured in both degrees and centimetres.

Procedures

Subject Groups

Subject volunteers (Appendix A) were informed of the time and location of testing and were instructed to wear flat soled shoes and to provide their own putters. The use of individualized putters was adopted to minimize the effects of adapting to a foreign standardized putter which may have negatively affected the consistency of the putting stroke.

Testing Procedures

Upon arrival at the gymnasium, the subjects completed an informed consent form (Appendix B) and a golf thesis testing information sheet (Appendix C). The subjects were provided ample time to read the information sheet and urged to ask questions if anything was unclear.

Each subject was allowed fifteen warm-up putts on the indoor putting surface to familiarize themselves with the speed of the surface. This permitted the subjects an opportunity to become comfortable in the testing situation and "groove" their putting stroke. Prior to initiation of data collection, each subject was weighed on the force platform while holding their putter. The tester readied the force platform to collect data and the subject was cued by the command "whenever you're ready". The subject then initiated the stroke when they felt ready to do so.

The force platform data, the time of ball contact and the final ball position for each trial was recorded. The time of ball contact was then plotted from the horizontal axis of the force time curve to the vertical force curve provided by the force platform (see Figure 3.2). The shape of the vertical force curve on either side of the ball contact point provided an indication of whether a force shift occurred onto the target foot. Additional balls were placed on the photoresistor for each successive trial and the timer reset. Ten golf balls (Titleist) were utilized and numbered from one to ten, thereby, ensuring that each subject used the same ball on successive trials. This procedure was repeated for ten trials at both putting distances (ten feet, fifteen feet) for each subject.

Design

A differential research design was used to allocate the subjects to their respective groups based upon attested hdp. The normalized proportion of weight distributed on the target foot was compared at ball contact for each hdp group. The higher and more consistent the force expressed on the target foot at ball contact the more stable the subjects position. The ball position with respect to the target foot was also noted for each subject as it was felt that it would have a direct influence on the amount of weight displaced onto the target foot. A foot position scale was marked in centimetres on the putting surface to measure the location of the ball relative to the target foot. The ball position information relative to the target foot permitted more meaningful generalizations about the performances for each group.

A ratio between the maximum vertical force and the vertical force at ball contact was compared across groups. As this ratio increased, the subject's weight was over the front foot and may have contributed to a more consistent putting performance. With an ideal ratio of one, where the maximum vertical force and the vertical force at ball contact were equal, there would be no weight transfer onto the target foot. This left the subject in a more stable position which may lead to improved stroke consistency.

A time ratio between the time of ball contact and the time of maximum vertical force was also investigated. Similar to the vertical force ratio, a higher time ratio suggested a smaller period of time between the time of ball contact and the time of maximum vertical force. If the differential between the time of ball contact and the time of maximum vertical force enlarged, it would have suggested that a more dramatic weight transfer had occurred.

The mean total and thirty percent values for the mediolateral excursion or the displacement of the centre of pressure or centre of mass along the X plane was calculated and compared for each group. In both instances, the lower value was indicative of a smaller force transference onto the target foot placing the subject in a more secure position. A smaller distance covered by the center of pressure indicated a more stable base of support from which to build a solid putting stroke. Once again, this more secure position should result in a better putting performance. The standard deviation of the mean total and thirty percent values of the mediolateral excursion of the centre of pressure for each group was computed, serving as a measure of consistency. Similarly, the average X and Y position of the centre of pressure on the platform was also compared across groups. The more negative the X position of the center of pressure, the greater the amount of weight displaced toward the target inhibiting any lateral movement during the stroke. Alternatively, the more positive the Y position of the center of pressure, the more weight displaced over the toes toward the ball. Finally, the total putting accuracy scores for each group were compared to determine whether a relation existed between the weight transfer patterns and the putting accuracy. A summary of the dependent measures along with abbreviated short forms and definitions for each is provided in appendix D.

Statistical Analysis

A 3 X 2 (groups by distance) analysis of variance (ANOVA) with repeated measures on the second factor was used to determine whether the kinetic measures obtained for the three hdp groups and the total putting accuracy scores were significantly different. A one-way analysis of variance was utilized to determine whether the three hdp groups responses to the questionnaire were significantly different. The Neuman-Keuls procedure was used for post hoc analysis of any significant findings. The standard deviation was used as a measure of consistency. A multiple regression analysis was incorporated to determine which measures were the best predictors of skill level. The possible relation between the total excursion and the normalized vertical forces at ball contact with the putting accuracy scores was investigated by conducting a Pearson Product Moment Correlation Coefficient. A Spearman Rank Order Correlation was used to determine whether a relation existed between the skill level of subjects, the normalized vertical force at ball contact and the total excursion of the centre of pressure. A summary of all variables with the statistical analysis pertaining to each is provided in table 3.1.

Table 3.1

Variables and their Statistical Analyses

3 X 2 Analysis of variance	Oneway analysis of variance
Normalized vertical force	Age started playing golf
Vertical force ratio	Years playing the game
Time ratio	Three putts per game[a]
Total excursion	Total putts per game[a]
Thirty percent excursion	Number of games per week[a]
X center of pressure	Games played -- test week
Y center of pressure	Tournaments per year[a]
Foot placement	Practice time per week[a]
Final ball position	Practice time -- test week
Number of successful putts	

Pearson product momment correlation coefficient	Spearman rank order correlation coefficient
Final ball position -- Total excursion	Skill level of subjects -- Normalized vertical force
Final ball position -- Normalized vertical force	Skill level of subjects -- Total excursion

Multiple Regression	
Skill level of subjects --	Normalized vertical force; time ratio; total excursion; vertical force ratio; final ball position; x and y center of pressure; thirty percent excursion

Note. [a]average values

CHAPTER 4

RESULTS

To determine whether a significant relationship existed between the skill level of golfers and their weight distribution patterns during the putting stroke, a number of variables had been investigated including, kinetic measures, putting accuracy scores, relationships between skill level and performance, and questionnaire results.

Kinetic Measures

Table 4.1 lists the individual group means and standard deviations for each of the kinetic measures. The only significant difference discovered for the kinetic measures was between the normalized vertical force displayed for the two putting distances (ten and fifteen feet), $\underline{F}(1,33)=9.03$, $p=.005$ (see Appendix E for all statistical procedures). Sample vertical force readouts for each hdp group are provided in Appendix F. All other main effects of groups or distances and any potential interactions were nonsignificant at the pre-established level of significance (.05).

Accuracy Scores

A summary of the group means and standard deviations for the putting performance scores are provided in Table 4.2. The only main effect of groups was observed for the total number of successful putts, $\underline{F}(2,33)=6.67$, $p=.004$. A main effect of distance

Table 4.1

Kinetic Data for Handicap Groups

Variable	NFZ	FZR	TIR	TOTEX	30%EX	XCOFP	YCOFP	FOOT
Low Handicap Group								
10 Foot Putt								
M	.53	.91	.71	10.36	3.07	-12.14	5.16	9.70
SD	.06	.09	.37	1.15	.43	2.79	6.38	3.49
15 Foot Putt								
M	.55	.94	.76	10.27	3.14	-12.00	5.40	9.95
SD	.08	.05	.30	1.53	.47	2.94	5.67	3.80
Medium Handicap Group								
10 Foot Putt								
M	.53	.92	.68	18.37	3.99	- 9.12	1.88	12.16
SD	.09	.03	.39	23.06	1.05	5.81	4.81	4.64
15 Foot Putt								
M	.54	.91	.63	12.74	3.97	- 9.40	2.27	11.59
SD	.08	.03	.21	4.60	1.33	5.41	4.66	4.67
High Handicap Group								
10 Foot Putt								
M	.55	.89	.61	11.16	3.38	- 7.70	4.91	13.17
SD	.07	.10	.21	2.90	.76	5.68	6.47	5.38
15 Foot Putt								
M	.58	.92	.62	12.10	4.09	- 7.79	4.77	12.96
SD	.07	.05	.13	5.72	2.69	5.94	6.45	5.49

Note. NFZ=normalized vertical force; FZR=vertical force ratio; TIR=time ratio; TOTEX=weight transfer along x axis; 30%EX=first 30 percent of total excursion; XCOFP=center of pressure along x axis; YCOFP=center of pressure along y axis; FOOT=ball position in relation to the target foot.

TOTEX, 30%EX, XCOFP, YCOFP, and FOOT measured in centimetres.

was also observed for the number of successful putts, $F(1,33)=67.94$, $p<.001$. There was also a significant main effect of putting distance noted for the final ball position (degrees), $F(1,33)=27.31$, $p<.001$. The significant interaction between skill level and distance reflects that the effect of skill level on the

Table 4.2

Performance Data for Handicap Groups

Variable	PUTTACC(cm)	PUTTDEG(degrees)	PUTTMADE
Low Handicap Group			
10 Foot Putt			
M	36.49	248.75	5.50
SD	16.76	20.84	2.39
15 Foot Putt			
M	32.89	192.59	2.50
SD	10.04	34.52	1.41
Medium Handicap Group			
10 Foot Putt			
M	29.80	237.43	6.57
SD	8.23	26.43	1.53
15 Foot Putt			
M	34.93	204.67	2.79
SD	8.91	32.24	1.53
High Handicap Group			
10 Foot Putt			
M	35.18	193.68	4.07
SD	16.37	60.95	2.30
15 Foot Putt			
M	39.99	191.14	1.71
SD	10.64	47.82	1.14

Note. PUTTACC=final ball position from hole; PUTTDEG= final ball position in relation to hole; PUTTMADE= number of putts made.

final ball position was dependent upon the distance of putt involved, $F(2,33)=6.83$, $p=.003$ (Figure 4.1).

Correlations Between Skill Level and Performance

No significant relationship was realized between the total excursion or weight transfer pattern and the putting accuracy score (Table 4.3). Similarly, a comparison of the normalized vertical force and the putting accuracy score revealed no significant

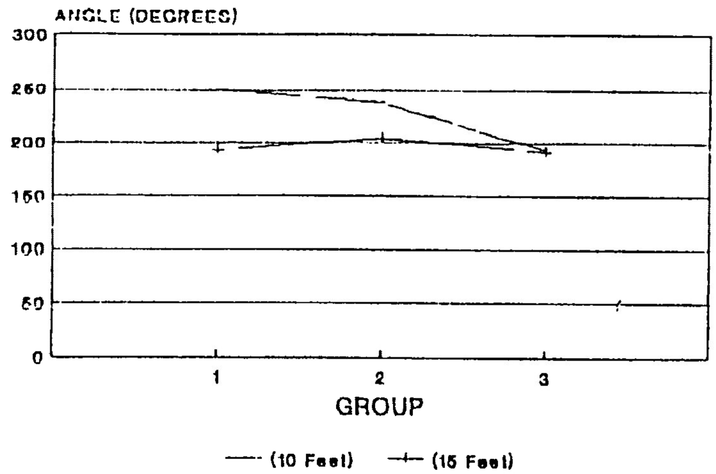


Figure 4.1. Interaction of final ball position (degrees).

relation. The potential relationship between the normalized vertical force and the total excursion with the skill level of subjects was also nonsignificant (see Table 4.3).

Table 4.3

Relationship between Weight Transfer Patterns, Skill Level and Putting Performance

	Weight Transfer Pattern	
	Total Excursion	Normalized Vertical Force
Skill Level[a]	.004	.096
Putting Accuracy[b]	.005	-.022

Note. [a]spearman rank order correlation coefficient

[b]pearson product moment correlation coefficient

A stepwise multiple regression analysis was performed on all dependent measures in an attempt to determine the best predictor of skill level, however, no variables were entered into the equation at the .05 criteria level (Appendix E). Upon further comparison of the group to kinetic measure correlations, it was evident that no kinetic measure approached significance. Indeed, the highest correlation was the position of the X center of pressure for the short putting distance ($r=.31$).

Questionnaire Results

The results of the questionnaire provided some interesting findings with the mean values for each hdp group summarized in Table 4.4. Subjects rated themselves in terms of their perceived skill level as putters and the results indicated that no group considered themselves superior (Table 4.5).

Table 4.4

Questionnaire Results

	Group			
	Low	Medium	High	*F*
Age started playing	12.00	13.79	27.79	5.72**
Total years playing	21.38	15.71	13.21	1.55
Three putts per game[a]	1.38	1.86	2.93	3.49*
Putts per game[a]	31.63	32.21	34.07	1.60
Games per week[a]	3.00	3.36	3.21	.24
Games played - test week	2.75	2.86	2.21	.60
Tournaments per year[a]	9.25	8.21	4.79	4.32*
Practice per week(min)[a]	32.50	23.43	22.86	.57
Practice(min) - test week	19.38	13.21	5.00	2.08

Note. [a]Average values
*p<.05. **p<.01.

Table 4.5

Subjective Putting Rating

	Group		
Rating	Low	Medium	High
Excellent	0	1	0
Good	3	5	5
Average	3	7	5
Fair	2	1	3
Poor	0	0	1

CHAPTER 5

DISCUSSION

Kinetic force measures, putting performance, and correlations between skill level and performance were investigated to determine the relation between skill level of golfers and their kinetic weight distribution patterns during the putting stroke. To augment these results, the subjects also provided responses to a questionnaire to indicate further differences between the three hdp groups.

Kinetic Measures:

The normalized vertical force (percentage of total body weight) was the only kinetic measure to attain statistical significance. All three hdp groups displayed a significantly greater amount of force on the target foot for the longer fifteen foot putt compared to the ten foot putt, $F(1,33)=9.03$, $p=.005$ (see Table 4.1). One can speculate that, as the length of putt increased, the more weight or force would be shifted onto the target foot. This increase in weight shift may have contributed to a lack of effectiveness and consistency in the putting stroke. According to Owens (1984), enough stability to keep motionless during the stroke was an important objective. Similarly, Ballesteros (1990) stated too many moving parts spell disaster.

All other kinetic measures did not reveal significant main effects of group, distance, or any interaction. General explanations for the lack of significance might include the fact that the putting stroke is a very complex skill where many factors must be co-ordinated in order to obtain a good performance. If a single kinetic measure had "seriously deviated from the norm", perhaps the overall effectiveness of the stroke would not be adversely effected. Perhaps the movement of the upper body compensated for any deviations in the kinetic force measures. Although putting makes up a large portion of the game (see Figure 1.1, Pelz, 1989), the hdp which was used to rank the subjects was a reflection of competence in all aspects of the game. A low hdp player may not necessarily have an effective putting stroke. Likewise, a high hdp player may not have a poor putting stroke, but lacks in other areas of the game.

Although significant differences were not observed, some of the kinetic measures help to reaffirm previous findings in the literature. The subjects had a putting stance where their weight was approximately 55% concentrated on the target foot (see Table 4.1). This was compatible to weight distribution patterns suggested by Knox and Yocom (1990), where sixty percent of the body weight was concentrated on the target foot.

The ball placement in relation to the target foot was approximately 11.5 cms inside the outside edge of the target foot and within the limits suggested by Owen (1984). This position was somewhere between the midpoint of the stance and as far forward as the target foot.

The position of the center of pressure along the Y axis, although nonsignificant, suggests that the low and high hdp groups displayed weight distribution patterns which would place their eyes more directly over the ball, as suggested by Cheatum (1975).

The remainder of the kinetic measures, although also nonsignificant, might help in further understanding the putting stroke. The vertical force ratio was very similar for all three hdp groups and the two putting distances (see Table 4.1). With the length of putts constant, the amount of weight shift necessary to roll the ball the required distance was similar for all subjects. Therefore, one could expect the differential in the force ratio among the groups to be nonsignificant, which in fact was the case. Interestingly, the group which came the closest to the ideal ratio of one, i.e. no weight shift at all, experienced the greatest number of successful putts (see Tables 4.1, 4.2).

The low hdp group displayed the highest time ratio and the ratio became progressively lower for the medium and high hdp groups (see Table 4.1). A lower time ratio indicated more time between the maximum vertical force and the vertical force at ball contact. Consequently, it may be concluded that the medium and high hdp groups were in a less stable position at the point of ball contact.

The X excursion or the path of the center of pressure along the X axis, and the first 30% of the total excursion was smallest and most consistent for the low hdp group (see Table 4.1). The longer X excursions for the other two groups were indicative of a longer weight shift on to the target foot. The X axis on the force platform ran mediolaterally towards the target. It was felt that a larger weight transfer may have left these groups more vulnerable to stroke inconsistencies and thus leading to a less effective putting performance.

In keeping with the previous results, the position of the center of pressure along the X axis did not attain conventional levels of statistical significance. The results obtained did conform to the researcher's original hypothesis however, in that, the more skilled subjects distributed more weight toward the target, i.e. higher negative X values (see Table 4.1). The low hdp group also displayed the greatest degree of consistency, based on standard deviation scores, thus promoting a more repetitive putting stroke. Perhaps a diagram or photograph, similar to the ones displayed in the Johnson and Schiffman (1992) study, showing where the forces should ideally be distributed would aid subjects to visualize and possible adopt a more advantageous weight shift pattern.

Putting Performance:

The total number of successful putts and the final ball position from the hole in centimetres and in relation to the hole in degrees were recorded (see Table 4.2). It was not surprising that the high hdp group made significantly fewer putts as compared to the medium and low hdp groups (see Table 4.2). Significant differences in kinetic factors such as the normalized vertical force and the higher standard deviation scores for the high hdp group, implying inconsistency for many of the nonsignificant kinetic measures, may have contributed to this groups poorer performance (see Table 4.1). Logically, more putts were made on the shorter, ten foot, putting distance as opposed to the longer fifteen foot distance, $F(1,33)=67.94$, $p<.001$ (see Table 4.2). The longer putting distance was less forgiving to stroke inconsistencies and any error at the point of ball contact was magnified when projected fifteen feet away, therefore, fewer putts were made. A range effect was noted for the final ball position in relation to the hole, measured in degrees. The final ball position was further past the hole for the shorter, ten foot, putt as compared to the longer, fifteen foot, putt, $F(1,33)=27.31$, $p<.001$ (see Table 4.2). This result suggested that the subjects were more confident or aggressive on the shorter putting distance, thus rolling the ball further past the hole. Interestingly, the final ball position, in degrees, for both putting distances was toward the left side of the hole, however, the overall distance from the hole was not significant.

The only significant interaction was observed for the final ball position, $F(2,33)=6.83$, $p=.003$. The low hdp group went much further past the hole on the shorter putt as compared to the medium and high hdp groups. On the longer putt, however, the low hdp group was less aggressive, the medium hdp group somewhat less aggressive, and the high hdp group displayed the most consistency on both putting distances (see Figure 4.1). Perhaps even a ten foot putt for the high hdp group was not perceived as being "makable" and thus they were cautious not to roll the ball too far past the hole. It would seem that the low and medium hdp groups had more confidence in their abilities and were less afraid to roll the ball past the hole for the shorter putting distance.

Correlations Between Skill Level and Performance

The absence of any relationship between the total excursion results with the putting accuracy scores and the skill level of subjects may suggest that the overall weight shift patterns were not as critical a factor for the putting stroke as it was for the full golf swing (see Table 4.3). According to Richards, Farrell, Kent and Kraft (1985), the weight shift for a 5-iron shot was very much influenced by skill level. Likewise, Johnson and Schiffman (1992), suggested that the high hdp players displayed a wider variation in the weight distribution at both impact and address. Unlike the Richards, Farrell, Kent and Kraft (1985), and Johnson and Schiffman (1992), studies, the total excursion or weight transfer was not influenced by the skill level of subjects (see Table 4.3). The total excursion was not a variable which separated low and high hdp players. It could be suggested that the hdp level of some of the subjects may not have been indicative of superior weight shift patterns and putting performance. Although it was difficult to make comparisons to full golf swing studies, the putting accuracy scores did not seem to be influenced by the total excursion displayed. The total excursion was not significantly effected by the skill level of players.

The normalized vertical force was also not significantly related to the skill level of subjects (see Table 4.3). This result could be seen as a confirmation of the normalized vertical force at ball contact results and the placement of the ball in the stance (see Table 4.1). The amount of force exerted on the target foot at ball contact was not dictated by the skill level of players. Similarly, no significant relation was noted between the final ball position, in centimetres, and the normalized vertical force. We have already seen that the weight distributed on the target foot at ball contact was not a factor which significantly predicted skill level, therefore, the absence of any relation to putting accuracy was not surprising.

One must not underestimate the contribution of the upper body to the overall performance of the putting stroke. The amount of force exerted on the target foot was but one factor in a very complex skill. Many factors must be co-ordinated to achieve a good putting performance. The legs are only part of the total putting stroke and it may be that the pendulum arm action was a more critical factor to consider than the weight transfer patterns. Any deviation in the excursion pattern may be offset or compensated for by deviations in the arm action.

The fact that no single dependent measure was entered into the equation to locate the best predictor of skill level served to highlight the complexity of the putting stroke. The putting stroke was the culmination of many intricate and precise movements and the ground reaction forces alone were not sufficient to distinguish between golfers of different skill level. Perhaps it was the arm motion, ball contact point, the club path or some other criterion variable which differentiated or predicted the skill level of players. It was also a possibility that a more skilled player would not necessarily have a superior putting stroke. Perhaps the more skilled players were more proficient in offsetting any weight shift with the upper body motion, resulting in superior performance. The weight shift patterns and foot placement in relation to the ball did however provide a foundation upon which the putting stroke may be developed.

Questionnaire Results

Interestingly, the low and medium hdp groups started to play golf at a significantly younger age than the high hdp group, $F(2,33)=5.72$, $p=.007$ (see Table 4.4). One might hypothesize that a certain percentage of the differences in the kinetic measures can be attributed to earlier exposure to the game. From past experience, the ability to master any skill or game was generally easier when exposed at a younger age. This may have been the case with the low and medium hdp groups, helping to explain why they made more putts.

One yardstick often used to measure the effectiveness of a putting performance was the number of three putt greens in a game. The three groups were significantly different in this regard, $\underline{F}(2,33)=3.49$, $p=.04$, with the high hdp group experiencing a three putt green almost three times per game and the low hdp group only one and a half times per game. Careful consideration must be given to these results as the high hdp group may have been three putting more often because their average putting distance from the hole was longer as compared to the low hdp group. The high hdp group's approach shots to the green were, on average, less accurate and consequently increased the likelihood of three putting a green. As the skill level increased, the average putting distance from the hole decreased, thereby reducing the chances of a three putt performance.

It was clear that the low and medium hdp groups entered a significantly greater number of tournaments per year compared to the high hdp group, $\underline{F}(2,33)=4.32$, $p=.02$ (see Table 4.4). From this one may conclude that the low and medium hdp groups were less intimidated by the testing procedures and displayed a truer representation of their putting stroke. Alternatively, the high hdp group may have been less comfortable in the testing situation and did not reproduce their normal putting stroke. However, just how much of the differences in the kinetic measures can be attributed to the number of tournaments the groups entered each year was difficult to ascertain. It was this researcher's opinion that this discrepancy did not explain a significant amount of the differences between the groups.

The remainder of the questionnaire results (see Table 4.4) were nonsignificant.

CHAPTER 6

Summary

The purpose of the study was to determine whether a significant relationship existed between the skill level of golfers and the weight distribution patterns exhibited during the putting stroke. The relation was investigated using kinetic ground reaction force measures and putting performance. The results of this study should be of special interest to instructors, coaches and to the ever increasing population of golfers.

A differential research design, based upon hdp, was utilized to allocate thirty-six subjects into groups of eight low (0-5) hdp, fourteen medium (6-14) hdp, and fourteen high (15-25) hdp players. The majority of the subjects were from Thunder Bay, Ontario and the immediate surrounding area. The subjects were allotted fifteen practice putts and then executed ten putts at a ten foot target and ten putts at a fifteen foot target. The foot placement relative to the ball, final ball position (cm and degrees), the time of ball contact, and various ground reaction forces were recorded for each trial.

A 3 X 2 (groups by distance) analysis of variance (ANOVA) with repeated measures on the second factor was used to assess the kinetic measures of the three groups. A multiple regression analysis was implemented to determine which kinetic measures were the best predictors of skill level. A Pearson Product Moment Correlation Coefficient was used to determine the possible relation between the total excursion values and the normalized vertical force at ball contact with the putting accuracy scores. The possible relation between the skill level of subjects with both the normalized vertical force at ball contact and the total excursion displayed was investigated utilizing a Spearman Rank Order Correlation Coefficient. Group responses to the questionnaire were analyzed for any significant differences via the one-way analysis of variance procedure.

Results indicated that there was a significant difference between the normalized vertical force at ball contact between the two putting distances. Significantly larger vertical force at ball contact were observed for the fifteen foot putting distance as opposed to the ten foot distance. As far as the group and interaction were concerned, differences in the normalized vertical force were nonsignificant.

The final ball position (degrees) was also significantly different for each putting distance, in that, the final ball position (degrees) was farther past the hole for the ten foot putt than the fifteen foot putt. The final ball position (degrees) for the three hdp groups were nonsignificant. The interaction between the two putting distances and the groups was found to be significant. The low and medium hdp groups rolled the ball much farther past the hole than the high hdp group on the shorter putting distance. Conversely, with respect to the longer putting distance, the low and high hdp groups rolled the ball just past the hole whereas the medium hdp group rolled the ball furthest past the hole.

The total number of successful putts for each group was also significantly different. As expected, the low and medium hdp groups made a significantly greater number of putts than the high hdp group. It was also determined that more putts were made on the shorter putting distance than on the longer putting distance. The interaction between the groups and the distances proved to be nonsignificant.

The remainder of the dependent measures (vertical force ratio, time ratio, total excursion, thirty percent excursion, both the X and Y positions of the centre of pressure, and the putting accuracy scores) revealed no significant differences among the groups, the two putting distances, or any interaction.

It was also determined that no significant relation existed between the putting accuracy and either the total excursion or the normalized vertical force at ball contact. A similar result was obtained for the relation between the skill level of the subjects and the total excursion and the normalized vertical force at ball contact. Finally, a stepwise multiple regression analysis was conducted at a critical level of .05 in an attempt to determine significant predictors of skill level, however, no variables were entered in the analysis.

Significant differences among the responses to the questionnaire included the age at which the groups started playing golf, the average number of three putt greens per game, and the average number of tournaments entered per year. The groups were not significantly different with regard to the number of years playing golf, the average number of putts per game, the average number of games played each week, the number of games played during the test week, the average amount of time (min) spent practising per week, and the amount of time (min) spent practising during the test week.

Conclusions

Based upon the literature presented and the results obtained, the following conclusions may be drawn:

1. As the length of putt increased, a greater amount of force may be distributed onto the target foot.
2. The lower hdp players tended to disperse their weight further toward the target than the higher hdp players.
3. The lower hdp players were more aggressive by rolling the ball further past the hole on putts of ten feet than the higher hdp players.
4. The players were less aggressive on the fifteen foot putt as compared to the ten foot putt.
5. Consistency of the ground reaction forces was the most crucial factor in dictating performance as opposed to where the forces were distributed.
6. The lower hdp players had a smaller total excursion of the

center of mass than the higher hdp players and as a result, may have been in a more stable position when the ball was contacted.

7. Exposure to the game at an early age may predispose the player to a better putting stroke.
8. The skill level of players was not distinguishable on the basis of weight shift patterns.
9. The weight shift patterns did not predict the final ball position.
10. The evaluation of the total putting performance may have been dependent upon more than the player's weight shift pattern.
11. There was no significant difference for ground reaction forces as a function of the various skill levels of the golfing population used in the study.
12. A high vertical force ratio was a critical factor in determining the total number of successful putts.
13. The results suggested that the weight should be dispersed in such a way that the position of the X centre of pressure was located approximately ten centimetres toward the target.

Recommendations

In an effort to enhance the present study or provide direction for further research, the researcher would suggest keeping the following recommendations in mind:

1. It would be advisable to increase the number of subjects in

order to increase the strength of the statistical analysis.

2. Rather than speculating what was occurring on the back foot, one would be urged to enlarge the force platform in order to accommodate both feet.
3. Perhaps a greater differential between the putting distances would have enhanced the differences between the skill level of players.
4. Ideally, it would have been preferred to test the subjects on a natural outdoor putting surface.
5. It would be advantageous to test subjects from other areas in order to increase the generalizability of the findings.
6. It would also be advised to add a third putting distance. An increased value for the ten foot putt to the fifteen foot putt may have been a temporary occurrence. A third putting distance would provide a third point of reference, thus further enhancing the results.
7. To further assess the subjects levels of confidence and aggression it would be advisable to have the subjects putt out their missed attempts and record the total number of putts required.
8. The researcher would also advocate the coordination of video analysis of the upper body with the force platform data of the lower body to investigate the putting stroke in its entirety.
9. Perhaps the use of the gait analysis software was not

specific enough for the study. Therefore, one would be urged to investigate the application of a stability software package, available through A.M.T.I., to better understand the weight shift patterns.

10. Teaching methodologies should encourage a putting stance where the head and body remain as steady as possible with approximately 55 percent of the body weight on the target foot.

11. A diagram or photograph displaying where the forces should ideally be distributed may help the subjects visualize a more advantageous weight shift pattern.

12. The researcher would advocate the initiation of data collection both before and during the putting stroke in order to determine whether a weight shift had occurred prior to the start of the putting stroke.

13. A pretest of the subjects putting abilities on a real putting green may have been a more effective method to classify the subjects as opposed to using the handicaps to rank the subjects.

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APPENDICES

APPENDIX A

ATTENTION PUTTERS!!!

So you think you are a good putter!!! Would you like an opportunity to prove it to yourself and your playing partners from a scientific perspective. All you require is an attested handicap (0-25), your putter and a "little" free time. If you are interested please sign your name, phone number and current handicap in the appropriate section below. Your scientific chance of a lifetime can become a reality sometime in July, but only you can make it happen!!! The exciting adventure will take place in the C.J.Sanders Building at Lakehead University. I am a graduate student at the university and an avid golfer as well. A call providing more information regarding the specifics will be made in the middle of July. If your curiosity is overwhelming, you can catch me during the junior golf camps run by the city by asking for Donald. Hope to see you on the links!!!

NAME	PHONE NUMBER	HANDICAP
1.		
2.		
3.		
4.		
5.		
6.		

APPENDIX B

INFORMED CONSENT
FOR
BIOMECHANICAL DATA COLLECTION
LAKEHEAD UNIVERSITY
DEPARTMENT OF PHYSICAL EDUCATION

You are invited to participate in a study of biomechanics which is being conducted by Donald Nault in conjunction with Dr.'s Bauer, McPherson, and Weeks. We hope to increase our knowledge regarding the consistency of the golf putting stroke.

If you decide to participate, each experimental session should last less than an hour and a half. There are no known expected discomforts or risks involved in your participation. It is hoped that the results of this experiment will help us to understand the principles which underlie a consistent putting stroke.

Any information obtained in connection with this study that can be identified with you will remain confidential, therefore, in any publication or results this information will remain anonymous. If you give us permission, by signing this document, the results may be published in an appropriate biomechanical journal.

Your decision whether or not to participate will not prejudice your future relations with Lakehead University or the physical education department. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. Should you decide to withdraw from the study, you may also withdraw any information collected about you.

If you have any questions, we expect you to ask us. If you have any additional questions later, Donald Nault can be reached at 683 -8646. We will be happy to answer any questions you may have.

You are making a decision whether or not to participate. Your signature indicates that you have decided to participate having read the information provided above.

____________________________ ____________________________
Date Time Subject's Signature

____________________________ ____________________________
Witness Investigator's Signature

APPENDIX C

Name: ______________________________

Member (Y/N) ______ Club ______________ Green fee player ______

GOLF THESIS TESTING

Firstly, I would like to welcome and thank you for your co-operation and participation in volunteering your time to be a part of my study. The following questions will be used so that we can get to know each other and make the results even more meaningful! Please take the time necessary to answer the questions as accurately as possible.

1. HOW MANY YEARS HAVE YOU BEEN PLAYING GOLF? ______________

2. ON AVERAGE, HOW MANY TIMES PER WEEK DO YOU PLAY GOLF? _______

3. ON AVERAGE, HOW MANY TIMES PER YEAR DO YOU ENTER GOLF TOURNAMENTS? ______________

4. WHEN YOU PLAY GOLF DO YOU PREFER TO PUT A "WAGER" ON THE GAME OR DO YOU JUST PLAY FOR FUN? ______________

5. AT WHAT AGE DID YOU START PLAYING GOLF? _____________

6. ON AVERAGE, HOW MUCH TIME (MINUTES) PER WEEK DO YOU SPEND ON PRACTISING YOUR PUTTING? ______________ MINUTES.

7. RATE YOURSELF AS A PUTTER ON THE FOLLOWING SCALE?

   POOR FAIR AVERAGE GOOD EXCELLENT
   ----

8. IN AN 18 HOLE GAME, HOW MANY PUTTS DO YOU "NORMALLY" USE? _________

9. IN AN 18 HOLE GAME, HOW MANY TIMES WILL YOU THREE PUTT A GREEN? ________

10. HOW MANY TIMES HAVE YOU PLAYED GOLF THIS WEEK? ___________

11. DID YOU PRACTICE YOUR PUTTING THIS WEEK, AND IF SO, FOR HOW LONG? ______________ MINUTES.

APPENDIX D

DEPENDENT MEASURES

1. FZDISTSH -- Normalized vertical force readings on the short putt (10 feet).

2. FZDISTLO -- Normalized vertical force readings on the long putt (15 feet).

3. FZRATSH -- Comparison of the maximum vertical force with the vertical force at ball contact for the short putt (10 feet).

4. FZRATLO -- Comparison of the maximum vertical force with the vertical force at ball contact for the long putt (15 feet).

5. TIMRATSH -- Comparison of the time of maximum vertical force and the time of ball contact for the short putt (10 feet).

6. TIMRATLO -- Comparison of the time of maximum vertical force and the time of ball contact for the long putt (15 feet).

7. TOTEXSH -- Weight transfer along the X axis for the short putt (10 feet).

8. TOTEXLO -- Weight transfer along the X axis for the long putt (15 feet).

9. THIRTYSH -- The first thirty percent of excursion for the short putt (10 feet).

10. THIRTYLO -- The first thirty percent of excursion for the long putt (15 feet).

11. XCOFPSH -- The X centre of pressure for the short putt (10 feet).

12. XCOFPLO -- The X centre of pressure for the long putt (15 feet).

13. YCOFPSH -- The Y centre of pressure for the short putt (10 feet).

14. YCOFPLO -- The Y centre of pressure for the long putt (15 feet).

15. ACCSCSH -- Final ball position (cm) from the hole for the short putt (10 feet).

16. ACCSCLO -- Final ball position (cm) from the hole for the long putt (15 feet).

17. PUTSMDSH -- Total number of putts made for the short putt (10 feet).

18. PUTSMDLO -- Total number of putts made for the long putt (15 feet).

19. TOTALACC -- Total accuracy score for both putting distances.

20. FZTOTAL -- Total normalized vertical force for both putting distances.

21. AGESTART -- Age at which the player started to play golf.

22. YRSPLAY -- Total number of years the player has been playing golf.

23. SNAKPERG -- Average number of times the player will three putt a green during an 18 hole game.

24. PUTPERGA -- Average total number of putts the player will use during an 18 hole game.

25. TIMPERWK -- Average number of games played per week.

26. GAMTSTWK -- Number of games played during the test week (last 7 day period).

27. TRNYPERY -- Average number of tournaments the player will enter in one year.

28. PRACTIME -- Average amount of time (min) practising putting during 1 week.

29. PTITSTWK -- Amount of time (min) spent practising putting during the test week (7 day period prior to test date).

30. ANGLESH -- Final ball position (degrees) from the hole for the short putt (10 feet).

31. ANGLELO -- Final ball position (degrees) from the hole for the long putt (15 feet).

32. FOOTCMSH -- Position of target foot in relation to ball position for the short putt (10 feet).

33. FOOTCMLO -- Position of target foot in relation to ball position for the long putt (15 feet).

APPENDIX E

STATISTICAL ANALYSIS

MANOVA FZDISTSH FZDISTLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. FZDISTSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.530	.059	8
GROUP	2	.532	.090	14
GROUP	3	.549	.074	14
For entire sample		.538	.076	36

- - - - - - - - - - -

Variable .. FZDISTLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.554	.076	8
GROUP	2	.544	.079	14
GROUP	3	.575	.072	14
For entire sample		.558	.075	36

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	.36	33	.01		
CONSTANT	20.14	1	20.14	1829.00	.000
GROUP	.01	2	.00	.40	.672

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	.03	33	.00		
DISTANCE	.01	1	.01	9.03	.005
GROUP BY DISTANCE	.00	2	.00	.46	.637

MANOVA FOOTCMSH FOOTCMLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. FOOTCMSH

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	9.700	3.493	8
GRP	2	12.164	4.639	14
GRP	3	13.171	5.381	14
For entire sample		12.008	4.791	36

Variable .. FOOTCMLO

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	9.950	3.799	8
GRP	2	11.593	4.666	14
GRP	3	12.957	5.492	14
For entire sample		11.758	4.849	36

SPSS/PC+

* * ANALYSIS OF VARIANCE DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	1466.27	33	44.43		
CONSTANT	9025.74	1	9025.74	203.13	.000
GRP	106.84	2	53.42	1.20	.313

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	51.39	33	1.56		
DISTANCE	.54	1	.54	.34	.562
GRP BY DISTANCE	1.73	2	.87	.56	.579

MANOVA FZRATSH FZRATLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. FZRATSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.913	.089	8
GROUP	2	.923	.029	14
GROUP	3	.888	.097	14
For entire sample		.907	.075	36

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Variable .. FZRATLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.935	.053	8
GROUP	2	.907	.032	14
GROUP	3	.917	.047	14
For entire sample		.917	.043	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	.21	33	.01		
CONSTANT	56.09	1	56.09	9022.18	.000
GROUP	.01	2	.00	.42	.659

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Si_ificance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	.05	33	.00		
DISTANCE	.00	1	.00	1.77	.193
GROUP BY DISTANCE	.01	2	.00	2.80	.076

MANOVA TIMRASH TIMRALO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. TIMRATSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.737	.372	8
GROUP	2	.676	.392	14
GROUP	3	.612	.214	14
For entire sample		.665	.323	36

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Variable .. TIMRALO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	.757	.303	8
GROUP	2	.631	.214	14
GROUP	3	.622	.130	14
For entire sample		.655	.211	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	4.42	33	.13		
CONSTANT	30.38	1	30.38	227.09	.000
GROUP	.17	2	.09	.65	.529

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	.61	33	.02		
DISTANCE	.00	1	.00	.02	.876
GROUP BY DISTANCE	.01	2	.01	.40	.674

MANOVA TOTEXSH TOTEXLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. TOTEXSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	10.357	1.147	8
GROUP	2	18.371	23.059	14
GROUP	3	11.155	2.896	14
For entire sample		13.784	14.654	36

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Variable .. TOTEXLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	10.265	1.525	8
GROUP	2	12.743	4.600	14
GROUP	3	12.097	5.721	14
For entire sample		11.941	4.625	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	5159.38	33	156.34		
CONSTANT	10496.70	1	10496.70	67.14	.000
GROUP	350.20	2	175.10	1.12	.338

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	2588.16	33	78.43		
DISTANCE	42.62	1	42.62	.54	.466
GROUP BY DISTANCE	166.83	2	83.42	1.06	.357

MANOVA THIRTYSH THIRTYLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. THIRTYSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	3.065	.432	8
GROUP	2	3.992	1.048	14
GROUP	3	3.379	.761	14
For entire sample		3.548	.897	36

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Variable .. THIRTYLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	3.141	.469	8
GROUP	2	3.974	1.328	14
GROUP	3	4.089	2.687	14
For entire sample		3.834	1.877	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	96.46	33	2.92		
CONSTANT	874.18	1	874.18	299.08	.000
GROUP	7.97	2	3.98	1.36	.270

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	45.00	33	1.36		
DISTANCE	1.10	1	1.10	.81	.376
GROUP BY DISTANCE	2.08	2	1.04	.76	.474

MANOVA XCOFPSH XCOFPLO BY GROUP (1,3)/ WSFACTORS DISTANCE
(2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. XCOFPSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	-12.142	2.789	8
GROUP	2	-9.124	5.813	14
GROUP	3	-7.700	5.679	14
For entire sample		-9.241	5.382	36

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Variable .. XCOFPLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	-11.997	2.936	8
GROUP	2	-9.404	5.405	14
GROUP	3	-7.786	5.944	14
For entire sample		-9.351	5.318	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	1770.64	33	53.66		
CONSTANT	6312.61	1	6312.61	117.65	.000
GROUP	190.69	2	95.35	1.78	.185

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	41.77	33	1.27		
DISTANCE	.09	1	.09	.07	.790
GROUP BY DISTANCE	.47	2	.23	.18	.833

MANOVA YCOFPSH YCOFPLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. YCOFPSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	5.158	6.379	8
GROUP	2	1.882	4.812	14
GROUP	3	4.908	6.465	14
For entire sample		3.787	5.886	36

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Variable .. YCOFPLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	5.403	5.673	8
GROUP	2	2.274	4.656	14
GROUP	3	4.769	6.453	14
For entire sample		3.939	5.641	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	2157.97	33	65.39		
CONSTANT	1110.69	1	1110.69	16.98	.000
GROUP	147.95	2	73.97	1.13	.335

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	19.54	33	.59		
DISTANCE	.46	1	.46	.78	.383
GROUP BY DISTANCE	1.03	2	.52	.87	.428

```
MANOVA ACCSCSH ACCSCLO BY GROUP (1,3)/ WSFACTORS DISTANCE
     (2)/ PRINT CELLINFO (MEANS).
```

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. ACCSCSH

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	36.485	16.759	8
GROUP	2	29.800	8.227	14
GROUP	3	35.178	16.374	14
For entire sample		33.377	13.767	36

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Variable .. ACCSCLO

FACTOR	CODE	Mean	Std. Dev.	N
GROUP	1	32.886	10.041	8
GROUP	2	34.929	8.914	14
GROUP	3	39.989	10.643	14
For entire sample		36.442	10.029	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	5762.88	33	174.63		
CONSTANT	81745.74	1	81745.74	468.10	.000
GROUP	382.35	2	191.18	1.09	.346

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	3779.70	33	114.54		
DISTANCE	75.04	1	75.04	.66	.424
GROUP BY DISTANCE	228.76	2	114.38	1.00	.379

MANOVA ANGLESH ANGLELO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. ANGLESH

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	248.750	20.837	8
GRP	2	237.429	26.429	14
GRP	3	193.679	60.949	14
For entire sample		222.931	48.008	36

Variable .. ANGLELO

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	192.587	34.520	8
GRP	2	204.671	32.240	14
GRP	3	191.143	47.824	14
For entire sample		196.725	38.930	36

SPSS/PC+

* ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	93131.84	33	2822.18		
CONSTANT	3002497.33	1	3002497.3	1063.89	.000
GRP	13900.61	2	6950.31	2.46	.101

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	18866.44	33	571.71		
DISTANCE	15612.95	1	15612.95	27.31	.000
GRP BY DISTANCE	7811.97	2	3905.98	6.83	.003

MANOVA PUTSMDSH PUTSMDLO BY GROUP (1,3)/ WSFACTORS DISTANCE (2)/ PRINT CELLINFO (MEANS).

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations
Variable .. PUTSMDSH

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	5.500	2.390	8
GRP	2	6.571	1.158	14
GRP	3	4.071	2.303	14
For entire sample		5.361	2.206	36

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Variable .. PUTSMDLO

FACTOR	CODE	Mean	Std. Dev.	N
GRP	1	2.500	1.414	8
GRP	2	2.786	1.528	14
GRP	3	1.714	1.139	14
For entire sample		2.306	1.411	36

SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Cell Means and Standard Deviations (CONT.)
Tests of Between-Subjects Effects.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	111.79	33	3.39		
CONSTANT	999.77	1	999.77	295.14	.000
GRP	45.21	2	22.61	6.67	.004

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SPSS/PC+

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests involving 'DISTANCE' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	75.79	33	2.30		
DISTANCE	156.04	1	156.04	67.94	.000
GRP BY DISTANCE	7.16	2	3.58	1.56	.226

```
     Variable  PUTSMDSH
  By Variable  GRP

Multiple Range Test

Student-Newman-Keuls Procedure
Ranges for the  .050 level -

         2.88   3.46

The ranges above are table ranges.
The value actually compared with Mean(J)-Mean(I) is..
        1.3837 * Range * Sqrt(1/N(I) + 1/N(J))

(*) Denotes pairs of groups significantly different at the  .050 level

---------------------------------------------------------------------
Page  23                              SPSS/PC+

                                  - O N E W A Y -

     Variable  PUTSMDSH
     (Continued)

                           G G G
                           r r r
                           p p p

    Mean        Group      3 1 2

    4.0714      Grp 3
    5.5000      Grp 1
    6.5714      Grp 2
```

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

CORRELATIONS/VARIABLES TOTALACC WITH TOTALEXC

CORRELATIONS/VARIABLES TOTALACC WITH FZTOTAL

SPSS/PC+

Correlations: TOTALACC

TOTALEXC .0054

N of cases: 36 1-tailed Signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

SPSS/PC+

Correlations: TOTALACC

FZTOTAL -.0222

N of cases: 36 1-tailed Signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

SPEARMAN RANK ORDER CORRELATION COEFFICIENT

RANK GROUP TOTFZ TOTEX

FROM VARIABLE	NEW VARIABLE	LABEL
GROUP	RAN001	RANK OF GROUP
TOTFZ	RTOTFZ	RANK OF TOTFZ
TOTEX	RTOTEX	RANK OF TOTEX

CORRELATIONS/VARIABLES RAN001 WITH RTOTFZ

CORRELATIONS/VARIABLES RAN001 WITH RTOTEX

SPSS/PC+

Correlations: RTOTFZ

RAN001 .0963

N of cases: 36 1-tailed signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

SPSS/PC+

Correlations: RTOTEX

RAN001 .0044

N of cases: 36 1 tailed signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

MULTIPLE REGRESSION ANALYSIS

```
REGRESSION/VARIABLES GROUP FZDISTSH FZDISTLO FZRATSH FZRATLO
    TIMRATSH TIMRALO ACCSCSH ACCSCLO TOTEXSH TOTEXLO
    THIRTYSH THIRTYLO YCOFPSH YCOFPLO XCOFPSH XCOFPLO/
    STATISTICS DEFAULTS CHANGE/ DEPENDENT GROUP/ METHOD
    STEPWISE.
```

SPSS/PC+

* * * *   M U L T I P L E   R E G R E S S I O N   * * * *

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   GROUP

Block Number 1. Method: Stepwise   Criteria   PIN .0500   POUT .1000

End Block Number   1   PIN =   .050 Limits reached.
No variables entered/removed for this block.

CORRELATIONS/VARIABLES GROUP WITH FZDISTSH FZDISTLO FZRATSH
FZRATLO TIMRATSH TIMRALO ACCSCSH ACCSCLO TOTEXSH
TOTEXLO THIRTYSH THIRTYLO YCOFPSH YCOFPLO XCOFPSH
XCOFPLO.

SPSS/PC+

Correlations:	FZDISTSH	FZDISTLO	FZRATSH	FZRATLO	TIMRATSH	TIMRALO
GROUP	.1064	.1334	-.1537	-.1306	-.1497	-.2237

N of cases: 36 1-tailed Signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

SPSS/PC+

Correlations:	ACCSCSH	ACCSCLO	TOTEXSH	TOTEXLO	THIRTYSH	THIRTYLO
GROUP	.0009	.2872	-.0236	.1244	.0618	.1792

N of cases: 36 1-tailed Signif: * - .01 ** - .001

" . " is printed if a coefficient cannot be computed

SPSS/PC+

Correlations:	YCOFPSH	YCOFPLO	XCOFPSH	XCOFPLO
GROUP	.0296	-.0006	.3069	.2988

N of cases: 36 1-tailed Signif: * - .01 ** - .001

" is printed if a coefficient cannot be computed

QUESTIONNAIRE STATISTICS

ONEWAY/VARIABLES AGESTART BY GRP (1,3)/ STATISTICS 1/
RANGES=SNK.

SPSS/PC+

ONEWAY /VARIABLES AGESTART BY GRP (1,3) /STATISTICS 1 /RANGES SNK.

SPSS/PC+

- - - - - - - - O N E W A Y - - - - - - - - -

Variable AGESTART
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	1852.2857	926.1429	5.7226	.0074
Within Groups	33	5340.7143	161.8398		
Total	35	7193.0000			

SPSS/PC+

- - O N E W A Y - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	12.0000	8.8802	3.1396	4.5760	To	19.4240
Grp 2	14	13.7857	7.8071	2.0865	9.2780	To	18.2934
Grp 3	14	27.7857	17.5332	4.6859	17.6624	To	37.9091
Total	36	18.8333	14.3358	2.3893	13.9828	To	23.6839

Group	Minimum	Maximum
Grp 1	2.0000	32.0000
Grp 2	6.0000	39.0000
Grp 3	.0000	52.0000
Total	.0000	52.0000

Variable AGESTART
By Variable GRP

Multiple Range Test

Student-Newman-Keuls Procedure
Ranges for the .050 level -

2.88 3.46

The ranges above are table ranges.
The value actually compared with Mean(J)-Mean(I) is..
8.9955 * Range * Sqrt(1/N(I) + 1/N(J))

(*) Denotes pairs of groups significantly different at the .050 level

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SPSS/PC+

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Variable AGESTART
(Continued)

Mean	Group	Grp 1	Grp 2	Grp 3
12.0000	Grp 1			
13.7857	Grp 2			
27.7857	Grp 3	*	*	

ONEWAY/VARIABLES YRSPLAY BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

- - - - - - - - - - - - O N E W A Y - - - - - - - - - -

Variable YRSPLAY
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	340.9107	170.4554	1.5500	.2273
Within Groups	33	3629.0893	109.9724		
Total	35	3970.0000			

SPSS/PC+

- - O N E W A Y - - - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	21.3750	11.3507	4.0131	11.8856	To	30.8644
Grp 2	14	15.7143	8.8006	2.3521	10.6330	To	20.7956
Grp 3	14	13.2143	11.5037	3.0745	6.5722	To	19.8563
Total	36	16.0000	10.6503	1.7750	12.3965	To	19.6035

Group	Minimum	Maximum
Grp 1	5.0000	40.0000
Grp 2	4.0000	30.0000
Grp 3	4.0000	44.0000
Total	4.0000	44.0000

ONEWAY/VARIABLES SNAKPERG BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

- - - - - - - - - - - - O N E W A Y - - - - - - - - - -

Variable SNAKPERG
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	14.4821	7.2411	3.4875	.0423
Within Groups	33	68.5179	2.0763		
Total	35	83.0000			

SPSS/PC+

- - O N E W A Y - - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	1.3750	.7440	.2631	.7530	To	1.9970
Grp 2	14	1.8571	.8644	.2310	1.3580	To	2.3563
Grp 3	14	2.9286	2.0555	.5494	1.7417	To	4.1154
Total	36	2.1667	1.5399	.2567	1.6456	To	2.6877

Group	Minimum	Maximum
Grp 1	1.0000	3.0000
Grp 2	1.0000	3.0000
Grp 3	.0000	7.0000
Total	.0000	7.0000

ONEWAY/VARIABLES PUTPERGA BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

- - - - - - - - - - - - O N E W A Y - - - - - - - - -

Variable PUTPERGA
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	38.4782	19.2391	1.5986	.2174
Within Groups	33	397.1607	12.0352		
Total	35	435.6389			

SPSS/PC+

- - O N E W A Y - - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	31.6250	2.0659	.7304	29.8979	To	33.3521
Grp 2	14	32.2143	2.2931	.6129	30.8903	To	33.5383
Grp 3	14	34.0714	4.7953	1.2816	31.3027	To	36.8401
Total	36	32.8056	3.5280	.5880	31.6119	To	33.9993

Group	Minimum	Maximum
Grp 1	30.0000	36.0000
Grp 2	26.0000	36.0000
Grp 3	26.0000	42.0000
Total	26.0000	42.0000

ONEWAY/VARIABLES TIMPERWK BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

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Variable TIMPERWK
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	.6508	.3254	.2356	.7914
Within Groups	33	45.5714	1.3810		
Total	35	46.2222			

SPSS/PC+

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Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	3.0000	1.6036	.5669	1.6594	To	4.3406
Grp 2	14	3.3571	1.1507	.3075	2.6927	To	4.0216
Grp 3	14	3.2143	.8926	.2386	2.6989	To	3.7296
Total	36	3.2222	1.1492	.1915	2.8334	To	3.6111

Group	Minimum	Maximum
Grp 1	1.0000	5.0000
Grp 2	1.0000	5.0000
Grp 3	2.0000	5.0000
Total	1.0000	5.0000

ONEWAY/VARIABLES GAMTSTWK BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

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Variable GAMTSTWK
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3.1786	1.5893	.5989	.5553
Within Groups	33	87.5714	2.6537		
Total	35	90.7500			

SPSS/PC+

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Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	2.7500	1.8323	.6478	1.2182	To	4.2818
Grp 2	14	2.8571	1.5619	.4174	1.9553	To	3.7590
Grp 3	14	2.2143	1.5777	.4216	1.3034	To	3.1252
Total	36	2.5833	1.6102	.2684	2.0385	To	3.1282

Group	Minimum	Maximum
Grp 1	1.0000	7.0000
Grp 2	1.0000	6.0000
Grp 3	.0000	5.0000
Total	.0000	7.0000

```
ONEWAY/VARIABLES TRNYPERY BY GRP (1,3)/ STATISTICS 1/
    RANGES=SNK.
```

SPSS/PC+

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Variable TRNYPERY
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	129.3413	64.6706	4.3182	.0216
Within Groups	33	494.2143	14.9762		
Total	35	623.5556			

SPSS/PC+

- - O N E W A Y - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	9.2500	5.3385	1.8875	4.7869	To	13.7131
Grp 2	14	8.2143	4.3355	1.1587	5.7110	To	10.7175
Grp 3	14	4.7857	1.9682	.5260	3.6493	To	5.9221
Total	36	7.1111	4.2209	.7035	5.6830	To	8.5393

Group	Minimum	Maximum
Grp 1	4.0000	20.0000
Grp 2	1.0000	15.0000
Grp 3	2.0000	8.0000
Total	1.0000	20.0000

```
      Variable  TRNYPERY
   By Variable  GRP

Multiple Range Test

Student-Newman-Keuls Procedure
Ranges for the  .050 level -

          2.88   3.46

The ranges above are table ranges.
The value actually compared with Mean(J)-Mean(I) is..
        2.7364 * Range * Sqrt(1/N(I) + 1/N(J))

(*) Denotes pairs of groups significantly different at the  .050 level

                         G G G
                         r r r
                         p p p

    Mean       Group     3 2 1

    4.7857     Grp 3
    8.2143     Grp 2     *
    9.2500     Grp 1     *
```

ONEWAY/VARIABLES PRACTIME BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

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Variable PRACTIME
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	547.0794	273.5397	.5683	.5720
Within Groups	33	15885.1429	481.3680		
Total	35	16432.2222			

SPSS/PC+

- - O N E W A Y - - - - - - - - - -

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	32.5000	23.6039	8.3452	12.7667	To	52.2333
Grp 2	14	23.4286	18.1859	4.8604	12.9284	To	33.9288
Grp 3	14	22.8571	24.3148	6.4984	8.8182	To	36.8961
Total	36	25.2222	21.6678	3.6113	17.8909	To	32.5535

Group	Minimum	Maximum
Grp 1	10.0000	75.0000
Grp 2	.0000	60.0000
Grp 3	.0000	60.0000
Total	.0000	75.0000

ONEWAY/VARIABLES PTITSTWK BY GRP (1,3)/ STATISTICS 1.

SPSS/PC+

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Variable PTITSTWK
By Variable GRP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	1128.3234	564.1617	2.0796	.1411
Within Groups	33	8952.2321	271.2798		
Total	35	10080.5556			

SPSS/PC+

- - O N E W A Y - - - - - - - - -

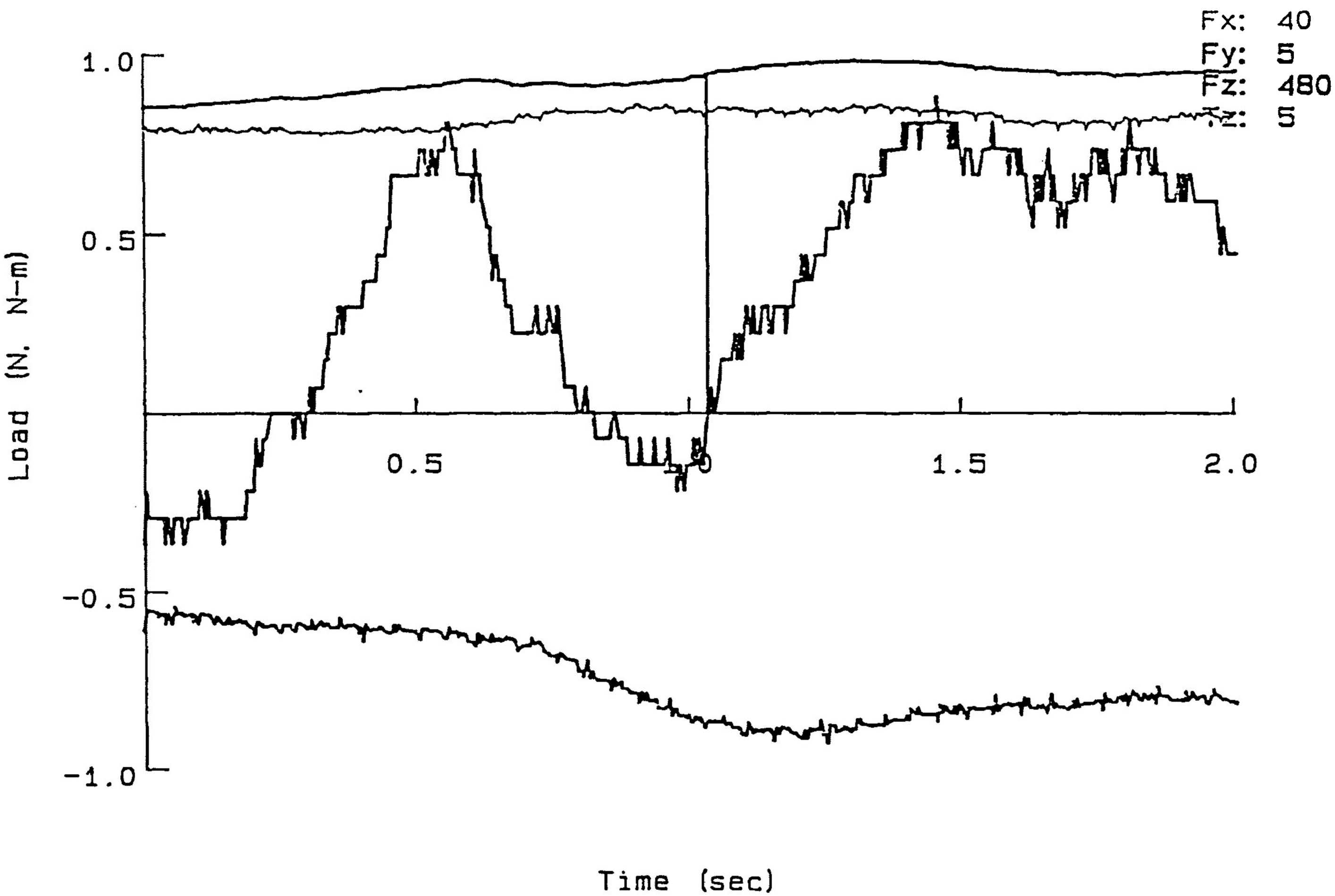
Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	19.3750	30.7568	10.8742	-6.3383	To	45.0883
Grp 2	14	13.2143	11.5371	3.0834	6.5530	To	19.8756
Grp 3	14	5.0000	6.7937	1.8157	1.0775	To	8.9225
Total	36	11.3889	16.9710	2.8285	5.6467	To	17.1311

Group	Minimum	Maximum
Grp 1	.0000	75.0000
Grp 2	.0000	30.0000
Grp 3	.0000	20.0000
Total	.0000	75.0000

ROGER Putting Distance - 10 Feet
A7 Time of Ball Contact - 1.01 sec.
Body Weight on Left Leg - 54%
Low Handicap Group

08-18-91
af2978

Platform: 1

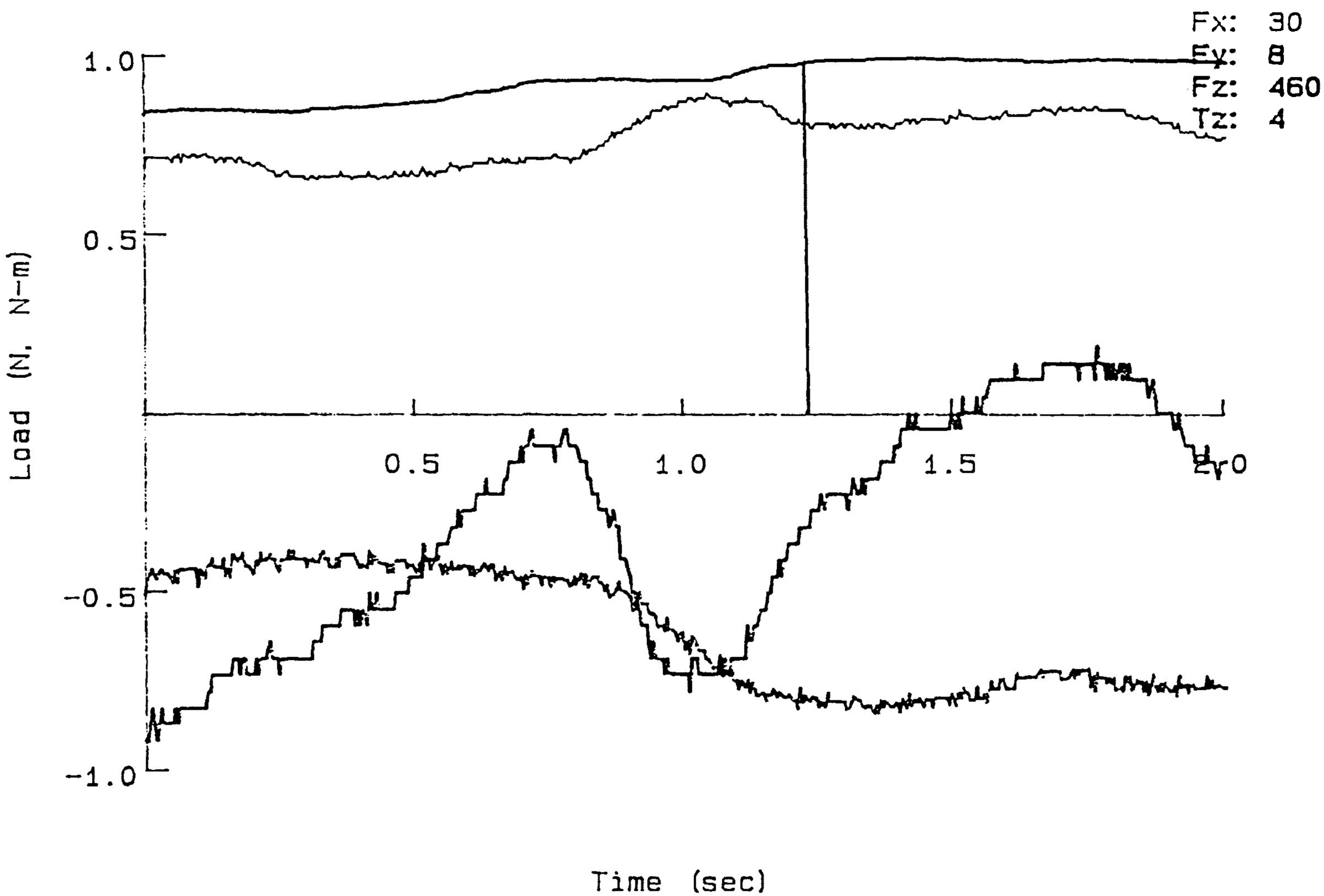


FORCES AND TORQUE VS. TIME

ROGER Putting Distance - 15 Feet
B7 Time of Ball Contact - 1.21 sec.
Body Weight on Left Leg - 54%
Low Handicap Group

08-18-91
af2701

Platform: 1

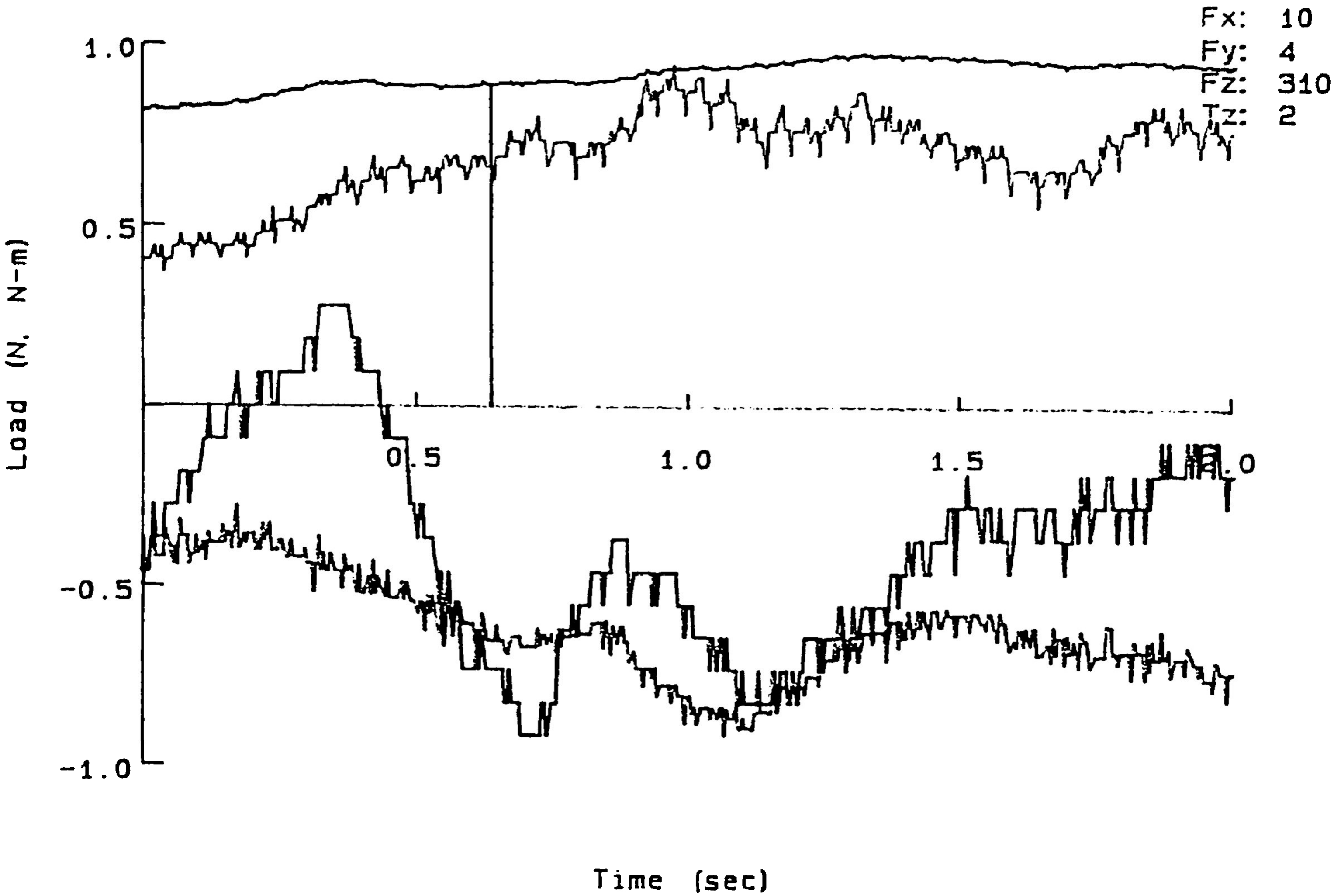


FORCES AND TORQUE VS. TIME

DAVE Putting Distance - 10 Feet
A1 Time of Ball Contact - .63 sec.
Body Weight on Left Leg - 49%
Medium Handicap Group

08-19-91
b0930a

Platform: 1

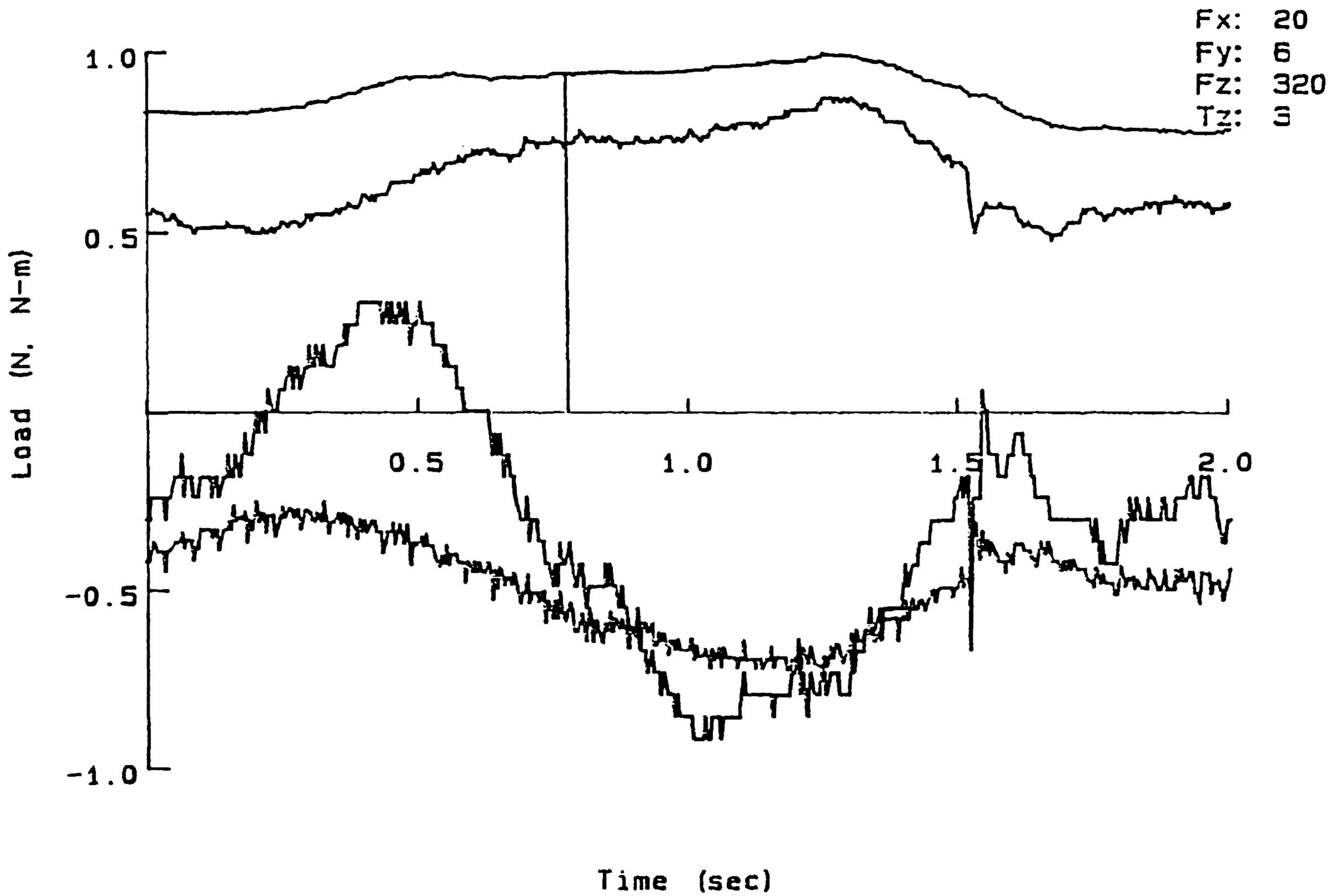


FORCES AND TORQUE VS. TIME

DAVE Putting Distance - 15 Feet
B3 Time of Ball Contact - .76 sec.
Body Weight on Left Leg - 52%
Medium Handicap Group

08-19-91
b09019

Platform: 1

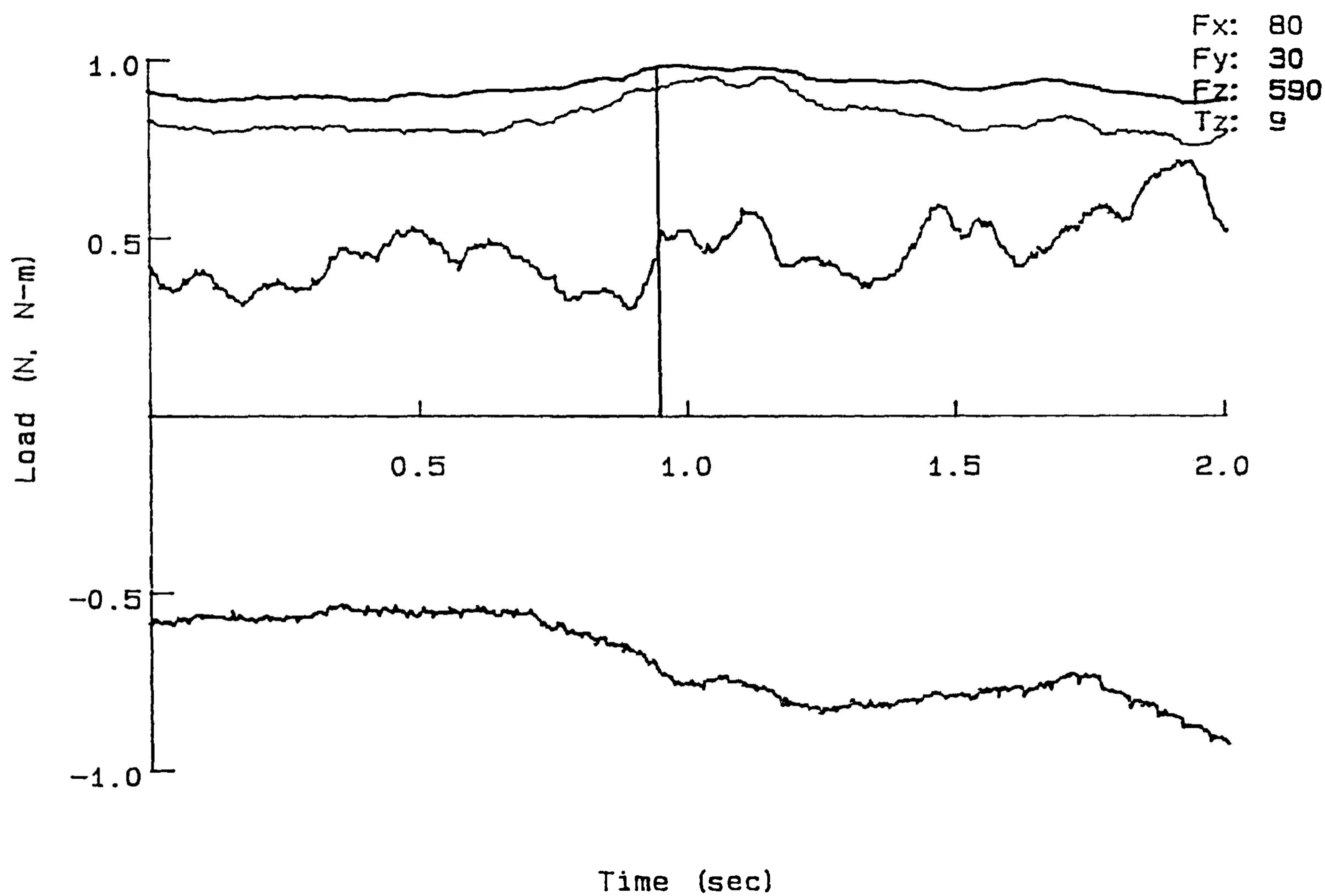


FORCES AND TORQUE VS. TIME

TERRY Putting Distance - 10 Feet
AB Time of Ball Contact - .93 sec.
Body Weight on Left Leg - 56%
High Handicap Group

08-13-91
a87f47

Platform: 1

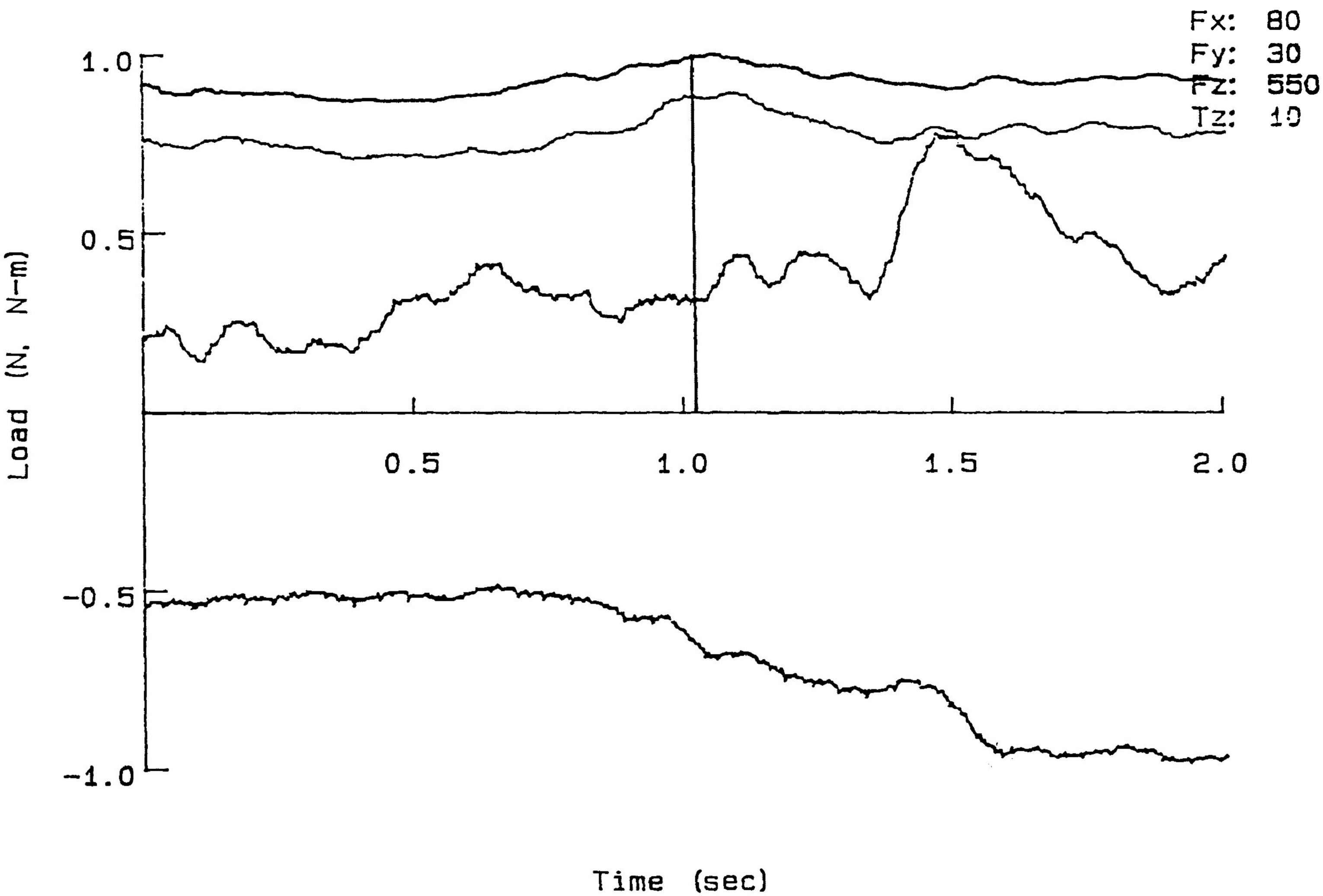


FORCES AND TORQUE VS. TIME

TERRY Putting Distance - 15 Feet
B7 Time of Ball Contact - 1.01 sec.
Body Weight on Left Leg - 54%
High Handicap Group

08-13-91
a87b7d

Platform: 1



FORCES AND TORQUE VS. TIME