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EMG Activation of the Upper Extremity During a Standing Backhand Disc Golf Throw

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Abstract

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Introduction: Disc golf is a sport that has grown increasingly popular in recent years. However, there is a lack of research pertaining to electromyography in a disc throw. **Purpose**: To analyze the muscle activation of upper body musculature during a standing backhand disc golf throw. **Methods**: Five male recreational disc golf players performed a maximal effort standing backhand disc golf throw with EMG electrodes placed on the posterior deltoid, extensor carpi ulnaris (ECU), and triceps brachii. The subjects performed a standardized warm-up prior to testing. The subjects completed five maximum effort throws using the same disc while resting 60 seconds between each trial. The mean activation, peak activation, and time to peak activation were measured. **Results:** The primary outcome of this study was the timing of peak muscle activation occurring first in the triceps brachii (15.6$\pm$11.0%), followed by the ECU (21.3$\pm$12.1%) and the posterior deltoid (50.3$\pm$18.1%). **Conclusion**: The timing of a disc golf throw is critical, these data suggest coaches and sport participants should consider movement efficacy when throwing a disc. Further, poor between-subjects reliability indicated the varying techniques individuals have during a disc golf throw.

Review of Literature

Disc golf has emerged as a highly popular recreational and competitive sport that combines elements of traditional golf with the enjoyable activity of throwing discs (Gregoire et al., 2020). Players compete by throwing discs from designated tee areas toward a target, typically metal baskets, aiming to complete each hole within the fewest possible throws. Disc golf courses are typically built in natural environments, incorporating diverse terrains and obstacles to provide an engaging and challenging experience.

The roots of disc golf are difficult to be traced back to a certain point in time but some of the earliest documentations of play date back to the 1960s when a man named George Sappenfield and his colleague Kevin Donnelly, both recreation class instructors out of California, thought the youth they worked with would enjoy playing golf via frisbees (PDGA, n.d.). The two would eventually push for disc golf tournaments across the nation and were a huge part of disc golf becoming a sanctioned sport in 1974. The PDGA was founded in 1976 as the sport's governing body, validating and facilitating its subsequent growth. The PDGA played a crucial role in standardizing the rules and scoring system of disc golf, contributing to its broader recognition as a sanctioned sport.

The first official disc golf course was created in 1975 in Pasadena, California by the professional disc golfer “Steady” Ed Headrick who is hailed as the “Father of Disc Golf” (Gregoire et al., 2020). Ed was an executive at the frisbee company Wham-O when he decided to include disc golf in Wham-O’s 1975 World Frisbee Championships, and it ended up being a hit. This event marked a significant milestone in the history of disc golf, highlighting its potential as a competitive and engaging sport. With the growing interest and participation in disc golf, tournaments and competitions started to emerge throughout the United States.

Disc golf has experienced substantial growth and development over the last several decades, especially at the time of writing, seeing a 13% increase in the total number of courses over the year 2021 (UDisc, 2023). The number of disc golf courses worldwide has expanded significantly, offering a variety of challenging and enjoyable playing environments for players of all skill levels. As of 2022, there are over 14,000 disc golf courses worldwide (UDisc, 2023). The sport has also gained increased media exposure, with televised tournaments and the emergence of professional players who have helped raise awareness of the sport. In the present day, disc golf thrives as both a recreational pastime and a competitive sport, supported by a wide community of pros and enthusiasts.

The progression from casual frisbee throwing to the establishment of disc golf as its own distinct and organized sport represents a milestone in its evolution. Early enthusiasts of frisbee play recognized the potential for competitive engagement and began adapting the principles of traditional golf to their frisbee throwing activities (Gregoire et al., 2020). This transition involved the introduction of designated targets, such as utility poles, to serve as focal points for accuracy and distance challenges (Bauerlein, 2022). Ed Headrick patented the "Disc Golf Pole Hole" in 1975 to avoid disputes in whether or not a disc hit a pole, the pole included an elevated metal basket with a hanging ring of chains, these baskets are what are currently used in today's games. Concurrently, the development of specialized discs designed for disc golf, not just ultimate frisbee, played a crucial role in the sport's advancement. Early frisbees were modified to cater to the demands of disc golf, leading to the creation of discs with diverse flight characteristics and specific usage purposes.

Discs designed as drivers, mid-range discs, and putters offer players a range of options to optimize their throws in terms of distance, accuracy, and control (Immonen, 2021). Drivers are designed for long-distance throws and have a sharp edge and a streamlined profile to maximize distance. They come in various stability ratings, with under stable drivers having a tendency to turn right for right-handed throwers, while stable or over stable drivers exhibit less turning in flight. Mid-range discs offer versatility and are suitable for accurate throws at moderate distances. With slightly larger diameters than drivers, mid-range discs provide stability and control during flight, making them useful for approach shots and shorter drives. Putters, on the other hand, are designed for short-distance and precision shots, especially for the final throws to land the disc in the target. They feature a blunt edge and shallow rim, allowing for a slow and controlled flight. Putters offer superior accuracy and control, making them an excellent choice for precise putting and short approach shots. To excel in disc golf, players must have a thorough understanding of the characteristics and flight patterns of different discs. This knowledge enables them to choose the appropriate disc for specific situations, considering factors such as distance, wind conditions, and desired flight characteristics.

The design of disc golf courses, often involving walking or hiking while navigating the course, adds an element of physical activity similar to walking or light hiking, providing players with an enjoyable way of staying physically active. When playing disc golf, the players engage various muscle groups, including both lower and upper extremities, through the act of throwing the discs. Disc golf throwing performance is likely linked to muscular parameters, however, without direct evidence describing the involvement of various musculature in disc golf, definitive statements cannot be made.

Moreover, disc golf provides players with an opportunity to engage in regular physical activity in an enjoyable and social setting (Bauerlein, 2022). Unlike traditional gym workouts or solitary exercises, disc golf combines physical exertion with recreational play, making it an appealing option for those seeking an alternative to traditional fitness routines. The social aspect of disc golf, such as playing with friends or participating in tournaments, can also serve as a motivating factor for participants to maintain an active lifestyle.

Basic Mechanics of Throwing

Effective body positioning is essential for generating optimal throwing power and accuracy in disc golf. To achieve this, the throwing motion is divided into three phases: 1) wind-up 2) acceleration and 3) follow-through (Hummel, 2003). Due to lack of research on the biomechanics of a disc golf throw, we will describe the typical run-up throw of a right-handed frisbee player. During wind-up, the players torso will twist away from the target to the left. The thrower then shifts their weight onto the left foot and allows the arm to adduct horizontally, drawing the disc towards the torso, whilst the forearm flexes and having the wrist curl around the disc. Upon reaching the maximum amount of desired rotation of the torso to the left the acceleration phase begins. The torso will begin to twist right and weight will shift to the right foot. It is during this phase that the maximum ranges of torso left rotation, elbow flexion, wrist flexion, and shoulder adduction occur. Upon release of the Frisbee, the torso tilts forward, the humerus and torso x axes are almost aligned, and the arm is externally rotating at the shoulder. The forearm pronates and the elbow extends but not fully. The wrist however will fully extend. Phase three of follow-through is completed when maximum right twist of the torso is achieved. Due to the above information, it can be inferred that a standing backhand throw will be mechanically similar, minus much of the lower-body movement. It can be hypothesized that the legs will stand still and there will remain some twisting of the torso, but less than that in a run-up throw due to players wanting to produce less force in a standing throw.

The most common throw in disc golf is the backhand throw (Bocks, 2019). In a backhand throw, the thumb is placed on the top surface of the disc, while the other fingers grip the bottom of the disc to provide support (Straková, 2006). There are three main variations of this grip that players use based on desired outcome and personal preference. The first being “Single-Finger”, where the index finger touches the outer rim of the disc. This variation provides for great control during the drive and release but does not provide as much force as the other methods. It can be particularly useful when throwing from a high position, such as on top of a hill. The next variation is called “Split-Fingers”, the index finger is again placed on the outer rim but this time with the remaining fingers spread apart to produce more power. The last variation is the “Power Grip”, where all the fingers on the bottom of the disc are curled close to each other in order to grasp the edge of the disc. This allows for the maximum amount of force to be applied and is typically used for long distance throws.

Measurements of EMG in Throwing Sports/Tasks

Researchers have extensively studied EMG patterns in upper body muscles during various throwing motions in sports such as baseball, but much remains untouched in the area of disc golf. By uncovering more research in the area of disc golf, this can allow researchers and players to improve their training methods and studies in regard to this ever-growing sport. The backhand groundstroke in tennis is similar biomechanically to a backhand disc golf throw, so it would be fair to assume some of the same musculature is activated, but without specific research this cannot be certain. A backhand groundstroke shows most of its EMG activation coming from the supraspinatus, infraspinatus, and middle deltoid muscles (Ryu et al., 1988). With a smaller amount of activity being produced in the latissimus dorsi, subscapularis, pectoralis major, and serratus anterior muscles.

The purpose of this study was to perform a preliminary assessment of upper extremity muscle activation during a backhand disc golf throw.

Methodology

Subjects

Five male recreational disc golf players (height (cm) = 177.86±3.3; weight (kg) = 88.76±11.3) with no known upper body trunk issues or disorders were studied in the Exercise Science laboratory at East Tennessee State University, Johnson City, Tennessee. All subjects signed informed consent in accordance with the University Institutional Review Board.

Procedures

Each participant performed a standardized warm-up consisting of 5 minutes on a stationary bike, 10 body weight squats, 30 seconds each of forward and backward arm swings, and 5 sub-maximal disc throws. All of the subjects performed a backhand disc throw using the "Power" grip for 5 total trials while resting 60 seconds between each trial.

Testing was performed inside the Exercise Science laboratory. The skin was prepared using an abrasive material and alcohol pad then surface electrodes were placed on the muscles. Surface electromyography was recorded from the posterior deltoid, extensor carpi ulnaris, and triceps brachii (Delsys, Boston, MA, USA). The Delsys Trigno sensors were placed in accordance with SENIAM guidelines. EMG data were collected at 2kH sampling rate. Raw EMG data was processed by amplifying the signal x1000, in addition to full wave rectification and a root mean square smoothing calculation. An additional Trigno sensor was fixed on the wrist of the throwing arm to be used as an accelerometer for the determination of the start-point of the movement. The EMG envelope was normalized based on this acceleration data, and the beginning of the movement was defined as the point when backwards (y-direction) acceleration increased from baseline. The time-normalization process considered each movement on a scale of 0-100% duration. Variables considered were mean activation (mV), peak activation (mV), and time to peak activation (%) of each muscle.

The throw was divided into three phases: wind-up, acceleration, and follow-through. Stage I, the wind-up stage, is characterized by shoulder abduction, extension, and early external rotation in concert with lateral trunk flexion and trunk lower extremity rotation. Stage II, the acceleration phase, begins with internal rotation of the shoulder and continues until release of the disc. Rapid and forceful shoulder adduction and elbow extension drive the movement. Stage III, follow-through, starts at the end of elbow flexion and ends with the release of the disc from the fingers.

Statistical Analysis

Descriptive data (mean + SD) were calculated for all dependent variables. For this analysis, within subject and between subject reliability was assessed using intraclass correlation coefficient (ICC) and coefficient of variation (CV). ICC was deemed acceptable when the coefficient exceeded 0.8. Further interpretation of between subjects data was considered after calculating the mean of all 5 trials for each subject.

Results

Descriptive data are represented in Table 1. Within subject reliability indicated large ICC values (0.96 to 1), while CV values indicated poor to moderate reliability (Table 2). Between subject reliability indicated small ICC values (0.07 to 0.62) along with large CV values (Table 3).

Considering time to peak activation, subjects achieved peak activation of the triceps brachii first, on average. This occurred at 15.6±11.0% of the total movement duration. The extensor carpi ulnaris was the next muscle to achieve peak activation, occurring at 21.3±12.1% of the total movement duration. Posterior deltoid peak activation occurred at the latest point in the movement cycle, achieving peak activation at 50.3±18.1% of the total movement duration.

Table 1. EMG Descriptive Data (mean ± SD)

	Mean Activation (mV)			Peak Activation (mv)			Time to Peak Activation (%)		
Posterior Deltoid	0.123	±	0.124	0.313	±	0.236	50.3%	±	18.1%
Triceps Brachii	0.090	±	0.045	0.256	±	0.118	15.6%	±	11.0%
Extensor Carpi Ulnaris	0.093	±	0.040	0.422	±	0.318	21.3%	±	12.1%

Table 2. Within-Subjects Reliability

	Posterior Deltoid		Triceps Brachii		Extensor Carpi Ulnaris	
	ICC	**CV (%)**	**ICC**	**CV (%)**	**ICC**	**CV (%)**
Mean Activation (mV)	1	15.2%	1	9.1%	0.96	17.0%
Peak Activation (mV)	1	12.8%	0.99	13.9%	1	21.3%
Time to Peak Activation (%)	0.98	15.2%	0.98	26.7%	0.98	19.1%

Table 3. Between-Subjects Reliability

	Posterior Deltoid		Triceps Brachii		Extensor Carpi Ulnaris	
	ICC	**CV (%)**	**ICC**	**CV (%)**	**ICC**	**CV (%)**
Mean Activation (mV)	0.14	100.4%	0.35	50.3%	0.07	43.1%
Peak Activation (mV)	0.31	75.2%	0.03	46.0%	0.11	75.3%
Time to Peak Activation (%)	0.1	36.0%	0.16	70.4%	0.62	56.9%

Discussion

In regard to the timing of movement, it was originally hypothesized that the time to peak activation of the tested muscles would go in the order of the posterior deltoid, triceps brachii, then extensor carpi ulnaris. The result of this investigation (Table 1) indicated the triceps brachii, extensor carpi ulnaris, then posterior deltoid reached time to peak activation in said order. In retrospect, this pattern of time to peak activation makes more sense taking in consideration the external rotation of the shoulder on the follow-through section of the movement.

With little research having been performed on EMG activity in disc golf, it is difficult to compare the findings in this study to other research. However, looking at a similar sporting movement, the baseball bat swing, it is interesting to take note that one study shows the posterior deltoid reaching peak activation in the pre-swing portion of the movement followed by the triceps brachii reaching peak activation later on in the movement (Escamilla, 2009). This is in contrast to the data seen in Table 1 where the triceps brachii reaches peak activation first. Further, this may indicate that the backhand disc golf throw is unique to other similar sporting movements, therefore necessitating further investigation.

This preliminary investigation could help provide other researchers with information to consider when performing future studies on disc golf. The data collected in this preliminary investigation is limited by the small sample size and skill level of the participants. Future studies could take into consideration using a larger sample size and a way to gauge player skill level, such as a PDGA ranking. It could also be beneficial to study the difference in time to peak, mean, and peak activation between subjects that are recreational players vs. players with a pro ranking to see if there is any difference. Another limitation of the study was only including EMG data, without contextual kinetic and kinematic variables. Future research should consider incorporating these factors into the movement analysis.

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