Throwing Techniques for Ultimate Frisbee

Evan Winograd, Jack R. Engsberg

Abstract

The goal of this study was to determine if certain throwing techniques for the sport of Ultimate Frisbee were advantageous relative to other techniques. The defense can attempt to force a thrower to utilize a specific throw; knowing the advantages of different throws can influence a defender’s decision to force the thrower to use a certain throw.

Motion capture was used to monitor the flight of a disc (Discraft Ultrastar 175g) for three throwing techniques. The two main groups of throws were backhand (BH) and forehand (FH) throws, with the forehand throws divided into a closed forehand grip (CF) and a split forehand grip (SF). Sixteen participants were recruited with experience ranging from 3 years to 8 years based on survey. Throws were analyzed with regards to linear velocity, angular velocity, precession, and accuracy. Players threw a total of 45 throws: five throws for all combinations of the three throwing techniques combined with three objectives: accuracy, maximum spin, and maximum velocity. The order of the nine throwing groups was randomized.

Throws were analyzed for linear velocity, angular velocity, precession, and accuracy. Linear velocity was calculated by measuring the distance traveled in the first 0.02 seconds of flight, and angular velocity was measured by calculating the time required for four unique points on the disc to complete one rotation. Precession was measured by calculating the average angular deviation from the average normal plane of the disc, and accuracy was measured by the distance between the center of the disc and the target at closest approach using a quadratic fit to the known flight path.

There was a very strong linear correlation between linear velocity and angular velocity. There was no difference in linear velocity between backhand and forehand throws, although the closed grip forehand had a higher linear velocity than the split grip forehand. Backhand throws had higher angular velocities than forehand throws for a given speed; there was no difference in angular velocity between closed grip and split grip forehand throws. Backhand throws had less precession than forehand throws, and there was no difference in precession between closed grip and split grip forehand throws. There were no statistically significant differences in accuracy between any of the throws.

These results show that backhand throws tend to have more spin and wobble less making the backhand a superior throw. Throws with less spin have greater instability; as a defender, forcing the thrower to utilize a forehand throw would result in a throw with less stability than a backhand throw. Forehand throws did not perform better than backhand throws for any category tested.

Additionally, new players are often taught that the split-grip forehand is a bad throw, and that the closed-grip forehand should be used instead. The results show that the split-grip forehand performs on par with the closed-grip forehand with the exception of maximum velocity. New players should not be discouraged from using a split-grip forehand while learning the mechanics of the forehand, as the only disadvantage is a slight decrease in maximum velocity.

Key Words: Forehand, Backhand, Flick, Frisbee

Introduction

In the sport of Ultimate Frisbee, players use two primary throws: backhand and forehand. My hypothesis, from personal experience, is that backhand throws will wobble less, have less spin, be
more accurate, and travel faster than forehand throws. The aim of this study was to determine if one throw had a comparative advantage with respect to linear velocity, angular velocity, precession, and accuracy. Also, the split-grip forehand is often thought of as an inferior throw relative to the closed-grip forehand. The closed-grip forehand is expected to outperform the split grip forehand.

Players must be able to utilize both throws as the defenders can force players to throw one way or the other by positioning their bodies on a certain side of the thrower. As a defender, knowing advantages and disadvantages of each throw can factor into defensive strategies to increase the chances of a disc being thrown with sub-optimal flight characteristics as a result of differing throwing techniques. This may cause a higher incidence of turnovers due to incomplete passes.

Previous research has shown that a disc thrown with less angular velocity will result in a throw with less stability (1). Therefore, whichever throw has higher angular velocities will be the more stable throw and will be more likely to reduce turnovers. The angular velocity of a disc in flight does not have a significant effect on lift and drag coefficients (2).

Methods

Participants

Participants were recruited by open invitation to the St. Louis Ultimate Association and both the Washington University in St. Louis men’s and women’s club ultimate teams. Participants completed a questionnaire to determine experience and skill level. The skill level was a ten point scale with 1=Beginner, 4=Recreational, 7=Competitive college, and 10=Elite. Of the participants, 5 were placed in the ‘elite’ category and 11 were placed in the ‘non-elite’ category. Experience was divided into seven categories: 0-1 years, 1-2 years, 2-4 years, 4-5 years, 5-8 years, 8-15 years, and 15+ years (see Table 1). No participants were excluded from the study and all participants performed the same number of each test.

Testing occurred at the Washington University School of Medicine Human Performance Lab after the participant signed the IRB-approved informed consent form. No financial compensation was provided for participating in the study.

Data Collection

Data were collected using a Motion Analysis system consisting of six high-speed Eagle Digital Cameras at 250 Hz and Cortex software. Three cameras were located above and behind the thrower (relative to the direction of the throw) with one camera directly behind the thrower, and the other two cameras located a couple meters to either side. These cameras were focused on the latter portion of the throw. The other three cameras were located in the same arrangement, but above the target, and focused on the volume around the thrower. This set up provided the largest capture volume so the throw would be in view of at least two cameras at all times. Seven reflective markers were used. One marker was placed on the thumbnail of the throwing hand with one marker in the center of the disc and three markers placed approximately five inches from the center marker in a triangular formation. Additionally, one marker was placed adjacent to one of the perimeter markers to provide an asymmetric model. The final marker was placed on a target, used to evaluate accuracy. Participants stood approximately 2.5 meters from the target and net. Participants threw 45 total throws consisting of nine categories: Backhand Accuracy (BHA), Backhand Spin (BHS), Backhand Velocity (BHV), Closed Forehand Accuracy (CFA), Closed Forehand Spin (CFS), Closed Forehand Velocity (CFV), Split Forehand Accuracy (SFA), Split Forehand Spin (SFS), and Split Forehand Velocity (SF_V). The order was randomized for each participant prior to data collection. For each category, participants had two practice throws followed by three throws, which were used for analysis.

Variables
The following variables were calculated: linear velocity, angular velocity, precession, and accuracy. For each throw, data processing began when the marker on the disc closest to the thumb marker was 0.3 meters away from the thumb marker indicating the disc had left the thrower’s hand. Linear velocity was calculated by computing the distance traveled over the first 0.02 seconds (5 frames). Angular velocity was calculated by tracking the time required for five different pairs of markers to complete one cycle. A cycle began when one marker’s y-coordinate crossed the other marker’s y-coordinate. The cycle ends after the first marker’s y-coordinate crosses the second marker’s y-coordinate twice. The angular velocity was calculated by averaging the times for each of the five pairs. Precession was calculated by calculating the average angular deviation from the average plane of the disc. The angles were calculated by taking the cross product of two vectors defined by two of the perimeter markers and the center marker. Accuracy was calculated by measuring the closest approach of the projected flight path to the center of the target. The flight path projection was calculated using a quadratic fit to the known flight path.

**Statistical Analysis**

The data were analyzed using SPSS Statistics® and Microsoft Excel®. Two sample paired t-tests were used to compare different throws and two sample t-tests (assuming equal variance) were used to compare elite vs. non-elite players. The significant threshold employed was \( p < 0.05 \). Regression analysis was used to determine whether correlations existed between linear velocity and both angular velocity and precession. Since angular velocity varied by linear velocity, the ratio of angular velocity to linear velocity was used to determine which throw achieved the highest angular velocities.

**Results**

**Elite vs. Non-Elite**

The only difference found between elite and non-elite players was the maximum speed of throws: elite players had higher maximum velocities than non-elite players. There was no difference in accuracy, precession, or angular velocity to linear velocity ratios. With the exception of maximum velocity, no differences were found between elite and non-elite players; as a result, throw comparisons included both elite and non-elite players (see Table 2).

**Throw Comparison**

No significant differences were found between backhand and closed grip forehand or backhand and split grip forehand velocities. Closed grip forehands were found to have higher maximum velocities than split grip forehands. Backhand throws had an average maximum velocity of 20.1 m/s, closed grip forehand throws had an average maximum velocity of 20.6 m/s, and split grip forehands had an average maximum velocity of 19.2 m/s.

Backhand throws were found to have a higher angular velocity / linear velocity ratio than both closed grip and split grip forehands by more than 4 RPM per meter per second. No differences were found in the angular velocity / linear velocity ratio for closed grip forehands vs. split grip forehands (see Figure 1).

When participants were instructed to throw for maximum spin, throws were found to have higher angular velocity to linear velocity ratios than throws for accuracy and velocity; differences of greater than 5.5 RPM per meter per second were found for all three grips (see Table 3).

No correlation was found between velocity and precession.

No differences were found in accuracy for backhand, closed grip forehand, or split grip forehand throws, with average distances varying by less than 0.03 meters (1.25 inches). Backhand throws were
found to have less precession than both closed grip forehands and split grip forehands by more than 35%. No differences were found between closed grip forehands and split grip forehands (see Figure 2).

Strong linear correlations were found between angular velocity and linear velocity when considering throws for maximum velocity and accuracy. Values of greater than 0.9 were found for all three categories.

Discussion
This study has limits that should be taken into consideration. First of all, several of the subjects have learned their throwing techniques from the same group of players, so certain efficiencies or inefficiencies in technique may affect results. Secondly, all participants use a closed-grip forehand; closed-grip forehand throws have been practiced by the participants, whereas split-grip forehand throws have not been practiced. Additionally, participants were throwing in a room with expensive equipment; participants may have altered their throws to ensure they hit the net. Accuracy data may have been inconclusive because the target was located 2-3 meters from the thrower. Also, certain throws may be more accurate for shorter distances and less accurate for longer distances. Limitations of being in a confined space may have prevented any significant results related to accuracy. The cameras also had a difficult time of tracking the higher velocity throws (18+ m/s). As a result, flight paths had to be reconstructed from partial data.

Backhand throws appear to be superior to forehand throws due to the higher angular velocity (see Figure 1) and less precession (see Figure 2) than forehand throws. Morrison found that angular velocity increases the stability of the disc (1) as the angular momentum provides gyroscopic stability, so backhand throws should be more stable than forehand throws. There were no differences in maximum linear velocity or accuracy between backhand and forehand throws. The only difference between the two forehand throws was that closed-grip forehands were thrown faster than split-grip forehands (see Table 3). There were no differences in the angular velocity to linear velocity ratio, precession, or accuracy for split-grip and closed-grip forehands.

Angular velocity can be predicted accurately by knowing linear velocity and intent of throw (maximum linear velocity, angular velocity, or accuracy). No predictors of precession were found in the study.

No previous studies have compared flight characteristics of forehand and backhand throws.

Conclusion
Based on the results obtained, it would be advantageous to force the opposing team to throw forehand throws. Doing so results in throws with less stability as a result of less angular momentum, and more precession. It is possible that lower angular velocity and higher precession could lead to a decrease in distance traveled and stability. Additionally, higher precession values could expose the disc to more drag, causing the wind to affect the throw more.

Based on the results for forehand throws, the only advantage to throwing with a closed grip is the maximum attainable velocity. By using a closed grip, participants did not show any improvement in angular velocity or precession. Thus, the only instance where a closed-grip forehand is advantageous relative to a split-grip forehand is when a player is trying to throw for distance.

The hypothesis that backhand throws would wobble less was shown to be true and that backhand throws would have less spin was shown to be false. The hypotheses that backhand throws would be more accurate and travel faster were not supported by any results.

Overall, it appears that it would be advantageous to force the offense to throw more forehand throws than backhand throws and new players should not be discouraged from learning to throw a split-grip forehand while learning throwing mechanics.
Applications In Sport

From a strategic standpoint, teams can change defensive strategies to force the opposition to use an inferior throw. Additionally, new players can be taught advantages and disadvantages of different grips. New players are often taught that the split-grip forehand is inferior to the closed-grip forehand, although the only disadvantage of the split-grip forehand is the maximum speed of the throw. For new players, if the split-grip is more comfortable than the closed grip, they will achieve the same angular velocity and precession as a closed-grip throw.

Acknowledgements

I would like to sincerely thank Dr. Jack Engsberg for making this research possible. He welcomed my research proposal with open arms, having nothing to gain from the study. Jack has a true passion for helping others and I am extremely fortunate to be one of the many persons he has helped. He has guided me through every step of the research process offering invaluable advice along the way. Jack, thank you for being an amazing mentor and great friend.

REFERENCES


TABLES

Table 1

Participant Survey

<table>
<thead>
<tr>
<th>Age</th>
<th>Years Played</th>
<th>Skill Level</th>
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<tr>
<td>22</td>
<td>4.6</td>
<td>8.1</td>
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<tr>
<td>(1.9)</td>
<td>(2.5)</td>
<td>(1.2)</td>
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*Note:* Standard Deviations appear in parentheses below the means.

Table 2

Comparison of Elite and Non-Elite Players

<table>
<thead>
<tr>
<th></th>
<th>BH</th>
<th></th>
<th>FH</th>
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<tbody>
<tr>
<td></td>
<td>Elite</td>
<td>Non-Elite</td>
<td>Elite</td>
<td>Non-Elite</td>
</tr>
<tr>
<td>Maximum Velocity (m/s)</td>
<td>21.2 (3.0)**</td>
<td>17.7 (2.4)</td>
<td>20.7 (2.7)**</td>
<td>18.3 (1.5)</td>
</tr>
<tr>
<td>Accuracy (m)</td>
<td>0.24 (0.13)</td>
<td>0.33 (0.15)</td>
<td>0.25 (0.20)</td>
<td>0.32 (0.19)</td>
</tr>
<tr>
<td>Precession (degrees)</td>
<td>2.3 (1.5)</td>
<td>2.6 (1.1)</td>
<td>3.8 (2.0)</td>
<td>3.7 (1.8)</td>
</tr>
<tr>
<td>Angular Velocity to Linear Velocity Ratio (RPM per m/s)</td>
<td>44.1 (9.7)</td>
<td>48.0 (6.9)</td>
<td>38.9 (6.5)</td>
<td>38.1 (6.2)</td>
</tr>
</tbody>
</table>

*Note:* BH is backhand, FH is forehand.

** Denotes significantly different from non-elite (p < 0.05)
### Throw Comparison

<table>
<thead>
<tr>
<th></th>
<th>BH</th>
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<th>CF</th>
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<th>SF</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>V</td>
<td>S</td>
<td>A</td>
<td>V</td>
<td>S</td>
</tr>
<tr>
<td><strong>Maximum Velocity (m/s)</strong></td>
<td>—</td>
<td>20.1 (3.2)</td>
<td>—</td>
<td>20.6 (2.6)^</td>
<td>—</td>
<td>19.2 (2.5)**</td>
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<tr>
<td><strong>Accuracy (m)</strong></td>
<td>0.30 (0.14)</td>
<td>—</td>
<td>—</td>
<td>0.28 (0.18)</td>
<td>—</td>
<td>0.27 (0.21)</td>
</tr>
<tr>
<td><strong>Precession (degrees)</strong></td>
<td>—</td>
<td>2.4 (1.3)**</td>
<td>^</td>
<td>—</td>
<td>3.7 (1.7)</td>
<td>—</td>
</tr>
<tr>
<td><strong>Angular Velocity to Linear Velocity Ratio (RPM per m/s)</strong></td>
<td>40.2 (3.4)^</td>
<td>40.4 (2.9)^</td>
<td>47.8 (11.5)^</td>
<td>36.5 (3.1)‡</td>
<td>34.8 (2.1)‡</td>
<td>43.8 (11.3)†</td>
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<tr>
<td></td>
<td>—</td>
<td>42.8 (7.9)**</td>
<td>^</td>
<td>—</td>
<td>38.4 (7.8)</td>
<td>—</td>
</tr>
</tbody>
</table>

**Note:** BH is backhand, CF is closed grip forehand, and SF is split grip forehand. A is accuracy, V is velocity, and S is spin.

**Denotes significantly different from CF (p<0.05), ^ Denotes significantly different from SF (p<0.05)**

† Denotes significantly different from V (p<0.05)
‡ Denotes significantly different from S (p<0.05)

### Figures

**Figure 1**

Graph of Angular Velocity vs. Linear Velocity

![Angular Velocity vs. Linear Velocity](image)

**Figure 2**

Graph of Precession vs. Linear Velocity
Corresponding Author
Jack R. Engsberg, PhD
Washington University School of Medicine: Human Performance Laboratory
4444 Forest Park, Campus Box 8505
St. Louis, MO 63108
engsbergj@wustl.edu
314 - 286 - 1632

Main Author
Evan Winograd
Washington University School of Engineering and Applied Science
6985 Snow Way Drive Box 6861
St. Louis, MO 63130
ewinograd@go.wustl.edu
713-805-8609

Author Bios

Evan Winograd
Evan Winograd is an undergraduate student studying Mechanical Engineering at the Washington University in St. Louis School of Engineering and Applied Science.

Jack Engsberg
Jack Engsberg is a Professor of Occupational Therapy and Neurosurgery at Washington University School of Medicine in St. Louis. His work in the Human Performance Laboratory focuses on rehabilitation for persons with disabilities including cerebral palsy, stroke, scoliosis, spinal deformity, spinal cord injuries, and amputations using high-speed motion capture systems, force plates, electromyography, and an isokinetic dynamometer.