Review Article

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A Review of HIFEM-Induced Core Muscle Strengthening and its Effects on Golf Driving Distance

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Abstract

Maximizing golf driving distance relies on clubhead speed, efficient rotational mechanics, and optimal energy transfer. Core strength plays a critical role in these factors, making targeted muscle training essential for performance enhancement. HIFEM technology has emerged as a non-invasive method for inducing supramaximal muscle contractions, leading to significant improvements in core strength, neuromuscular activation, and mobility. This review examines the biomechanical principles of the golf swing and explores HIFEM's mechanisms of action. While HIFEM has demonstrated effectiveness in increasing muscle hypertrophy and explosive strength, its potential role in golf-specific performance optimization remains an area for further investigation. Integrating HIFEM with traditional resistance training, mobility exercises, and swing practice may offer a comprehensive approach to improving golf performance and injury prevention.

Keywords: Clubhead speed; Muscle training; Non-invasive; Muscle contractions; HIFEM technology; Neuromuscular; Golf swing

Introduction

Maximizing driving distance in golf is a subject of broad interest, ranging from professional players to recreational enthusiasts. Key factors contributing to driving distance include increasing clubhead speed, optimizing launch angle, and achieving an appropriate level of backspin [1]. Among these, enhancing clubhead speed is crucial for raising the ball's initial velocity, which depends heavily on muscle strength, explosive power, and the efficient rotational mechanics of the body [2,3].

This review examines how HIFEM technology, a method of muscle strengthening [4], may increase trunk rotational speed and explosive power in golfers, thereby potentially improving driver distance. HIFEM utilizes powerful, focused electromagnetic fields to induce supramaximal muscle contractions in deep muscle layers [4]. First, this article outlines the physics underpinning golf driving distance. It then describes the underlying mechanisms by which HIFEM enhances muscle strength, reviews existing studies on HIFEM's impact, and discusses implications for golf performance and future research directions.

Physics of Golf Driving Distance

Projectile Motion Model

Driving distance in golf can be simplified using a projectile motion model. Assuming no air resistance, the distance can be described by the horizontal distance formula (Figure 1):

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$$R = \frac{v^2}{g}\sin(2\theta)$$

Figure 1: Horizontal range of the projectile.

While real-world golf shots are subject to drag and lift forces due to the ball's dimple design and backspin, this formula illustrates the importance of optimizing launch velocity and spin to achieve greater distance [5]. Launch velocity is primarily determined by clubhead speed, which depends on a combination of muscular power, efficient rotational mechanics, and optimized energy transfer through the golf swing [6].

While efficient mechanics and energy transfer can be developed through practice, muscle strength, and power can be enhanced through various training methods, including resistance training and flexibility exercises [7].

Application of angular momentum conservation

The golf swing entails sequential rotational movements (a kinetic chain) from the backswing to the downswing, enabling the body and arms to accelerate the clubhead to a peak velocity at impact [8,9]. Conservation of angular momentum plays a critical role (Figure 2).

$$I_1\,\omega_1 = I_2\,\omega_2$$

Figure 2: Angular momentum equation.

A large moment of inertia at the top of the backswing can be rapidly reduced before impact, causing an increase in angular velocity. A stable and powerful trunk rotation is crucial for this energy transfer, thus making trunk muscle strength an important factor for maximizing clubhead speed [3,10].

Collision Mechanics and Energy Transfer

During impact, energy is transferred to the ball in accordance with Newtonian mechanics and the principle of conservation of energy. The kinetic energy imparted to the ball is given by the equation in Figure 3.

$$K = \frac{1}{2}\,m\,v^2$$

Figure 3: The equation for kinetic energy.

The smash factor (ball speed/clubhead speed) is commonly used to measure energy transfer efficiency in a golf shot. While a higher clubhead speed generally results in increased ball speed and longer distance, optimal impact conditions—such as centered contact, proper launch angle, and spin rate—are also critical for maximizing driving distance.

HIFEM: Principles and Mechanisms of Muscle Strengthening

Fundamentals of HIFEM

HIFEM technology for muscle toning and strengthening utilizes high-intensity electromagnetic pulses to target specific body regions, inducing supramaximal muscle contractions that exceed the capacity of voluntary contractions. Its mechanism is based on Faraday's law of electromagnetic induction (Figure 4), which generates a rapidly changing magnetic flux that, in turn, induces electric fields within tissues [11].

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

Figure 4: Faraday's law of electromagnetic induction.

This process stimulates the nerve membrane, leading to depolarization within the axon and triggering the opening of voltage-gated sodium and potassium ion channels. Consequently, an action potential is initiated and further propagated through the physiological mechanisms of nerve conduction, inducing deep and effective muscle contractions [12,13]. Unlike conventional electrical muscle stimulation devices, which primarily affect superficial tissues, HIFEM penetrates deeper muscle layers due to its intensive magnetic field, broad treatment area, and high-frequency stimulation.

Core strength and HIFEM

Strengthening the core muscles, including the external obliques, rectus abdominis, and erector spinae, is critical for stabilizing the rotational axis of the golf swing and generating powerful trunk rotation. Concentrated HIFEM treatments targeting these muscle groups have been shown to improve core strength by 97% [14] while also enhancing muscle function [15,16], potentially leading to greater rotational speed and improved kinetic chain efficiency during the swing.

Existing Research Findings

HIFEM technology induces supramaximal contractions by depolarizing motor neurons. Its effects, like muscle hypertrophy and increased strength, are similar to those achieved through high-intensity resistance training [17]. While HIFEM has been shown to enhance muscle mass and neuromuscular activation [17], direct evidence regarding its role in improving the rate of force development or optimizing the ATP-PCr (phosphocreatine) system remains limited. However, by facilitating greater recruitment of muscle fibers and improving overall muscle output, HIFEM may help golfers develop the explosive power required for a more forceful and controlled swing. Conversely, its effects on endurance-based performance are likely minimal, as sustained energy output in prolonged play relies on aerobic capacity, which is best developed through traditional endurance training.

Implications for Golf Performance

Importance of core rotational speed

Core strength is fundamental in golf performance, as it serves as the central link between the lower and upper body, facilitating efficient energy transfer throughout the swing. Multiple studies evaluating the effectiveness of HIFEM have demonstrated significant improvements in core muscle strength. A strong and stable core enhances rotational power, balance, and control, all of which contribute to generating greater clubhead speed and improving swing mechanics [15,18]. The ability to produce explosive trunk rotation is particularly crucial, as it allows golfers to maximize torque and efficiently channel energy from the lower body to the upper body and ultimately to the clubhead [19,20]. By enhancing core stability and rotational power, HIFEM may help golfers achieve improved overall swing mechanics and driving distance [21]. Additionally, a stronger core contributes to injury prevention by reducing stress on the lower back, a common issue among golfers [22].

Muscle–tendon–joint coordination

Nevertheless, muscular strength alone does not fully determine golf performance. Optimal intermuscular coordination, joint mobility, and timing are equally critical. While HIFEM is primarily recognized for its ability to enhance muscle strength, research also supports its effectiveness in improving range of motion, reducing stiffness, and enhancing overall mobility and flexibility. However, to maximize performance gains, combining HIFEM with stretching, mobility exercises, and swing practice is recommended, ensuring a well-rounded approach that strengthens muscles while refining movement efficiency and technical aspects of the golf swing.

Future Directions and Research Gaps

Large-scale clinical studies

While evidence for HIFEM-induced muscle hypertrophy and trunk rotational speed improvement is growing, existing data are largely drawn from small pilot studies [23]. To establish robust evidence, large-scale randomized controlled trials must be conducted. Future studies investigating the effects of HIFEM on golf performance should assess muscle hypertrophy in key golf-related muscle groups, which are crucial for rotational power. Such trials should account for variables like age, gender, and golf experience, and measure changes in driving distance and core strength over longer follow-up periods.

Hybrid approach with conventional training

While HIFEM technology effectively enhances muscle strength and hypertrophy through supramaximal contractions, its impact can be further amplified when integrated with conventional resistance or functional training [24]. Traditional training methods offer neuromuscular coordination benefits; therefore, combining HIFEM with resistance exercises presents an optimal strategy for maximizing strength gains and improving golf performance.

A promising area of future research lies in hybrid training protocols, where HIFEM is paired with targeted resistance training or golf-specific movement drills. For instance, performing rotational exercises, resistance band drills, or weighted swings immediately following a HIFEM session could enhance both muscle activation and motion-specific neuromuscular adaptations. This sequential approach may accelerate strength development, improve force transfer efficiency, and contribute to more explosive and controlled golf swings.

Personalization and individual variability

Factors including baseline strength, joint mobility, comorbidities, age, and sex can significantly influence HIFEM outcomes. Personalizing treatment frequency, output level, and targeted muscle groups may optimize benefits and minimize risks. For elite players and low-handicap amateurs, careful coordination of HIFEM sessions with ongoing swing adjustments is essential. Beginners and older players might profit from a gentler, progressive approach tailored to their physical limits.

Additional Theoretical Considerations

Angular kinematics and energy

To better elucidate the role of rotational mechanics in golf, one may reference several fundamental equations of motion [25].

First, the angular kinematics of the swing can be described by the given equation in Figure 5.

$$\tau = I\alpha$$

Figure 5: Angular kinematics of the swing.

During the downswing, golfers reduce the moment of inertia by repositioning their arms and club, often referred to as "bringing the club closer to the body" which increases angular velocity via the principle of angular momentum conservation:

$$L = I\omega = \text{constant}$$

Figure 6: Principle of angular momentum conservation.

Though the golf swing does involve external forces (e.g., gravity, ground reaction), short bursts of internal reconfiguration can temporarily approximate a nearly conserved angular momentum system, thereby boosting clubhead velocity.

From an energy perspective, the rotational kinetic energy of the golfer-plus-club system is given by the equation in Figure 7.

$$E_{\text{rot}} = \frac{1}{2} I\omega^2$$

Figure 7: Rotational kinetic energy.

Increasing angular velocity significantly raises rotational kinetic energy, which, if transferred efficiently to the ball, contributes to greater driving distance [25,26].

Impulse and collision analysis

When examining the collision between the clubhead and the ball, the concept of impulse is useful:

$$J = F\Delta t = \Delta p$$

Figure 8: Impulse (change in momentum).

Although the collision lasts only a few milliseconds, a larger impulse can lead to a higher ball launch speed. In this context, muscular strength and rotational velocity both help the golfer generate a larger impulse during the brief impact interval [27].

Implications for HIFEM

By strengthening trunk and core muscles, HIFEM may enable golfers to achieve a higher angular velocity and, potentially, a more substantial torque during the swing. This may enhance rotational kinetic energy, promoting a more efficient transfer of force during ball-club impact. Nevertheless, golf performance is governed by multiple factors beyond muscle strength, including flexibility, coordination, and swing mechanics [28]. While stronger core muscles can improve torque generation, improper wrist action or poor shoulder alignment may still limit the effective transfer of energy to the ball, highlighting the need for a well-rounded approach that includes mobility and technique refinement.

Conclusion

This review has examined the potential for HIFEM-induced core strengthening to improve golf driving distance, particularly by enhancing driver performance. Since clubhead speed is the primary determinant of launch velocity—and, consequently, total distance—increasing trunk rotational speed through core muscle development can offer a competitive advantage.

HIFEM utilizes electromagnetic energy to induce supramaximal muscle contractions, leading to measurable increases in muscle strength. However, golf swing mechanics rely on more than just strength. Factors such as intermuscular coordination, swing technique, and joint mobility also play crucial roles. Therefore, HIFEM should be seen as a complementary tool rather than a standalone solution for maximizing distance.

Ultimately, while the golf swing relies on a coordinated kinetic chain, HIFEM may serve as a valuable adjunct in accelerating strength gains, particularly for time-constrained or rehabilitation-focused golfers. With further research, HIFEM holds promise as a valuable addition to existing training methods, offering incremental yet meaningful improvements in driving distance and overall performance.

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