

INTRODUCTION

This study is submitted to Dr. Paul Ward, Co-ordinator for the Elite Athletes Project for javelin, shot put and discus. This phase of the project was conducted at the Biomechanics Laboratory in the Department of Kinesiology at U.C.L.A. Participants in the data collection and reductions phases were in alphabetical order: John Garhammer, PhD, FACSM

Robert Gregor, PhD, FACSM

Raymond McCoy, MSc

Robert Rich, BSc

Paul Ward, PhD

Lisa Wilson

The data presented should not be considered a final report but rather the beginning of an ongoing, continuous interaction between the U.C.L.A. Biomechanics Lab, the U.S.O.C. and athletes and coaches involved in the javelin, shot put and discus. We feel there can be no final report since all questions are far from being answered. Dr. Paul Ward developed some initial parameters to study and with two separate filming sessions complete we are now in a position to see which parameters ^{are} important and which ones are not. The model to study these events continues to be developed.

Seventy six percent (76%) of the monies given U.C.L.A. by the U.S.O.C. has been utilized for student salaries. We feel we are now in a position to be extremely efficient in our operation. Software has been developed to respond directly to Dr. Ward's questions and with continued input to this facility by the U.S.O.C. we feel we can greatly refine the model and continue to give feedback to the athlete and coach. A good working relationship has been developed, students working on the selected events will remain at U.C.L.A. until 1984. Consequently, the output from this facility can only improve in both quality and quantity.

METHODS

I SUBJECTS

The athletes who participated in this phase of the Elite Athlete Project were all internationally known throwers in track and field. They are listed below by events:

SHOT PUT: LORNA GRIFFIN
DAVE LAUT
BRIAN OLDFIELD

DISCUS: LORNA GRIFFIN
BEN PLUNKNET
JOHN POWELL
MAC WILKINS

JAVELIN: BOB ROGGY

II DATA COLLECTION

Several trials (throws) were filmed for each athlete on two separate occasions during the spring of 1982. All individuals were filmed at Drake Stadium, U.C.L.A., on March 13, 1982 and at El Toro High School on May 8, 1982. The only exception to this filming sequence was Bob Roggy who could not be filmed on the second date. Consequently, he was filmed at the Pepsi Invitational Meet at U.C.L.A.

DRAKE STADIUM (3/13/82): Three separate cameras overhead, side and frontviews, were utilized to film each subject at least four times. The overhead and side cameras for shot put and discus were supplied by the U.C.L.A. Biomechanics Laboratory (Photosonics IP) and operated at a nominal speed of 100 frames per second. The overhead and front views for the javelin were also supplied by U.C.L.A. The third view

in each event (ie side for javelin and rear for shot put and discus) was filmed by Dr. Juris Terauds. Dr. Terauds was kind enough to volunteer his services free of charge for the day. Additionally Mr. Dick Freeborg of Photosonics supplied their high speed video system for the day free of charge. To summarize the views:

JAVELIN: Front View - U.C.L.A.
Overhead View - U.C.L.A.
Side View - Dr. Terauds

SHOT PUT: Rear View - Dr. Terauds
Overhead View - U.C.L.A.
Side View - U.C.L.A.

DISCUS: Rear View - Dr. Terauds
Overhead View - U.C.L.A.
Side View - U.C.L.A.

EL TORO HIGH SCHOOL (5/8/82): Again three separate cameras were utilized, one supplied by U.C.L.A., the remaining two by Dr. Gideon Ariel of the Coto Research Center. The same views for at least four trials were filmed for shot put and discus as were filmed on March 13th. The javelin was not filmed during this data collection session.

U.C.L.A. PEPSI INVITATIONAL (5/16/82): Bob Roggy was filmed from the side view alone during the javelin competition. A Photosonics IP camera was utilized and operated at a nominal speed of 100 frames per second.

During all filming sessions appropriate camera speed calibrations were utilized to verify frame speed and provide a time base for subsequent data reduction. Additionally, both a three dimensional cube (for Coto Research Center) and linear multiplier were filmed at appropriate times to provide real life dimensions on the film for subsequent data reduction.

III DATA REDUCTION

All data reduction yielding the results presented in this report was conducted at the U.C.L.A. Biomechanics Laboratory in the Department of Kinesiology. All film was digitized by means of a Vanguard Motion Analyzer linked to a Hewlett Packard 9830 Digitizer/Calculator System. In an effort to establish a model to study the javelin, shotput and discus Dr. Paul Ward, Co-ordinator of the Throwers for the Elite Athlete Project met several times with the staff of our laboratory and subsequently posed the questions (ie. parameters to study) found on the following pages. As with the development of any model these parameters are a start. Some are good and some are not. Some need refinement, further explanation and generate additional questions. The data presented in this report focuses on these parameters. The staff of this lab, however, feels it is important to emphasize that this is just the beginning. Comparisons are made initially between the best and worst throws for each test session. Obviously, more data is required. Correlations are presented but must be viewed very carefully in light of the low number of subjects and trials. Many graphs are presented in direct response to Dr. Ward's questions but further evaluation and feedback are needed. The following sequence of events took place prior to the submission of this report.

1. Meeting between Dr. Ward and staff of biomechanics lab at U.C.L.A. (3/10/82). The purpose was to generate the initial parameters to study in the development of a feasible model.
2. Data Collection 3/13/82.
3. Data Reduction
 - a. digitization
 - b. position and velocity data calculated
4. Feedback to Dr. Ward for further refinement of data output and parameters to include in the model.

BIOMECHANICAL ANALYSIS (JAVELIN)

I. TIMING

(viewing perspective is determined by what is measured)

- a. ground times, flight times of last four strides.
- b. stride frequency of last four strides

II. SEGMENT RELATIONSHIPS

SIDE VIEW

FRONT VIEW

- a. javelin/hand path
- b. hip path
- c. C of G path
- d. Rt hip, shoulder, elbow, hand path

OVERHEAD VIEW

- a. Path of javelin
- b. path of C of G (shoulders)
- c. Left arm, shoulder, rt arm and javelin position throughout PP

III. ANGLES

SIDE VIEW

FRONT VIEW

- a. attitude of javelin, last 4 strides
- b. trunk angle, last 4 strides
- c. front leg & knee angle at release
- d. angle of release-javelin
- e. hip/leg angle at release
- f. javelin arm angle in last 4 strides and prior to arm strike

- a. lateral trunk angle at release & when hips are square

OVERHEAD

- a. left arm, shoulder, rt arm, javelin angles
- b. angle of javelin path with respect to straight line through javelin sector

IV. DISTANCES

SIDE VIEW

FRONT VIEW

- a. length of last 4 strides
- b. horiz S of javelin/hand from C of G (hips) at last four contacts & exists of each foot.
- c. length of pull in throwing stance (PP) to release
- d. Horiz S of javelin at release from front foot
- e. height of release
- f. Vertical and horiz travel of C of G (hips) from rt foot ground to release.

- a. S of javelin/hand from head & axis of rotation, throughout & at release
- b. rt foot left foot lateral S in pp
- c. Height of release

OVERHEAD

- a. distances of javelin/hand from axis of rotation or head throughout power position

V. VELOCITIES

SIDE VIEW

FRONT VIEW (not applicable)

- a. velocity of release
- b. Horiz vel of C of G (hips) during
- c. vertical vel of C of G during PP to release

OVERHEAD

- a. velocity of release
- b. angular vel of javelin/hand throughout PP to release

ELITE ATHLETE PROGRAM
USOC
BIOMECHANICAL ANALYSIS (SHOT)

DR. PAUL WARD

3/10/1982

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I. TIMING

(viewing perspective is determined by what is measured)

- a. start to rear foot off.
- b. start to rear foot on. (Middle)
- c. rear foot on to front foot on.
- d. leg drive-both feet on to rear (or front) foot off.
- e. rear foot off to front foot off.
- f. start to both feet on.
- g. both feet on to release.
- h. total time of throw-from start to release.

II. SEGMENT RELATIONSHIPS

SIDE VIEW

- a. shot path
- b. hip path
- d. front foot path
- e. rear foot/shot relationship when rear foot & front foot are on.

OVERHEAD VIEW

- a. shot path
- b. free arm path
- c. position of: shoulder, hip,
- d. rear foot path ???
- e. hip path
- f. C of G path
- g. center of shoulder path
- h. front foot path

III. ANGLES

SIDE VIEW

- a. rear knee, hip & trunk- start
- b. rear knee, hip & trunk-at exit
- c. front knee, hip trunk-at exit
- d. rear knee- lowest point in power position (PP)
- e. front knee-lowest point-PP
- f. angle of release-shot
- g. angle of trunk at release

OVERHEAD VIEW

- a. shoulder/hips at start
- b. should/hips-(PP) both feet on ground.
- c. shoulder/hips when shoulders are square to front
- d. angle of shot path from straight line projected through middle of ring

IV. DISTANCES

SIDE VIEW

- a. from start to release-shot
- b. rear foot from back to center
- c. distance between feet in PP
- d. Height of shot at start
- e. Height of shot at PP lowest position
- f. distance of PP low to release-shot
- g. height of release-shot
- h. distance of vertical hip movement from PP low to release.
- i. horizontal (distance of hips from growing of both feet to release
- j. distance of shot from toeboard at release-horizontal distance
- k. horizontal distance of shot from rear foot PP when both feet are on.

OVERHEAD VIEW

- a. from start to release-shot
 - b. from start to PP-shot
 - c. PP to release-shot
 - d. shot form head throughout PP to release.
 - e. Distance shot from toeboard on release
-
- 1. vertical distance of shot travel from both feet on to release

NOTE: PP = POWER POSITION

BIOMECHANICAL ANALYSIS (SHOT)

V. VELOCITIES

SIDE VIEW

- a. velocity of release
- b. velocity of shot from exit to rear foot ground
- c. velocity of shot from exit to both feet on in PP
- d. Velocity of shot from rear foot on to front foot on
- e. velocity of shot from rear foot on to release
- f. velocity of shot from both feet on in PP to release
- g. velocity of shot from start to PP (both feet on)

OVERHEAD VIEW

- a. velocity of shot from start to rear foot on PP
- b. Velocity of shot from rear foot on to front foot on
- c. velocity of shot from both feet on to release
- e. velocity of release

I. TIMING

(viewing perspective is determined by what is measured)

- a. double leg support (start to rt foot off)
- b. rt foot off to left foot off
- c. start to left foot off- riding time
- d. rt foot off to rt foot on
- e. rt foot off to left foot on
- f. lt foot off to right foot on
- g. lt foot off to lt foot on
- h. right & lt foot on to release (PP) double support to release at front of circle
- i. rt foot on to (rt/left) foot off (PP)
- j. total time - start to release
- k. POWER POSITION- which foot brakes contact first, rt or left?

II. SEGMENT RELATIONSHIPS

SIDE VIEW

- a. discus path
- b. hip path
- d. left foot path
- e. rear foot/hip or C of G/ discus position when rear foot/front foot are on.

OVERHEAD VIEW

- a. discus path
- b. free arm path
- c. rt leg path with respect to C of G or hips in PP

III. ANGLES

SIDE VIEW

- a. trunk angle at exit from back
- b. trunk angle at PP-double support
- c. trunk angle at release
- d. angle of discus projection (release)
- e. Rt & ~~left~~ knee angle in PP
- f. angle (position) of discus when front foot makes contact in PP.
(12 o'clock = back of ring)

OVERHEAD VIEW

- a. shoulder/hip/arm at start
- b. shoulder/hip/arm in PP
- c. shoulder/hip/arm position when hips are square to front
- d. angle(position) of discus when front foot makes contact in PP (12 o'clock = back of ring)
- e. angle of discus from straight line projected through middle of ring after release

IV. DISTANCES

SIDE VIEW

- a. horiz. S of hips from start to release.
- b. S from exit from back to rt foot ground in PP(Hip movement plus rt and lt foot movement)
- c. PP- rt/lt foot distance, throwing base
- d. ht of release
- e. horiz distance of hips in PP to release
- f. vert distance of hip in pp to release
- g. height of discus at release
- h. horiz S of discus from front foot at release (+ or -)

OVERHEAD VIEW

- a. Horiz. S of C of G from start to release
- b. Path of discus (length) from start to release
- c. various S's of discus to axis of rotation-thoughtout

NOTE: PP = POWER POSITION

ELITE ATHLETE PROGRAM (USOC)

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3/10/82

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BIOMECHANICAL ANALYSIS (DISCUS)V. VELOCITIESSIDE VIEW

- a. velocity of release
- b. horiz velocity of C of G (hips)
from exit to PP
- c. Vertical vel. of C of G (hips)
from exit
- d. Horiz. vel. of C of G from PP
- e. Vert. vel. of C of G from PP
to release

OVERHEAD VIEW

- a. angular velocities at various
positions throughout
- b. velocity of release
- c. linear vel. of C of G from
exit to PP
- d. Linear velocity of C of G from
PP to release.
- e. Linear velocity and direction
from start to exit from back

5. Data Collection 5/8/82
6. Data Reduction
7. Data Collection Pepsi Invitational 5/16/82
8. Data Reduction
9. Feedback to Dr. Ward for continued refinement of parameters. Several meetings took place between Dr. Ward and our staff in efforts to develop adequate means of feedback to the athlete. Dr. Ward and our staff met with the athletes on several occasions attempting to explain what we found and seeking feedback from them to further improve our role in this project.

The questions posed to our group at U.C.L.A. are standard biomechanics questions. While our lab has more sophisticated kinetic and 3D kinematic capabilities we chose to analyze and present the data in the most applied way possible. A true challenge to our staff was not the actual calculations but the presentation of information in an understandable form. Dr. Paul Ward and the athletes play a key role in this process since they are the true experts. If we cannot make our findings relevant to the performer we have literally wasted our time. Our goal then is to continue this interaction with the athlete so we understand their needs and they understand what we might be able to provide them.

RESULTS AND DISCUSSION

The results of this study are presented in three sections. Appendix A presents data on the shot put, Appendix B on the discus and Appendix C on the javelin. The following table describes how the data is presented in each section.

Appendix A: Shot Put

Lorna Griffin 3/13/82 Data
 Lorna Griffin 5/8/82 Data
 Discussion of Lorna's Data
 Additional Notes- page to insert additional comments

Dave Laut 3/13/82 Data Conventional Style
 Dave Laut 5/8/82 Data Conventional Style
 Dave Laut 3/13/82 Data Spin Style
 Dave Laut 5/8/82 Data Spin Style
 Discussion of Dave's Data
 Additional Notes- page to insert added comments

Brian Oldfield 3/13/82 Data
 Brian Oldfield 5/8/82 Data
 Discussion of Brian's Data
 Additional Notes- page for added comments

General Discussion of Shot Put
 Literature for the Shot Put

Appendix B: Discus

Lorna Griffin 3/13/82 Data
 Lorna Griffin 5/8/82 Data
 Discussion of Lorna's Data
 Additional Notes- page for added comments

Ben Plucknett 3/13/82 Data
 Ben Plucknett 5/8/82 Data
 Discussion of Ben's Data
 Additional Notes- page for added comments

John Powell 3/13/82 Data
 John Powell 5/8/82 Data
 Discussion of John's Data
 Additional Notes- page for added comments

Mac Wilkins 3/13/82 Data
 Mac Wilkins 5/8/82 Data
 Discussion of Mac's Data
 Additional Notes- page for added comments
 Literature for the Discus

Appendix C: Javelin

Bob Roggy 3/13/82 Data
 Bob Roggy 5/16/82 Data
 Discussion of Bob's Data
 Additional Notes- page for added comments
 Literature for the Javelin

This manner of presentation allows for the continued update of material. While each section has some text describing the interaction of selected variables for each athlete we have only "scratched the surface." The material now needs to be presented to each athlete, discussed and with appropriate feedback developed to more final conclusions. With data tabulated more trials will add validity to any correlations and present a better picture of the performance of each athlete as well as proper technique for each activity. Certainly, with more data a factor analysis might determine which variables are more important. This is one objective our lab will focus on in the future.

Each section has one page devoted to ADDITIONAL NOTES. The intent is to provide an opportunity for coach and athlete to respond to the information presented. They should ask additional questions, make comments and provide further insight to the analysis. Having these notes maintained in each section assures all information on each athlete to be in one text for future references. The literature cited are some of the more recent studies in each event and should serve as a base for future studies to be added. This should further ensure that all information on one activity be maintained in one text.

APPENDIX A

SHOT PUT

LORNA GRIFFIN

3/13/82

NAME: LORNA GRIFFIN

SHOTPUT - TIMING (Seconds)

DATE: 3-13-82



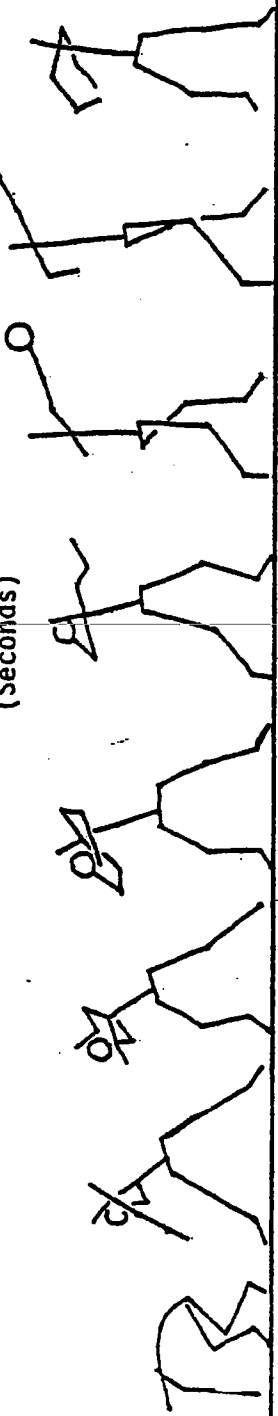
TRIAL	Left Foot OFF	Right Foot OFF	Right Foot ON	Left Foot ON	Right Foot OFF	Left Foot OFF	Right Foot OFF	Left Foot OFF	RELEASE	Right Foot ON	DISTANCE
1	0	.42	.52	.56	.77	—	.80	—	.80	1.10	51'06
2	0	.59	.69	.73	.94	—	.98	—	.98	1.32	53'03
3	0	.29	.39	.40	.57	—	.60	—	.60	.97	54'00
4	0	.58	.68	.76	.95	—	1.00	—	1.00	1.43	54'03
5	0	.54	.64	.70	.93	—	.96	—	.96	1.35	51'08
6	0	.37	.46	.53	.72	—	.75	—	.75	1.22	50'08
7											
8											
9											
10											

NAME: LORNA GRIFFIN

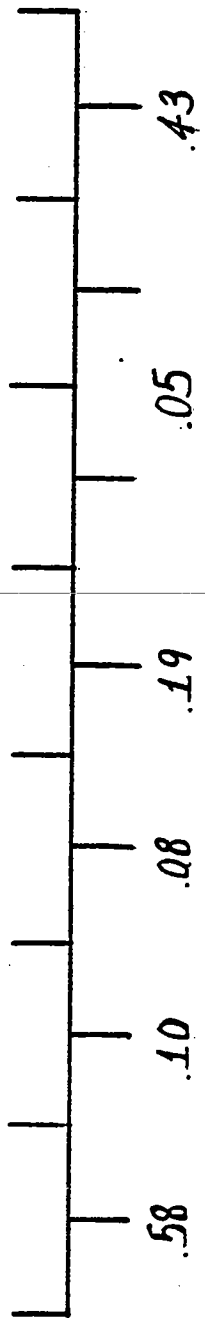
SHOTPUT - TIMING DIFFERENCES

DATE: 3-13-82

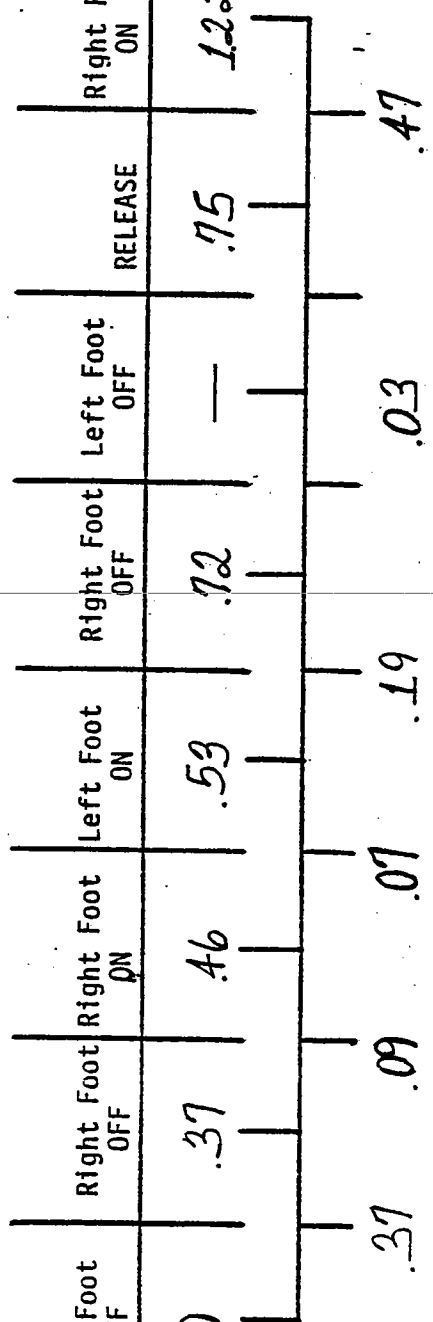
(Seconds)



TRIAL	Left Foot OFF	Right Foot OFF	Right Foot ON	Left Foot ON	Right Foot OFF	Left Foot OFF	RELEASE	Right Foot ON	DISTANCE
BEST	0	.58	.68	.76	.95	—	1.00	1.43	54'03



TRIAL	Left Foot OFF	Right Foot OFF	Right Foot ON	Left Foot ON	Right Foot OFF	Left Foot OFF	RELEASE	Right Foot ON	DISTANCE
WORST	0	.37	.46	.53	.72	—	.75	1.22	50'08



NAME: Lorna Griffin

SHOT ANGLES

DATE 3/13/82

(Degrees)

	BEST	WORST
<u>SIDEVIEW</u> (Reference to Right Horizontal)	(<u>54'03"</u>)	(<u>50'08"</u>)
1. Left knee		
A) Start	<u>96.05</u>	<u>81.09°</u>
2. Trunk Angles		
A) Start	<u>145.31</u>	<u>148.48</u>
B) Exit	<u>132.18</u>	<u>132.90</u>
C) Power position	<u>118.19</u>	<u>115.75</u>
D) Release	<u>85.73</u>	<u>93.50</u>
3. Shot Projection angle	<u>36.55</u>	<u>36.60</u>
<u>OVERHEAD</u> (Reference to right horizontal)		
1. Shoulders		
A) Start	<u>86.49</u>	<u>82.89</u>
B) Power Position	<u>126.65</u>	<u>118.56</u>
C) Shoulders Square	<u>88.53</u>	<u>90.34</u>
2. Hips		
A) Start	<u>88.12</u>	<u>85.60</u>
B) Power Position	<u>150.13</u>	<u>136.46</u>
C) Shoulders Square	<u>51.09</u>	<u>-</u>
3. Shot Projection angle. (Reference to Left horizontal)	<u>12.72</u>	<u>14.20</u>

NAME: Lorna Griffin

SHOT DISTANCES
(Feet)

DATE: 3/13/82

OVERHEAD

BEST
(54' 03")

WORST
(50' 08")

1. Distance of shot travel:

A. Start to Power Position

3.73

3.26

B. Power Position to Release

5.41

5.72

C. Start to Release

9.12

8.89

2. Distance of shot to
inside of toe board

+ .77

+ .77

3. Horizontal distance of shot to
center of head

Position: A. Release

2.13 (0 s)

1.88 (0s)

B.

1.79 (.03s)

1.50 (.04s)

C.

1.59 (.07s)

1.39 (.08s)

D.

1.08 (.11 s)

.90 (.12s)

E.

.41 (.15 s)

.34 (.16s)

NAME: Lorna Griffin

SHOT DISTANCES
(Feet)

DATE: 3/13/82

SIDEVIEW

BEST

WORST

(54'03")

(50'08")

1. Height of shot:

A) Start

2.97

2.94

B) Power Position

3.88

3.94

C) Release

6.82

6.65

2. Horizontal distance of shot:

A) Start to Power Position

3.30

3.65

B) Power Position to Release

4.49

4.41

C) Start to Release

7.79

8.06

3. Horizontal distance of shot

To Inside of Toe board at release

(+ = In front of Inside of Toe Board)

+ .06

-.43

4. Horizontal distance of shot

to rear foot in Power Position

(+ = In front of Rear foot)

-.14

+.52

5. Distance between feet in Power Position

3.99

3.94

6. Distance of Center of hips from
Power Position to Release:

A) Horizontal

.88

.85

B) Vertical

.62

.65

7. Distance of rear foot from start
to Power Positon

2.17

2.24

