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# How Biomechanics Shape a Powerful and Consistent Golf Swing

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## Abstract

Biomechanics is a scientific way of understanding how golfers generate power while still maintaining a consistent swing. This field of study analyses how forces act on the body, how different parts of the body move, and how well these movements are timed. This information helps researchers explain why some specific swings produce both long distance and accurate ball flight. However, achieving these two goals together is a struggle for most golfers.
They often end up sacrificing accuracy for power or vice versa. Some swings create a lot of power indeed but struggle with accuracy while others score high on accuracy but are underwhelming in terms of power. This paper investigates the biomechanical factors that allow golfers to generate both club-head speed and reliable impact with the ball.

The study starts with a qualitative review of existing biomechanics research and combines it with comparative case studies featuring elite golfers. Previous academic research papers related to ground reaction forces, kinematic sequencing, posture stability, and wrist mechanics are reviewed to identify patterns that result in effective, powerful golf swings. For a better understanding of these scientific findings, examples from the real-world featuring four professional golfers- Each golfer is an example of a specific biomechanical strength that helps make his/her swing more powerful and accurate.

When we examine research literature closely, some patterns become very clear. Power in the golf swing depends on the effective use of ground reaction forces and efficient sequencing of body segments from the lower body to the upper body and finally to the club. Consistency, on the other hand, comes from stable posture, controlled weight transfer, and how precisely wrists are positioned and moved during the course of the swing. The findings suggest that distance and accuracy are not necessarily opposing goals and golfers don't need to sacrifice one to achieve the other. In fact, both emerge from coordinated and repeatable movement patterns. An understanding of these biomechanical principles can help golfers improve their performance, train efficiently, and reduce the technical errors in their swing.

## Introduction

The average golf swing lasts 1.2 seconds (Sueltz, 2017). Within this time, a golfer must efficiently transfer the force of their body weight and properly rotate about their spine to hit the ball far and straight. A lack of rotation disables the ability to maximize club speed, while pressure in the wrong part of the foot will send a golf ball wayward. The golf swing is a coordinated movement which involves the rotation of the lower body, torso, arms, and club to generate both speed and accuracy (Nesbit, 2005).

With tournament courses reaching upwards of 7000 yards, professionals are constantly forced to keep up with the demand for both distance and accuracy that is found necessary in golf. Amateurs and juniors - making up the majority of golfers - are even farther from mastering the intricate biomechanics of golf. Of all the biomechanical necessities in the golf swing, the most influential factors are balance, rotation, timing, and force transfer.

Biomechanics are the foundation of all sports. Just as every arm movement is essential to hitting, shooting, or throwing a ball, the size of leg muscles determines one's vertical or kicking power. In golf particularly, one's bodily mechanics are the end-all-be-all. In a sport like baseball, you throw, run, and swing at full power. Golf, however, is nuanced. It is a sport involving touch, accuracy, and timing. A good golf swing doesn't just have to "look good". It needs to be efficient in creating both power and accuracy.

On the quest to the perfect golf swing, multiple different sensors and motion capture devices have been created to further our knowledge on the impact that biomechanics have on the golf swing. Force plates and pressure mats record the ground force created during your swing, most notably at impact. Launch monitors are used to record swing speed, distance, swing path, etc.

In order to get a better understanding of these biomechanical movements, modern science has created multiple tools such as motion capture systems and electromyography (EMG) to allow researchers to closely study muscle activity and movement patterns (Taylor, 2025). Each piece of information facilitates a golfer's ability to move closer to efficient body mechanics.

Because there are so many moving parts in the golf swing, only the most talented golfers are able to control each body part simultaneously. Accordingly, most juniors and amateurs are guilty of common deficiencies in their golf swing. Oftentimes, amateurs will either have an incorrect posture at address or lose their posture during the swing. Another example would be a reliance on arms to swing the club rather than a combination of arms and chest rotation. Amateurs and juniors are also guilty of an inconsistent club face, warranting a change in grip and wrist rotation. Overall, amateurs and juniors are missing a holistic mastery of the core biomechanics in the golf swing.

This happens because, despite numerous advances in data collection in golf, there are still common misunderstandings about the true source of power and accuracy in the golf swing. Natural size and strength, although important factors, ultimately do not decide the distance of one's golf shot. In fact, it is factors like the ability to reduce variability, use the ground, and accelerate quickly that create the circumstances under which the golf ball will go far and straight, consistently. However, there are many other biomechanical factors - unbeknownst to many - that guide the results of a golf swing. Understanding these biomechanical principles not only improves performance but also helps reduce the risk of injury (Nesbit & Serrano, 2005).

Thus, the purpose of this research paper is to analyze the biomechanical factors that help golfers generate both club head power and consistent ball striking. In doing so, focus was placed on data from both male and female golfers to get a comprehensive understanding of effective swing mechanics.

## Literature review

2.1 Phases of the Golf Swing

The golf swing consists of 6 key phases. The address is the moment just before the takeaway begins, i.e., the frame before movement in the backswing is noticeable (McNally, 2019). At address, the proper positioning of the feet, arms, head, and torso is essential for maintaining balance and control.

The backswing is the movement of the club to the top of the swing as the arms and upper body rotate together. By the end of the backswing, the golfer should be fully rotated and loaded onto the back half of their body. This step is essential to prepare for the “transition” part of the swing. During the backswing, the golfer winds to create a distance over which positive forces and torques can be applied to the club thus creating a potential to do work (Nesbit & Serrano, 2005). The backswing is the slowest part of the swing - because it is solely for preparation.

The transition is the point at which the club changes direction and begins the downswing. At this point, the stored potential energy begins to convert into kinetic energy.

The downswing is the continued acceleration of the golf club as it approaches the ball. During the downswing phase, the efficiency of the golfer's biomechanics becomes evident. In addition to utilizing ground forces, the golfer must also rotate their torso towards the target rapidly to generate speed.

Finally, the follow through, preceded by impact with the golf ball, is where the golf club begins to decelerate and end the swing. Research also shows that maintaining stable posture and limiting sideways movement helps golfers keep a consistent swing plane and improve accuracy (Merry, 2022). This is because the position at impact is supposed to mimic, or closely resemble, the position at address.

2.2 Biomechanical Factors Influencing Power Generation

Ground reaction forces are important for power generation. Elite golfers push against the ground more effectively, which helps them produce more force and speed during the downswing

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(Jones et al., 2021). This contact with the ground allows force to be transferred upward through the body, increasing the clubhead speed. Most of the power generated in the swing, if done right, comes from ground force. By loading their front foot during the transition phase, a golfer can produce copious amounts of potential energy. After shifting weight onto their front foot, a golfer is able to push upwards and towards the target, bringing the club with them. This movement creates speed within the golf swing, but not necessarily accuracy. However, power depends more on how well force is transferred through the body than on the amount of force produced.

Accuracy is mostly found in the rotational sequencing of the swing. During the golf swing, there is both pelvic and thoracic rotation. Research shows that the golf swing follows a proximal-to-distal kinetic chain, meaning that movement starts in the lower body and then moves through the torso, arms, and finally the club (Tinmark et al., 2010). This sequencing allows for the efficient transfer of energy across the body leading to an improvement in both speed and control.

Disruptions in this sequence, such as starting the downswing with the upper body or losing coordination between body segments, can make the swing more variable and reduce the consistency of ball striking.

The final biomechanical determinant of power in the golf swing is not as intuitive as the others may be. Higher club-head speed is also linked to good hip–torso separation, often called the X-factor. This separation stores energy during the backswing and releases it during the downswing (Cheetham et al., 2016). Greater separation stretches the body like a rubber band, storing energy that is released during the downswing. Similar to the way a pitcher or quarterback throws a ball, hip-torso separation in golf creates "lag", or potential energy, that is able to release during the downswing. This delayed release leads to higher clubhead speed at impact.

As shown in Figure 1, the golf swing moves through the six different phases from address to follow-through.

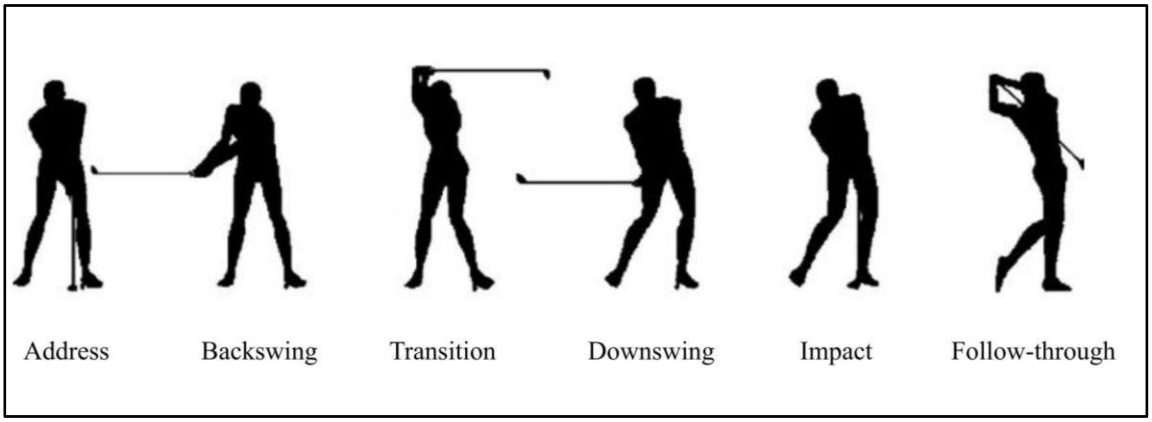


**Figure 1.** Phases of the Golf Swing Diagram.
Adapted from Full Swing Practice 1 by J. Woods. Copyright 2020. PGA of America.

2.3 Biomechanical Determinants of Consistency

Wrist mechanics are a vital component of the golf swing. During the backswing, a golfer "hinges" their wrists, creating wrist lag, a form of potential energy. The "release" of the club head is the motion in which the wrists roll over, allowing the club face to become square to the target. In addition to squaring the club face, this process creates club head speed by releasing energy stored in the wrist lag (Merry, 2022).

If the release of the club face is too early or too late, the club face will not be square to the target. This makes ball flight less consistent, since the clubface angle largely controls the direction of the shot (Bradshaw & Keogh, 2011). Incorrect timing of the release is a major cause of variability in the swing, considering that the wrists have a direct influence on the club face position. This issue is often seen in less experienced amateurs and juniors.

Certain clubs have different timings in terms of release. When using a driver, a golfer should release the clubhead earlier so that the club is already on its way up at impact. Conversely, a golfer may keep their wrists hinged through impact while chipping, in order to drive the ball into the ground with more control. By driving the golf ball into the ground, spin is created.

Evidently, wrist mechanics also have an impact on spin rate. In a study regarding golfers' efficiency in driving the golf ball, amateurs had a low vertical spot, less rise angle, and increased shaft angle – which increases the backspin, limiting the ball roll's efficiency (Merry, 2022). Factors like shaft angle and rise angle are controlled by the timing of club head release. Elite players maintain lag until late in the downswing. By utilizing wrist mechanics correctly, a golfer is able to manipulate spin rate, club face aim, and club head speed. These adjustments show how wrist mechanics influence both control and consistency across different shots.

Consistent timing in the golf swing is difficult to achieve and is a defining feature of the golf swing. A golfer must be able to have a similar tempo for each swing. The plane on which a golfer swings must also be consistent from swing to swing. Research shows that golfers with less movement variability tend to have more consistent and accurate shots (Horan et al., 2011; Bradshaw & Keogh, 2011)."

There are multiple facets of the golf swing that rely on near-perfect timing in order to be able to predict the distance, spin, and flight of one's golf ball. Table 1 refers to five major variables that influence swing consistency.

**Table 1:** Variables Influencing Swing Consistency

| Variables Influencing Swing Consistency | Influence on the Golf Swing | Phase of the Golf Swing with Most Emphasis |
|---|---|---|
| Posture Stability | Affects low point and club face contact | Address |
| Wrist Mechanics | Heavily impacts spin rate, launch angle, and club head speed | Downswing through Impact |
| Swing Plane Consistency | Plays a defining role in the curve and start line of the golf ball | Backswing through Downswing |
| Center-of-Pressure Movement | Shifts low point, shaft angle, and club head speed | Transition |
| Tempo Control | Affects club face contact and speed | Throughout the swing |

2.4 Muscle Activation and Mobility

The muscles involved in the golf swing are found throughout the lower body, upper body, and core. The gluteus maximus and quadriceps, muscles in the upper leg, are used to maintain a stable posture as well as assist in shifting the center of pressure during the swing. These muscles are attached to the hips and knees. Research shows that lower-body muscles are important for maintaining balance and controlling rotation during the swing (Dong et al., 2023; Lin et al., 2023)."

For the average golfer, the head and the left leg amplitudes of the swing motions increase at the moment of impact which can lead to less stable ball striking and slice trajectories (Dong et al., 2023). If a golfer's leg muscles contract too early or too late, their hips will rotate out of sequence towards the target, which can push the clubface offline

In the upper body, golfers must be able to utilize arm and shoulder muscles to control the club. Latissimus dorsi (lats) and forearm flexors play two different yet important roles in the golf swing. The pectoralis major, subscapularis and latissimus dorsi muscles of both sides showed their peak activity during the acceleration phase (Cabri et al., 2012). Pecs (Pectoralis) and Lats (Latissimus dorsi) are muscles proven to be essential to pulling the club during the downswing, which generates club speed.

Forearm flexors are also important upper body muscles for the golf swing. Forearm flexors are the muscles in the anterior compartment of the forearm responsible for flexing the wrist and fingers and pronating the forearm (TeachMeAnatomy, n.d.). These muscles help control the wrist motion, which in turn influences the clubface position and release timing.

The obliques represent the most important core muscle groups. They have a similar function to the leg muscles: dictating rotational ability of the hips and torso. They also help with coordinating the transfer of energy between the lower and upper body. A strong and well-coordinated core helps golfers generate power and stay consistent.

2.5 Technology in Golf Biomechanics and research gaps

Modern golf biomechanical research heavily relies on motion capture, force plates, and launch monitors (Taylor, 2025; Grober, 2010). However, gaps still remain in understanding how specific muscle groups influence performance. For example, while motion capture tracks abdominal rotation, it often does not reveal how forearm flexors contribute to clubface control through pronation or supination. Launch monitors are able to track ball and club data, however they do not track the bodily mechanics that were able to create those numbers. So, while the swing data can be recorded, there is often no way of measuring the bio mechanical processes that generate it. This gap can create uncertainty and miscommunication as to which physical factors most strongly contribute to a powerful and consistent golf swing.

Similarly, most launch monitors or swing analyzers do not capture the contribution of certain upper body muscles like the latissimus dorsi to the golf swing. This can limit a golfer's understanding of how these muscles influence swing and control (Taylor, 2025; Grober, 2010)

This problem negatively impacts both professional and amateur golfers alike. While professionals often have access to more detailed biomechanical analysis, the amateurs often struggle to identify the adjustments that will rectify their swing.

## Methodology

This study was conducted using both a qualitative and comparative research methodology. The dual approach included a literature review that examined existing research on golf swing biomechanics and a comparative analysis of elite golfers' swing mechanics. The goal of the methodology was to identify biomechanical factors that influence both power and consistency in the golf swing, and to understand how these factors appear in the swings of professional golfers.

The first step in the study was a structured literature review. The review used peer-reviewed papers and academic articles related to golf biomechanics and sports motion analysis. These sources were collected from academic databases such as Google Scholar, PubMed, and SPORT Discus, along with open-access sports science journals.

The literature examined key biomechanical concepts involved in the golf swing, including ground reaction forces, kinematic sequencing, hip-shoulder separation, posture stability, and wrist mechanics. To ensure transparency, the literature review broadly followed a structured review approach inspired by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This framework helps researchers clearly explain how academic sources were identified, screened, and selected for analysis.

Studies were included only if they:

- examined biomechanical aspects of the golf swing
- included motion analysis, kinematic data, or biomechanical measurements
- discussed factors related to power generation or swing consistency
- were published in peer-reviewed journals or reputable academic sources
- were written in English

Studies were excluded if they:

- focused only on golf putting mechanics
- did not include biomechanical measurements or motion analysis
- focused on non-human biomechanical models
- lacked a clear research methodology

Studies were selected through a three-stage screening process. In the first stage, relevant research papers were identified by reading titles and abstracts. In the second stage, duplicate studies and unrelated papers were removed. In the final stage, a full-text review was conducted to determine whether the studies were relevant and appropriate for inclusion in the research.

After the literature review, the study used a comparative case-study approach to analyze the biomechanical characteristics of elite golfers. Four professional golfers were selected as case studies: Tiger Woods, Rory McIlroy, Nelly Korda, and Collin Morikawa. These golfers represent different styles of golf performance, including players known for driving power and those known for shot accuracy.

The case studies were analyzed using findings from previous biomechanical research. Motion analysis studies have shown that professional golfers demonstrate more consistent rotational sequencing and lower variability in swing mechanics compared to amateur players (Tinmark et al., 2010). Additionally, advances in motion-capture technology and markerless pose estimation now allow researchers to analyze golf swing kinematics using video-based skeletal tracking and biomechanical modeling (Taylor, 2025).

The findings from the literature review and the case-study analysis were then examined using a thematic analysis approach. The research findings were grouped into several biomechanical themes, including:

- power generation through ground reaction forces

- kinematic sequencing of body segments
- posture stability and swing repeatability
- rotational biomechanics of the pelvis and torso
- technological tools used in golf swing analysis

This thematic approach allowed the study to compare how different biomechanical factors contribute to both distance and accuracy in golf performance.

The methodology also considers the limitations and assumptions of existing biomechanical studies. Many golf biomechanics studies are conducted in laboratory environments using small sample sizes and professional athletes, which may not fully represent the variability seen among amateur golfers. Recognizing these limitations helps provide a clearer understanding of how current research explains the biomechanics of the golf swing.

## Results

4.1 Tiger Woods- Sequencing Efficiency

*Background*

During his prime years from the late 1990s to mid-2000s, Tiger Woods combined great power with high precision through the biomechanics of his golf swing. His swing, characterised by fast rotation and efficient kinetic sequencing, allowed him to achieve club head speeds above 120 miles per hour. In an era which had much lower average driving distances, Tiger Woods achieved these performance levels years ahead of his peers, setting new standards in professional golf. Woods' physical condition, particularly his core strength and flexibility, helped him generate torque and stay balanced during his swing. His technique is often used as an example of efficient energy transfer and consistent movement patterns (Bourgain et al., 2022). His physical fitness, athletic ability and technical skill raised the bar for golfers and left a lasting impact on training methods across the sport (Taylor, 2025). Moreover, his dominance during his peak period is an example of how strong biomechanics can translate into competitive success.

*Biomechanical Characteristics*

<u>Kinetic Sequencing</u>

Tiger Woods' swing used coordinated body rotation along with effective use of ground force. His sequence began with the hips rotating first, followed by the torso and ended with the extension of the arms. This led to a smooth transfer of energy to the club head. As a result, he was able to achieve high club head speed while keeping his posture steady and limiting side to side movement.

<u>Ground Reaction Forces and Weight Transfer</u>

Tiger Woods was able to efficiently shift his weight which supported other biomechanical movements such as pelvic rotation. His strong lower body helped him use ground forces well, leading to both higher driving distance and better consistency. Studies also show that elite golfers who use ground forces and effectively and stay coordinated tend to have better driving performance (Betzler et al., 2012)."

Posture and Stability

This sequence helped Woods keep his posture steady and avoid too much side-to-side movement. When the spine angle stays stable, there's less extra motion, which makes shorts more consistent. Research also shows that swings with less variation tend to be more accurate and repeatable (Mahadas et al., 2019).

Strength, Mobility, and Coordination

His swing showed a strong mix of strength, flexibility, and timing, often used as a reference in professional training and motion analysis (Taylor, 2025). His strength and mobility helped him generate speed while staying in control. Research also shows that equipment can impact performance in golf depending on the golfer's physical ability (Yang et al., 2024)."

*Performance Impact*

Woods' swing showed a strong balance between distance and control, largely due to his precise kinematic sequence. His efficient biomechanics helped him hit the ball long distances while staying accurate in approach play and short game (Betzler et al., 2012). During his prime, he consistently won golf tournaments at the highest levels which could be linked to his repeatable, powerful, and precise golf swing. His overall performance shows how muscular control and efficient sequencing can produce high speeds without sacrificing consistency or precision ((Kwon et al., 2013; Mahadas et al., 2019).

4.2. Rory McIlroy - Ground Force Mechanics

*Background*

Rory McIlroy is an active professional golfer known for his long drives and efficient swing. Much of Rory McIlroy's driving power comes from how well he uses the ground to generate power. Modern golf research highlights that force in the golf swing begins at the ground and transfers upward through the body (Nesbit & Serrano, 2005). McIlroy displays this principle, using his lower body to start the swing and build speed. Even though he is not among the tallest players, he still ranks amongst the longest hitters on tour, which shows that his distance relies more on mechanics rather than his height or wingspan. Research shows that golfers who make use of vertical and horizontal ground forces produce more clubhead speed without needing more physical effort (Kwon et al., 2013). Mcllroy's technique reflects these findings, as his swing relies heavily on lower-body power with a strong ground force reaction.

*Biomechanical Characteristics*

Ground Forces and Power Generation

McIlroy's swing stands out because of how strongly he pushes against the ground particularly during the transition into the downswing. Research indicates that skilled golfers reach their peak vertical force just before impact, which significantly increases club head speed (Kwon et al., 2013). McIlroy does this by quickly increasing pressure on his lead foot and pushing off the ground to create upward force. Although he lacks height, McIlroy has strong leg muscles that contribute to this particular skill.

Weight Transfer and Sequencing

This movement is closely tied to how quickly his hips rotate, a key factor which helps transfer energy through the swing (Cheetham et al., 2016). His weight shift from his back foot to his lead foot is both smooth and well-timed, allowing him to build and release energy explosively. Figure 2 shows how the percentage of pressure applied on parts of both the lead and trail foot shifts during the golf swing. Additionally, his lower body provides a stable base helping him generate upper-body speed without losing control. These synchronized movements help McIlroy maximize both power and consistency in his swing.

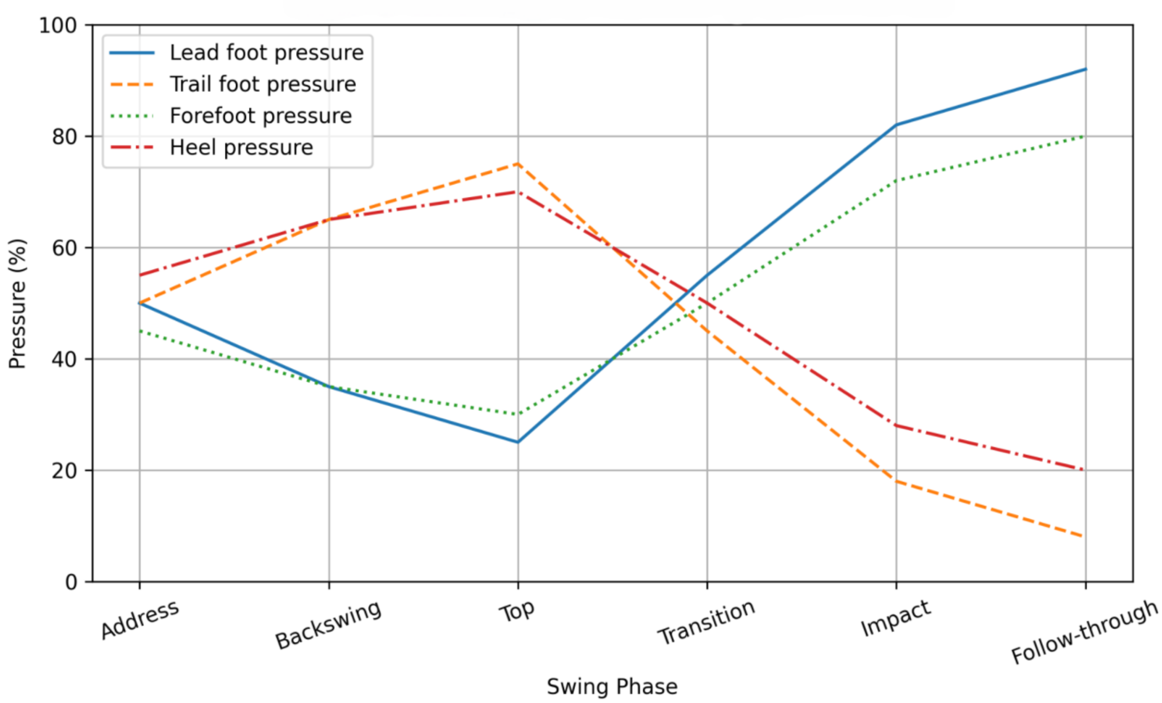


**Figure 2.** Center-of-pressure movement during the swing
Source: Created by the author using illustrative data

*Performance Impact*

The effective use of ground reaction forces enables McIlroy to hit exceptionally long drives while staying in control. By generating power from the ground, he increases club head speed efficiently, reducing reliance on upper-body effort (Nesbit & Serrano, 2005). His vertical force production also creates strong launch conditions, since increased upward force can influence launch angles and spin rate (Betzler et al., 2012). This often leads to a high launch and low spin ball flight that increases distance. Furthermore, his strong lower-body mechanics improve balance and stability. McIlroy's ability to harness these forces effectively helps him hit the ball farther and straighter than most players.

### 4.3 Nelly Korda- Stability and Rhythm

*Background*

Nelly Korda, a talented player on the LPGA Tour, has become one of the most consistent ball strikers in professional golf. Her success is not just a result of her physical strength and distance off the tee, but also her ability to repeat an efficient and controlled golf swing. In a sport where variability often separates amateurs from elite players, Korda's repeatability sets her apart. She demonstrates how efficient biomechanics can lead to continued success across different courses and conditions (Nesbit & Serrano, 2005)

Unlike many players who rely on corrective movements, Korda's mechanics are fundamentally sound and controlled. This allows her to maintain consistency under pressure. As a result, she is an ideal example for studying how stability and timing contribute to accuracy and power within the golf swing.

*Biomechanical Characteristics*

Smooth Tempo

Korda's golf swing is characterized by a smooth and controlled tempo, which plays a critical role in maintaining harmony between different parts of the body. Her downswing starts with the rotation of her lower body and is followed by the rotation of the torso and arms, creating an efficient kinetic sequence. This sequencing allows energy to move smoothly through the swing and increases both speed and control (Kwon et al., 2013).

Stable Posture

Additionally, Korda maintains a stable posture throughout her swing, minimizing unnecessary lateral movement and preserving her spine angle from address through impact. Nelly Korda is often known for her noticeably upright posture during the swing. This stable posture makes it possible for her golf club to remain on plane for the duration of the golf swing. By consistently maintaining posture, Korda makes it possible for her swing to be very powerful and consistent, compared to her competitors. Research shows that more stable swings help golfers hit the ball more consistently (Mahadas et al., 2019).

Low Swing Variability

Each of Korda's swings seems to mirror the previous one, enabling her to make subtle adjustments depending on course conditions. This repeatability helps her adapt to different situations without losing accuracy or control.

Many amateurs and even pros struggle with the ability to make adjustments in windy, wet, or cold conditions. Korda, due to her low swing variability and stable posture, is able to perform at her best in all conditions at all courses, contributing to her three major championship wins.

*Performance Impact*

The combination of her smooth tempo, stable posture, and low variability directly contributes to her high level of accuracy and consistency. By maintaining control over her body movements, she is able to square her clubface in a very repeatable manner. This results in a small shot dispersion and reliable ball flight, even under tournament pressure. Furthermore, her efficient mechanics reduce risk of injury on her body, allowing for sustained performance for the duration of her season and career. Rather than relying on physical size and strength, Korda's approach emphasizes efficiency and control, which are more reliable over time. Her ability to consistently reproduce her swing mechanics enhances her adaptability. All of these factors contribute to her very powerful and consistent swing.

### 4.4 Collin Morikawa - Precision Impacts Mechanics

*Background*

Collin Morikawa has quickly established himself as one of the most precise ball strikers in professional golf and is especially known for his iron play. Unlike many modern players who aim to maximize distance, Morikawa finds success in his ability to consistently hit the ball squarely on the club face at impact. His control over ball flight has made him one of the most reliable approach players on both the PGA tour and in major championship competitions. Morikawa's swing demonstrates how efficient technique and repeatability can outweigh physical power at the highest level of golf. Research in golf biomechanics suggests that reducing variability in swing mechanics is one of the most important factors in producing consistent outcomes (Nesbit & Serrano, 2005; Mahadas et al., 2019)." This trait can also be seen across the other golfers discussed in this paper. Morikawa's high accuracy also allows him to attack pins in situations where other players would not be able to do so. This gives Morikawa an advantage, which is reflected in his success at major championships including 2 major victories.

*Biomechanical Characteristics*

Morikawa utilizes a very stable lead wrist, minimal club face rotation, and a very controlled swing path. These mechanics help Morikawa maintain full control of the golf club and therefore the golf ball. One of the most defining elements of his biomechanics is his ability to maintain the position of his lead wrist through impact. This stability reduces unnecessary clubface movement and produces a swing that is very easy to replicate. This stability is essential, as even slight inconsistencies in wrist position can significantly alter ball flight and accuracy (Richardson, 2016). He minimizes his reliance on a perfect tempo by eliminating the factor of flexing and extending his wrist at the perfect time. Additionally, his club face has minimal rotation, which also decreases his reliance on perfect timing. Many amateur golfers rely heavily on timing which can wreak havoc when it comes to high-pressure moments due to the variability it creates. When these characteristics are combined with his efficient arm movements, they create a highly consistent swing.

*Performance Impact*

The biomechanical efficiency of Morikawa's swing results in his consistent ball flight and strong approach play. By controlling his club face using a strong lead wrist, Morikawa is able to minimize shot dispersion, which has contributed to multiple PGA tour victories throughout his career. Approach play is vital to creating birdies, therefore Morikawa, a global example of excellent approach play, has little problem making birdies and making swift recoveries after wayward teeshots. His mechanics also allow him to adapt his shots depending on the course conditions, whether that involves hitting a lower or higher shot, or shaping a draw or fade. Despite not being physically bigger than other players on the PGA tour, Collin Morikawa's consistent iron and approach play sets him apart and contributes to his success. Morikawa's control of his wrists, club face, and club path all contribute to his consistent swing.

## Discussion

5.1 Synthesis of Case Studies

The four case studies examined in this paper each demonstrate that elite golf performance is not a product of a single biomechanical characteristic, but a combination of many complicated body movements that work together to maximize power and consistency. Although Tiger Woods, Rory McIlroy, Nelly Korda, and Collin Morikawa possess different swing styles and strengths, each of them has achieved success through efficient biomechanics and repeatable swing patterns (Penjas Journal of Physical Education, 2023).

Tiger Woods and Rory McIlroy are golfers whose success is largely driven by their ability to generate power. Woods is known for his effective sequencing. He has exceptional rotation between his hips and shoulders, allowing him to store and release substantial energy during his swing. Similarly, McIlroy is known for his efficient use of ground reaction forces and lower body sequencing, which contribute to some of the highest clubhead speeds in the PGA Tour. Despite their emphasis on power, both golfers are able to maintain their balance and timing throughout the swing, ensuring their extra power does not come at the cost of accuracy (Kwon et al., 2013; Betzler et al., 2012).

In contrast, Nelly Korda and Collin Morikawa are examples of the value of precision-based biomechanics. Korda's smooth tempo, stable posture, and low swing variability enable her to consistently hit accurate shots - even under pressure. Likewise, Morikawa's stable wrists, minimal clubface rotation, and consistent swing path lead to his elite iron play.Their success shows that golfers do not need to rely solely on power to succeed at the highest level.

Together, these case studies reveal a common theme: regardless of whether a golfer prioritizes power or precision, success ultimately depends upon strong, efficient biomechanics. There is no substitute for the biomechanical movements that these players have mastered over years of practice and hard work. Although each golfer achieves this in a different way, effective sequencing, balance, stability, and ground force transfer all contribute to a performance which brings success at the highest levels (Kim et al., 2024). Table 2 is a comparative study in the elite golfer case studies.

**Table 2.** Case study comparison of elite golfers

| Golfer | Most Important Characteristic | Tempo | Ground Force Power | Sequencing | Consistency |
|---|---|---|---|---|---|
| Tiger Woods | Sequencing | Quick | High | Excellent | High |
| Rory McIlroy | Ground Force Power | Mechanical | Very high | Excellent | Medium |
| Nelly Korda | Tempo | Smooth | Medium | Smooth | Very high |
| Collin Morikawa | Consistency | Mechanical | Medium | Precise | Very high |

5.2 Interpretation of Findings

The findings of this research suggest that both power and consistency in the golf swing result from a combination of biomechanical movements rather than physical strength alone. While many golfers associate distance with muscular strength, the case studies and literature reviewed indicate that power is primarily generated through efficient sequencing, coordination and the transfer of energy through the body (Kwon et al., 2013; Penjas Journal of Physical Education, 2023).

Elite golfers are able to utilize the ground, transferring force through the lower body, torso, and arms. Figure 3 highlights this specific sequence in which forces are transferred through the body during the swing. Ultimately, this force is delivered to the clubhead at impact. When each segment of the body moves in the correct sequence, greater clubhead speed can be achieved with less wasted motion (Kwon et al., 2013). This principle is particularly evident in the swings of Tiger Woods and Rory McIlroy.

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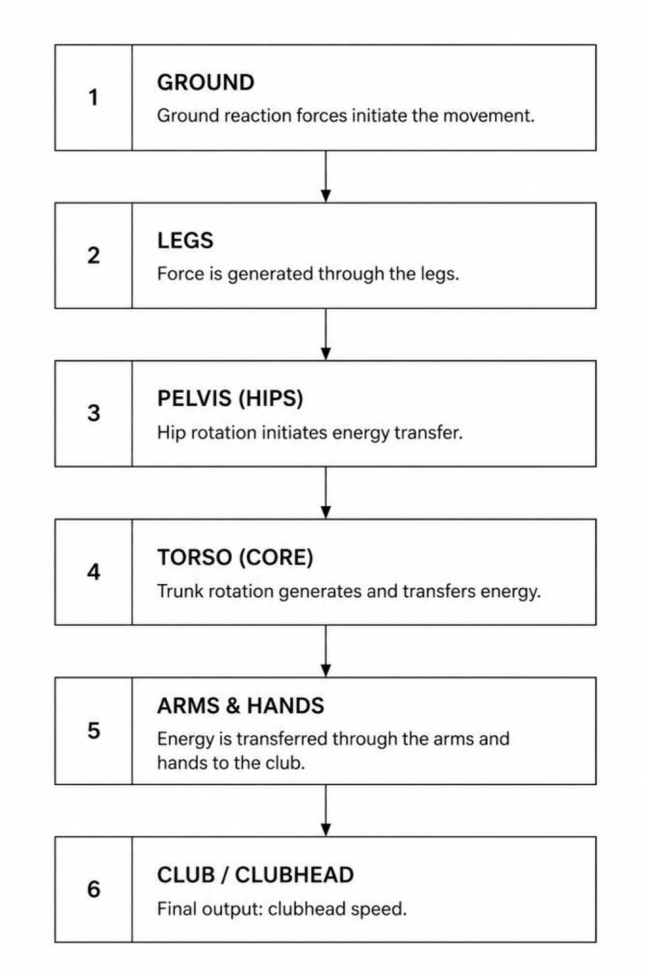


**Figure 3.** Energy transfer through the kinetic chain
Source: Created by the author using findings from the case studies.

Through the research on Morikawa and Korda, it can be deduced that consistency largely depends on posture stability and controlled clubface delivery. Maintaining balance and body positioning throughout the swing reduces variability and allows golfers to reproduce similar impacts from shot to shot (Mahadas et al., 2019). Additionally, precise control of the clubface is essential for producing predictable ball flight and minimizing errors. These characteristics are exemplified by Korda and Morikawa.

Ultimately, the distinction between power and consistency is smaller than it may appear. It is important to note that these characteristics are not mutually exclusive as both depend on efficient movement and energy transfer throughout the swing. Both outcomes rely on different movement patterns that allow golfers to efficiently control their bodies and energy transfer. Efficient biomechanics, therefore, serve as the foundation for all aspects of successful golf performance (Kim et al., 2024).

### 5.3 Coaching and Training Implications

The results of this research can provide useful insights for golf coaches and players. Efficient biomechanics are essential for power and consistency, therefore training programs should focus on improving the physical movements involved in the golf swing. This way, golfers can avoid developing bad habits that come in the way of their ability to generate power or consistency. However, rather than concentrating exclusively on just swing technique, coaches should look to incorporate drills that emphasize balance, mobility, and strength (Kim et al., 2024).

Balance training is particularly important because staying stable throughout the swing allows golfers to maintain their posture and produce more consistent shots. Mobility exercises can improve rotational flexibility in the hips, torso, and shoulders, allowing golfers to create more separation between the hips and shoulders during the wing. This separation helps golfers better store and transfer energy during the swing. Strength, although not the most important factor affecting performance, still contributes to the power generated by a player. Stronger muscles could also help reduce injury risk when paired with good flexibility. Overall good strength and mobility work together to help golfers move more efficiently through the swing.

The step-through drill is an example of a drill that encourages proper weight transfer and starting the downswing with the lower body. This contributes to the creation of ground reaction forces. Resistance band rotation drills can help golfers simulate the rotational strength necessary to develop an effective golf swing. Similarly, pressure shift training teaches golfers how to effectively use the ground reaction forces by exaggerating the pressure needed in certain spots.

By combining instruction with focused training devices and methods, golfers can work towards more biomechanically efficient swings. These improvements can lead to increased clubhead speed, greater consistency, and a reduced risk of injury, ultimately leading to better performance on the golf course (Penjas Journal of Physical Education, 2023; Kim et al., 2024).

### 5.4 Limitations of Current Research

Although biomechanical research has helped improve our understanding of the golf swing, it is important to point out several limitations. For example, many studies involve a relatively small number of participants who do not fully represent the golfing community. Groups like women, juniors, or people with different body types are often not sufficiently represented. As a result, it is difficult to know whether the findings apply equally to all golfers.

Another challenge is that much of the research takes place in controlled laboratory conditions. While technologies such as motion capture systems and force plates do provide important data about the golf swing, they cannot fully recreate what happens on the actual golf course. Golfers must deal with factors such as uneven ground, changing weather conditions, course management decisions, and tournament pressure that are not present in laboratory settings. Thus, some findings may not fully apply to real golf situations (Bourgain et al., 2022).

Additionally, a large portion of golf biomechanics research tends to focus on elite golfers. While studying highly skilled and successful players does provide valuable information on correct mechanics, it does not fully explain how amateur, junior, or developing golfers can develop those skills. In the future, more research involving under-represented groups such as junior, amateur golfers and female athletes, can help address this gap (Bourgain et al., 2022). Going forward researchers should study golfers in actual playing conditions to better understand how their swing mechanics change during competition. This would help researchers understand how biomechanics affects golfers of different skill levels under different playing conditions

## Conclusion

The golf swing is a highly coordinated movement that depends on a precise sequence of movements of the body. Throughout this research, it has become evident that elite performance in golf is not determined solely by physical strength or natural ability, but by a golfer's ability to efficiently create, transfer, and control energy during the golf swing. Understanding these biomechanical concepts provides insight into why certain golfers are able to consistently perform at the highest level while others struggle with inconsistency.

The research demonstrates that distance is primarily generated through the use of ground reaction forces and the kinetic chain. By transferring energy from the ground through the lower body, torso, arms and club, golfers are able to maximize club head speed. At the same time, accuracy is mostly dependent on posture stability, controlled clubface, and the ability to make consistent movements. These characteristics minimize variability in the actual flight of the ball.

The case studies of Tiger Woods, Rory McIlroy, Nelly Korda, and Collin Morikawa reinforce these findings. Although Woods and McIlroy emphasize powerful force production while Korda and Morikawa prioritize rhythm and tempo, each golfer uses the same biomechanical principles in order to achieve success. Their indisputable success as professional golfers demonstrates that there is no single ideal golf swing, but rather multiple different swings that are incredibly efficient and high quality.

Ultimately, the study of biomechanics in golf provides a framework for improving golf performance at all levels. By applying certain principles through targeted training, golfers can develop more efficient swing mechanics, reduce risk of injury, and create more consistent performance. As technology and research continue to advance, the study of biomechanics will only become more accurate and helpful.

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