ABSTRACT

THE EFFECTS OF TARGET DISTANCE ON KINEMATIC SEQUENCE OF THE APPROACH SHOT IN MALE COLLEGIATE GOLFERS

by Tess G. McGuire

The primary purpose of this study was to collect comprehensive data on 3D biomechanical variables of the approach swing at four target distances in college-aged, male golfers. Participants were instructed to hit five successful shots at each target distance: 30 yards, 50 yards, 70 yards, and full swing (maximal distance) yardage. A motion capture system recorded kinematic and temporal parameters of golfer movement, additional to a golf simulator that collected ball carry distance of each shot. Distance did have a significant ($p \leq 0.05$) effect on swing phase timing, angular velocities, and motion sequencing. Movement sequencing within the approach shot displayed irregular patterns across all distances and phases, with partial PDS (pelvis → shoulder girdle → arms → club) at best. The approach swing did present its own unique motion patterns that will require practice as its own skill.

THE EFFECTS OF TARGET DISTANCE ON KINEMATIC SEQUENCE OF THE APPROACH SHOT IN MALE COLLEGIATE GOLFERS

A Thesis

Submitted to the

Faculty of Miami University

in partial fulfillment of

the requirements for the degree of

Master of Science

by

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Miami University

Oxford, Ohio

2022

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This Thesis titled

THE EFFECTS OF TARGET DISTANCE ON KINEMATIC SEQUENCE OF THE APPROACH SHOT IN MALE COLLEGIATE GOLFERS

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Has been approved for publication by

The College of Education, Health and Society

and

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Table of Contents

List of Tables

List of Figures

Acknowledgements

This thesis would not be possible without the guidance and support from many individuals. Thank you to Dr. Walsh, my advisor and committee chair, for your continued dedication to my development. The time you have invested in me, from weekly meetings to long weekends in the lab, is deeply appreciated and created an environment of professional growth in my graduate experience. I also want to thank Dr. Smith and Dr. Ward for serving as committee members. Your insights contributed to the success of this project and have not gone unnoticed.

The foundation of this project was built upon previous research conducted by Dr. Young-Hoo Kwon at Texas Women's University. Dr. Kwon, I cannot thank you enough for your commitment throughout this research process; your expertise and involvement was invaluable. Additionally, Patrick Foppe, PGA, and Todd Casabella, PGA, you both were a great resource of golf coaching and provided the knowledge that made this research applicable to coaches and players alike. Thank you for your interest in this study and your help in the data collection process.

Finally, I would not be where I am without the love and encouragement from my peers, friends, and family. To my fellow graduate assistants, thank you for enhancing my learning experience at Miami. To my dear friends, thank you for providing constant comfort and laughs. To my loving family, thank you for being the people I want to make proud. None of my successes would be possible without you.

Chapter 1

Introduction:

Golf has become an increasingly popular sport in recent years. Whether it be a leisure weekend activity or a lifetime occupation, the game appeals to over 40 million individuals each year in the U.S. alone (National Golf Foundation, 2021). The ultimate objective is to hit the ball into a series of 18 holes in the fewest amount of strokes, utilizing several different clubs. The four types of shots required in the game include the drive (the first hit off the tee), the iron play (the hit off the fairway), the approach (the hit onto the green), and the putt (the final hit into the hole). Approach shots are typically hit with a wedge club and are the most practiced skill in elite-level players (James & Rees, 2008). According to U.S. PGA Tour data, accuracy of approach shots has been positively correlated with player proficiency, since the outcome of this shot determines the distance of the first putt (James & Rees, 2008). Due to the ability of a wedge to drop the ball onto the green at a range of 25-100+ yards, this multifunctional club sometimes requires a submaximal effort swing, or a partial shot. Partial shots have been found to be a difficult skill, as researchers have identified a 17% reduction in accuracy of shots that were 50-100 yards when compared to shots of 100-200 yards (James & Rees, 2008). Understanding the discrepancies between full and partial shots could potentially increase accuracy and performance in golf.

A successful swing is the result of an efficient interaction between the golfer's rotating body segments. Golfer movements can be modeled by an inclined axel-chain system, where the trunk is an inclined axel and it is linked to an open chain (Han, Como, Kim, Hung, Hasan, & Kwon, 2019). The open chain is further modeled as a functional double pendulum (FDP), consisting of the arms as the upper lever (UL) and the club as the lower lever (LL) (Kwon, Han, Como, Lee, & Singhal, 2013). These movements are visualized along the plane of angular motion from the mid downswing to the mid follow-through phases, known as the functional swing plane (FSP) (Kwon, Como, Han, Lee, & Singhal, 2012). The transfer of angular momentum from the body into the displacement of the ball is the kinematic sequence described by a proximal-to-distal sequencing (PDS) pattern within this axel-chain system. PDS is demonstrated in golf as proximal segments initiate rotation to generate energy for distal segments, for maximal control of club head velocity (Putnam, 1993). Proximal segments include the pelvis, trunk, and shoulders, while distal segments include wrists, hands, and the club head.

This movement sequence is advantageous to produce maximal angular velocity of the club at impact with the ball by summing the forces initiated by rotation of proximal body segments (Putnam, 1993).

Additional to the sequence of golfer movement, temporal parameters of golfer motion have been investigated across club conditions (Madrid, Avalos, Levine, Tuttle, Becker, & Kwon, 2020). The ratio of the backswing to downswing duration have been reported to increase as the club length increases (Madrid et al., 2020). Madrid and colleagues (2020) suggested the variance in timing of the phases across club conditions can be explained by the association of a faster downswing with increased club head speed. However, when average club head velocity is similar (>100 mph) across the different swing styles, variable timing and peak velocity outcomes can create inefficient sequencing of movement patterns (Han et al., 2019). Emphasis on the sequence and timing of segmented body rotation can enhance the player's performance variables (club head velocity, ball velocity, ball carry distance, etc.) as well as prevent musculoskeletal injuries (Han et al., 2019 and Madrid et al., 2020).

Evidence for similar temporal and kinematic sequence patterns in both long and short distance swings have been established (Tinmark, Hellström, Halvorsen, & Thorstensson, 2010). Tinmark and colleagues (2010) analyzed golfer motion by placing electromagnetic sensors on the pelvis, torso, and hand to record timing, velocity, and acceleration of body segments throughout each swing condition. A proximal-to-distal (pelvis-torso-hand) pattern was observed in which the body segments reached maximal angular speed in temporal order and magnitude for every testing distance (Tinmark et al., 2010). However, partial shots were not found to be biomechanically the same as full shots. When theoretically scaling the target distance and kinematic parameters down by 80%, actual recorded swing characteristics differed outside of that percentage between partial and full shots within the same club condition (Todd, Wiles, Coleman, & Brown, 2020); therefore, requiring practice of partial shots as a separate golf skill.

To date, there is no published study that has attempted to investigate the effect of short distances (<100 yards) on the axel-chain system of the golfer. Therefore, the primary purpose of this study was to collect comprehensive data on 3D biomechanical variables of the approach swing at four target distances in college-aged, male golfers. It was hypothesized that (1) timing and peak angular velocities of body segments would be significantly correlated with the distance of the shot, and (2) PDS would be observed in the backswing, transition, and downswing phases in the approach swing.

Chapter 2

Methods:

Subjects

Fifteen male collegiate golfers volunteered to participate in this study. Participant (Table 1) and lob wedge (Table 2) characteristics were collected. Wedge characteristics were measured using a GolfWorks Auditor Digital Swing Weight Scale (Newark, OH, USA) and GolfWorks Auditor Reference Frequency Analyzer (Newark, OH, USA). All subjects reported a handicap of 5 or less and were free from any musculoskeletal injury. Additionally, all subjects were given a written consent form (Appendix A) and medical questionnaire (Appendix B) to read and complete in its entirety prior to participation. This study was approved by the Miami University Institutional Review Board.

Table 1. Participant characteristics

Age (years)*	20.5±1.2
Height (cm)*	183.9±5.7
Body Mass (kg)*	76.9±12.4

*values expressed as mean±standard deviation

Table 2. Lob wedge characteristics

Wedge Moment of Inertia (kg・cm^2)*	2745.5±65.6
Wedge Mass (g)*	473.7±11.6
Wedge Swing Weight (g)*	451.9±8.9

*values expressed as mean±standard deviation

Experimental Setup

Forty-nine reflective, adhesive markers from the “TWUGolfer 3.0” set were placed on anatomical landmarks of each golfer for static capture (Kwon et al., 2012). Eleven markers placed on the club and five markers placed on the synthetic turf surface were also recorded for static capture. Positional data of all 65 reflective markers was recorded using an 11-camera motion capture system (Vicon Nexus 2.9.2, Oxford, UK) sampled at 250 Hz. The cameras and testing space were calibrated before each testing session. Each participant was instructed to dress in spandex shorts and remain shirtless for the duration of testing to minimize movement error of the markers. After collection of the static trials, 14 markers were removed before dynamic trials commenced. The lab space also included a GCQuad Golf Simulator (San Diego, CA, USA) to record ball measurements for each trial.

Trial Conditions

Participants hit a standard golf ball off a synthetic turf mat for each trial and used their own personal wedge (loft 58-60 degrees), glove, and golf shoes. Prior to dynamic trials, there was a five-minute span for individual warm-up. After a self-determined amount of practice swings, participants were instructed to hit five successful shots at each target distance: 30 yards, 50 yards, 70 yards, and full swing (maximal distance) yardage. Each target distance was completed as a block of trials such that all 5 shots were completed before the next target distance was performed. Participants were given verbal feedback of the distance of each shot. If a shot was unsuccessful, the participant was informed and instructed to hit again. A total of 20 successful shots were recorded. Success of a shot was characterized by ball carry distance, specifically if the ball lands within five yards of the goal distance. The carry distance of each shot was calculated by the GCQuad.

Data Processing

Captured trials were stored in C3D files and imported into Kwon 3D Motion Analysis Suite (Visol Inc., Seoul, Korea) for data processing. Through this processing, golfer hip line (HL), shoulder line (SL), upper lever (UL), and club vectors were defined along the functional swing plane (FSP) to detect body segment motion.

The swing events defined in Han et al. (2019) were used for the subsequent analysis: BA (Breakaway), MB (Mid Backswing), LBA, (Late Backswing, Arm-Based), LB (Late Backswing), EPR (End of Pelvis Rotation), TB (Top of Backswing), EDA (Early Downswing, Arm-Based), ED (Early Downswing), MD (Mid Downswing), BI (Ball Impact), MF (Mid

Follow- Through), and LF (Late Follow-Through) (Figure 1). From these events, the backswing, downswing, and transition phases were defined by BA-TB, TB-BI, and EPR-TB, respectively.

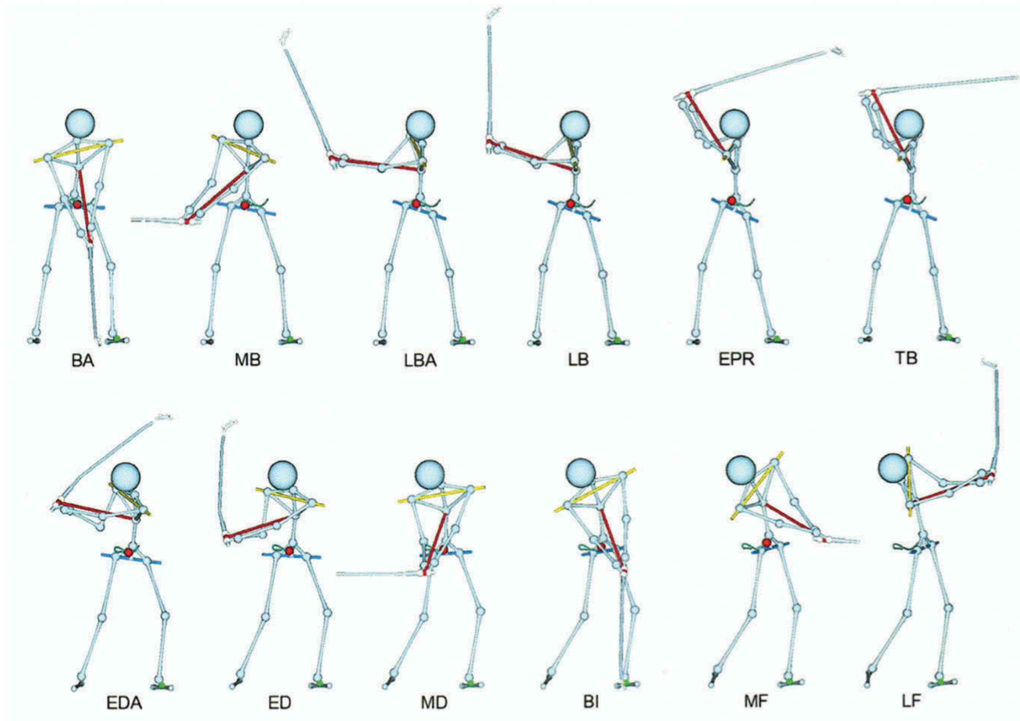

Figure 1. Swing events: BA (Breakaway), MB (Mid Backswing), LBA, (Late Backswing, Arm-Based), LB (Late Backswing), EPR (End of Pelvis Rotation), TB (Top of Backswing), EDA (Early Downswing, Arm-Based), ED (Early Downswing), MD (Mid Downswing), BI (Ball Impact), MF (Mid Follow- Through), and LF (Late Follow-Through) (Han et al. 2019).

Similar to Han et al. (2019) and Madrid et al. (2020), the following temporal and kinematic characteristics were analyzed:

- Phase times (ms): backswing, downswing, and transition
- Peak backswing and downswing angular velocities (°/s): HL, SL, UL, and club (backswing only)
- Peak-to-BI angular velocity decrease (°/s): HL, SL, and UL
- Times of peak backswing and downswing angular velocities, relative to BI (ms): HL, SL, UL, and club (backswing only)
- Transition times, relative to BI (ms): HL, SL, UL, and club

Statistical Analysis

The independent variables were distance (30, 50, 70, and full) and body segment (HL, SL, UL, and club). The dependent variables were phase times, peak angular velocities, and time of peak angular velocities (relative to BI) in the backswing, downswing, and transition phase. The mean values of the golfer's repeated trials were used for statistical analysis. A total of seven statistical tests were used to measure significant relationships between variables. The first test was a one-way repeated measures (RM) multivariate analysis of variance (MANOVA) used to determine if there were significant differences in swing phase times based on the target distance of the shot. The next three tests were one-way RM analysis of variance (ANOVA) used to determine if there were significant differences in peak angular velocity based on the target distance of the shot, in each of the three swing phases. The last three tests were two-way RM ANOVAs used to analyze the timing of the peak backward, transition, and downward angular velocities based on the target distance of the shot. The club was excluded in the downward sequence analysis since it reaches its peak velocity before BI (Han et al., 2019). Pairwise comparisons were conducted if any variable interaction showed significance. Significance level was set at $p \leq 0.05$ for all tests. All data was analyzed using IBM SPSS Statistics (version 28, SPSS Inc., Armonk, NY).

Chapter 3

Results:

The first one-way RM MANOVA examined the duration of each swing phase and yielded a significant ($p < 0.05$) distance effect (Wilks' $\lambda = 0.051$, $F = 25.972$, $p = <0.001$). Follow up pairwise comparisons revealed significant inter-distance differences in backswing, downswing, and transition phase time (Table 3). Backswing duration significantly increased as target distance goals increased from 30 yards to 70 yards. Downswing duration significantly decreased as target distance goals increased from 50 yards to full swing. Transition duration at 70 yards was significantly longer than at all other distances.

Table 3. Phase times (M ± SD; in ms)

	30 yards	50 yards	70 yards	Full	Sig. Diff.
Backswing (BA-TB)	663 ± 62	704 ± 78	736 ± 89	741 ± 71	30 < 50 < 70/F
Downswing (TB-BI)	313 ± 33	308 ± 38	296 ± 37	268 ± 39	30/50 > 70 > F
Transition (EPR-TB)	79 ± 44	81 ± 50	112 ± 46	91 ± 54	30/50/F < 70

The next three one-way RM MANOVAs examined the peak angular velocities and yielded a significant distance effect in the backswing (Wilks' $\lambda = 0.065$, $F = 15.581$, $p = <0.001$), downswing (Wilks' $\lambda = 0.012$, $F = 36.726$, $p = <0.001$), and peak-to-BI decrease (Wilks' $\lambda = 0.080$, $F = 19.739$, $p = <0.001$). All body segments reached peak backward and downward angular velocities in a significantly increasing order as target distance goals increased (Table 4). All body segments also decreased the magnitude of angular velocity in increasing order of distance goals.

The first two-way RM ANOVA examined the backswing sequence to peak angular velocity and yielded a significant distance * body interaction (Wilks' $\lambda = 0.119$, Greenhouse-Geisser $F = 8.755$, $p = <0.001$). The post-hoc test revealed significant inter-distance differences in only the SL and club but inter-body differences in all distances (Table 5).

The second two-way RM ANOVA examined the transition sequence to peak angular velocity and yielded significant distance effect (Wilks' $\lambda = 0.259$, Greenhouse-Geisser $F = 23.827$, $p = <0.001$) and body effect (Wilks' $\lambda = 0.189$, Greenhouse-Geisser $F = 28.694$, $p =$

<0.001), but insignificant distance * body interaction (Wilks' λ = 0.551, Greenhouse-Geisser F = 2.204, p = 0.122). The post-hoc tests revealed significant inter-distance differences in all body segments and inter-body time differences in all distances (Table 5).

The third two-way RM ANOVA examined the downswing sequence to peak angular velocity and yielded significant distance * body interaction (Wilks' λ = 0.143, Greenhouse-Geisser F = 6.746, p = 0.002). The post-hoc test revealed significant inter-distance differences in all body segments but only inter-body differences in the 30-yard condition (Table 5).

Table 4. Angular velocity parameters (M ± SD; in °/s)

	30 yards	50 yards	70 yards	Full	Sig. Diff.
Peak backward angular velocity					
Hip Line	–57 ± 15	–70 ± 16	–82 ± 19	–98 ± 23	30 < 50 < 70 < F
Shoulder Line	–179 ± 35	–202 ± 40	–221 ± 47	–248 ± 54	30 < 50 < 70 < F
Upper Lever	–217 ± 35	–252 ± 40	–283 ± 45	–324 ± 48	30 < 50 < 70 < F
Club	–331 ± 55	–381 ± 68	–429 ± 85	–494 ± 90	30 < 50 < 70 < F
Peak downward angular velocity					
Hip Line	170 ± 24	223 ± 37	283 ± 39	387 ± 55	30 < 50 < 70 < F
Shoulder Line	409 ± 51	502 ± 44	584 ± 38	706 ± 58	30 < 50 < 70 < F
Upper Lever	495 ± 47	649 ± 49	814 ± 51	1020 ± 62	30 < 50 < 70 < F
Club	965 ± 60	1272 ± 91	1620 ± 116	2089 ± 123	30 < 50 < 70 < F
Peak-to-BI angular velocity decrease					
Hip Line	14 ± 19	26 ± 30	59 ± 43	148 ± 81	30 < 50 < 70 < F
Shoulder Line	16 ± 17	30 ± 27	65 ± 45	177 ± 102	30 < 50 < 70 < F
Upper Lever	54 ± 29	97 ± 41	161 ± 51	261 ± 59	30 < 50 < 70 < F

Table 5. Transition times and peak angular velocity times (M ± SD; in ms, relative to BI)

	Hip Line	Shoulder Line	Upper Lever	Club	Sig. Diff.
Backward peak angular velocity time					
30 yards	–684 ± 38	–640 ± 43	–592 ± 38	–595 ± 60	HL<SL<UL/Club
50 yards	–714 ± 58	–671 ± 57	–609 ± 53	–603 ± 64	HL<SL<UL/Club
70 yards	–714 ± 59	–694 ± 72	–615 ± 64	–614 ± 68	HL/SL<UL/Club
Full (F)	–712 ± 70	–687 ± 77	–600 ± 75	–562 ± 68	HL/SL<UL/Club
Sig. Diff.	-	30<50<70	-	70<F	
Transition time					
30 yards	–364 ± 19	–329 ± 16	–320 ± 20	–312 ± 32	HL<SL/UL/Club
50 yards	–363 ± 20	–326 ± 17	–315 ± 24	–308 ± 37	HL<SL/UL/Club
70 yards	–360 ± 29	–317 ± 20	–306 ± 25	–298 ± 37	HL<SL/UL/Club
Full (F)	–339 ± 39	–291 ± 20	–280 ± 29	–273 ± 38	HL<SL/UL/Club
Sig. Diff.	50/70<F	30/50/70<F	30<F, 50<70<F	30< F, 50<70<F	
Downward peak angular velocity time					
30 yards	–39 ± 44	–36 ± 28	–61 ± 15	-	SL< UL
50 yards	–51 ± 35	–51 ± 24	–59 ± 11	-	-
70 yards	–75 ± 27	–62 ± 22	–59 ± 7	-	-
Full (F)	–75 ± 20	–71 ± 12	–65 ± 6	-	-
Sig. Diff.	30<70/F, 50<70	30<50/70/F, 50<F	70<F		

Chapter 4

Discussion:

The purpose of this study was to assess temporal and kinematic outcomes of the approach swing in college-aged male golfers. Each participant was instructed to hit a standard golf ball at 30 yards, 50 yards, 70 yards, and perform a full effort swing. To digitally assess movement patterns, the golfer's body was divided into segments. The hip line (HL), shoulder line (SL), and upper lever (UL) represented the pelvis, shoulder girdle, and collective arm motions, respectively. All angular motions and timing of phases were measured on the functional swing plane (FSP), the main plane of movement in the golf swing (Kwon et al., 2012).

The average times of the backswing, transition, and downswing phases were all significantly related to distance of the shot (Table 3). The duration of the backswing was longer as the distance goal increased from 30 yards to 70 yards. The duration of the downswing was shorter as the distance goal increased from 50 yards to full swings. The transition phase timing did not present a specific pattern across distances, as the duration of this phase was significantly greater at 70 yards than at all other distances.

These findings were partially consistent with a previous study that examined phase times and club head speed across three club conditions: driver, 5-iron, and pitching wedge (Madrid et al., 2020). The driver produced the greatest club head speed and was characterized by a 3.0 to 1 backswing to downswing ratio, when compared to the pitching wedge with a 2.7 to 1 ratio (Madrid et al., 2020). As club head speed has been correlated with displacement of the ball (Hume, Keogh, & Reid, 2005), our study supports the notion that increased backswing to downswing ratios are attributes of longer distance shots. Furthermore, Han et al. (2019) concluded that the duration of the transition phase is affected by individual golfer swing styles based on the X-factor stretch or angular position parameters (Han et al., 2019 and Cheetham, Martin, Mottram, & St. Laurent, 2001). These findings may contribute to the lack of pattern in the transition phase durations from the current study.

The magnitudes of peak angular velocity were significantly related to the distance of the shot in both the backward and downward phases (Table 4). Angular velocity decreases (peak angular velocity to ball impact) were also associated with the increasing distance tasks. The downswing peak angular velocities were found to be faster than the backswing peak angular velocities, and increased in speed as distance got further. The further the distance goal, the faster the peak rotational speed of the golfer. This established pattern is similar to other club's generation of speed (Madrid et al., 2020 and Tinmark et al., 2010), and should be a practiced skill when learning to control distance with the lob wedge.

The backward sequences were characterized as partial PDS, due to poor separation within the proximal segment and distal segments (Table 5). Swings at 30 and 50 yards tended to present a 'HL → SL → UL/club' sequence, while swings at 70 yards and full shots tended to exhibit a 'HL/SL → UL/club' sequence. No separation was observed between the arms and club in any distance condition. Additionally, it seems that the shoulder line moves together with the pelvis as distance goals increase in the backswing.

The transition consisted of only one partial PDS pattern throughout this phase (Table 5). All distances displayed a 'HL → SL/UL/club' sequence with no observed separation between the pelvis, arm, and club. This signifies that the hips lead the golfer motion through this phase and should be the focus when training for a faster transition phase. A faster transition phase is the result of the stretch shortening cycle (SSC). The SSC occurs when body segments initiate rotation in a countermovement, or stretch, then immediately contract, or shorten, those muscle groups for increased power and control (Hume et al., 2005). In golf, the backswing is the countermovement and a shorter transition time would mitigate any delay at the top of the backswing to preserve power and speed in the downswing (Hume at al., 2005).

Lastly, the downward sequences had the least amount of significant relationships with distance of the shot (Table 5). Swings at 30 yards showed the shoulders to reach peak velocity before the arms, without any associations to other body segments. No other distance showed significance with movement sequence. It is to note that even though partial PDS patterns arose within phases, the body segments did not uniformly increase across distances. In other words, the hip line did not significantly delay reaching peak angular velocity across distances in the backswing, even though the phase times were increasing in duration. Body segment motion was mostly clear, but the differences within body segments were inconsistent.

The primary hypothesis that distance is significantly associated with temporal and kinematic parameters may be accepted. Distance had an effect on timing of the swing phases, peak angular velocities, and golfer motion sequencing. The secondary hypothesis that proximal to distal sequencing is a common pattern among the backswing, downswing, and transition phase, cannot be accepted. Movement sequencing within the approach shot displayed irregular patterns across all distances and phases, with partial PDS at best. No separation between the arms and club, as well as varying shoulder separation was observed and needs to be taken into account for golf coaches/teachers when developing this skill.

Conclusion

The main purpose of this study was to assess temporal and kinematic outcomes of the approach swing at four different distances in college-aged, male golfers. Little research has focused on this skill within college golfers, which warranted our interest in this project. Distance did have an effect on swing phase timing, angular velocities, and motion sequencing. The behavior of these variables are partially similar to previous studies based on the kinematic sequence of different clubs, but the approach swing did present its own unique motion patterns that will require practice as its own skill.

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Appendices

Appendix A: Consent Form

MIAMI UNIVERSITY
OXFORD, OH • EST. 1809

Consent Form for Participation in a Research Study

Principal Investigator: Tess McGuire, Mark Walsh
Study Title: The Effects of Target Distance on Kinematic Sequence of the Approach Shot in Male Collegiate Golfers

We are asking for your consent to use the data we collect for research purposes. The testing we perform is used to assess swing kinematics in relation to distance of the shot. This consent form will give you the information you will need to understand why this study is being done and why you are being invited to participate. It will also describe what you will need to do to participate and any known risks, inconveniences, or discomforts that you may have while participating.

<u>PURPOSE OF THE STUDY</u>
The purpose of this research study is to evaluate how manipulation of distance to the hole affects swing movement patterns during the approach game. By completing this study, we will have a more complete understanding of this relationship with regard to factors relating to golf performance.

<u>RESEARCH PROCEDURES</u>
Informed Consent: Informed consent will be obtained upon arrival for session prior to any questionnaire data being collected.

Placement of markers on the participant, club, and mat (10-15 minutes)
Participants will be asked to wear just spandex shorts without a shirt on so we can place approximately 50 adhesive markers on anatomical landmarks on the upper and lower body. Simultaneously, another research assistant will be adding reflective tape and markers to the club.

Collect static motion capture data of the participant, club, and mat (5 minutes)
Participants will be instructed to stand in a 'T pose' in the middle of the lab testing space so the motion capture system can record a static capture of the markers on the body.

Warm up period (5 minutes)
Participants will be given time to complete an individualized warm-up and familiarize themselves with the swing task. Stretching and practice shots are encouraged at this time.

Collect dynamic motion capture and kinetic measures of each swing (15-20 minutes)
During this testing period participants will be verbally given a distance and will have to hit the ball towards a target. This will be repeated five times at four different distances. A total of twenty shots will be recorded.

Remove all markers from participant and club (5-10 minutes)
Once the testing is complete, a research assistant will remove all reflective markers from the participant and club.

POTENTIAL RISKS

As with any physical activity there is some risk involved. It is our belief that the tests we are asking the participants to perform pose similar or less risk than the participants are exposed during the physical activity of their normal daily life and physical activity. Although any physical activity has potential risks we believe the risks posed during our testing is much less than your normal practices. Miami University is not responsible for injuries or payment for any injuries.

POTENTIAL BENEFITS

While you may not directly benefit from participation in this study, the results from this study are expected to provide information regarding fitness and performance related factors for golfers across different levels of expertise. This data could be used in future research to develop targeted practice for the approach game shot.

CONFIDENTIALITY

Although your name will be linked with your data because we will be giving it to your coach/athletic trainer, the data we use for research will be treated as confidential. Regarding the data we use for research, only the Principal Investigator and approved members of the research team will have access to the participants' personal information. The original questionnaires will have identifying information, and will be kept in a locked file cabinet in the Principal Investigator's office. Electronic files we keep will never be linked to identifying information and all data will be coded to protect confidentiality. A code will be assigned to each subject, by which the questionnaire data will be referred to during analysis. The master list of codes will be maintained on the Principal Investigator's password-protected computer until the data analysis is completed. This list will not be shared with other researchers. All data will be shared statistically and will never be associated with personal information, assigned codes, or team information when published.

VOLUNTARY PARTICIPATION

Your participation in this study is strictly voluntary. You are free to withdraw from participation for any reason, at any time without penalty from researchers or Miami University. If you withdraw from the study, your questionnaire will be destroyed and no information will be used. You must be 18 years old to participate.

CONTACT INFORMATION

If you have any complaints, concerns, input or questions regarding your rights as a subject participating in this study you may contact the Office for the Advancement of Research and Scholarship at (513) 529-3600 or humansubjects@miamioh.edu. If you have additional questions regarding the specifics of the study, please contact Dr. Mark Walsh at (513) 529-2708 or walshms@miamioh.edu.

SIGNATURES

Informed consent is required of all participants in this research study. Whether or not you provide informed consent for this research study will have no effect on your current or future relationship with Miami University. By signing below, you acknowledge that 1) the purpose, procedures, and risks/benefits of participation in this study have been described to you; 2) that any questions you may have are adequately addressed by a member of the research team; and 3) that you are over 18 years of age.

Obtaining Consent

___________________________	___________________________	_____________
Participant Signature	Print Name	Date
___________________________	___________________________	_____________
Signature of Person	Print Name	Date

Appendix B: Medical Questionnaire

Medical History Questionnaire

Name: ____ Date: ________________________

Cell Phone: ___________________________ Email: ____________________________

Emergency Contact: ____

Age: __________ Height: __________ Weight: __________ Race/ethnicity: ________________

Year in school: 1 2 3 4 4+ Years playing golf (competitively): _______________

Handedness: R L Handicap: __________ Loft of wedge: __________

Typical range of distance you would hit with your wedge: __________

Have you suffered from any lower extremity pain or injury in the last 6 months? Yes__ No __

If yes, please describe:

____

____

Are you prohibited from any particular type of exercise? Yes____________

If yes, please describe:

____

____

Have you had surgery in the last 6 months? Yes______________

If yes, please describe:

____

____

Use the space below to describe any special needs or concerns you have about performing any of the experimental tasks: