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Different warm up protocols on immediate golf drive performance in recreational golfers

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DIFFERENT WARM UP PROTOCOLS ON IMMEDIATE GOLF DRIVE PERFORMANCE IN RECREATIONAL GOLFERS

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In Partial Fulfillment of the Requirements
for the Degree
Master of Science

By
Emily Travis
Spring 2015
THESIS OF EMILY TRAVIS APPROVED BY

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MASTER’S THESIS

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ABSTRACT

It has been recommended that golfers perform a warm up routine before playing. Currently, the optimal warm up routine to improve performance of a maximal golf drive is not clear, however, research does recommend active-dynamic stretching as opposed to static stretching during warm up. Currently, there have been no studies conducted using recreational golfers to research functional resistance exercises towards immediate performance of golf. The purpose of this study was to assess the effects of three different warm up protocols in recreational golfers on immediate golf performance of a maximal golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF). Golf performance factors were evaluated for 17 adult recreational golf participants after they performed three different warm up protocols: (1) no warm-up, (2) active-dynamic warm-up, and (3) functional resistance warm up, on three, non-consecutive days. No significant difference was found in MCHS, MDD, or SF between the three warm up protocols. Future research is needed in order to accurately assess and find an optimal warm up protocol for recreational golfers.
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Chapter 1

Introduction

Golf as a sport has a widespread appeal to a diverse range of ages and skill levels for its participants. It has been recommended that golfers perform a warm up routine prior to play because of the complexity and physical demands that the sport of golf requires (Fradkin, Finch, & Sherman, 2001; Gergley, 2009; Tilley & Macfarlane, 2012). There are vast amounts of variations of warm up techniques and strategies that can be utilized in preparation for specific activities, depending on the physical demands.

The term warm up has been defined as a period of preparatory exercise in order to enhance subsequent competition or training performance (Fradkin, Sherman, & Finch, 2003). A warm up can cause a variety of effects on the body in preparation for activity. Four related contributions that pre-exercise warm up provides are increasing body temperature, increasing muscle and tendon suppleness, stimulating blood flow to the periphery, and enhancing free, coordinated movement (Bishop & Middleton, 2013; McArdle, Katch, & Katch, 2010; McMillian, Moore, Halter, & Taylor, 2006; Smith, 1994; Tilley & Macfarlane, 2012; Vandervoort, 2009; Weerapong, 2005). The increase in work demands the blood flow, the activity of the muscles raises the temperature in the muscle by about four degrees Celsius, which enhance the flexibility of the muscle fibers and the greater movement, and the temperature increases the suppleness of the tendons and ligaments, which then increase the range of motion (Bishop & Middleton, 2013; McArdle et al., 2010).

The final benefit is raising core temperature by one to two degrees Celsius, which happens as the heat being produced by the muscles is carried away through the blood and
eventually to the surface of the skin to start the sweating process (McArdle, Katch, & Katch, 2015).

The American College of Sports Medicine (ACSM) suggest to begin a general exercise warm up session with 5 to 10 minutes of low to moderate intensity aerobic activity (e.g., walking, jogging, cycling) which should cause a rise in body temperature and decrease the potential for stiffening or soreness of the muscles (Pescatello, 2014). In addition, warm up should positively enhance the power-velocity relationship because of the skeletal muscle increasing speed due to the muscle tissue’s rising internal temperature (Vandervoort, 2009).

For sporting activities requiring flexibility, warming up with a general stretching routine is recommended (McArdle et al., 2010; McMillian et al., 2006; Narici & Maganaris, 2007; Samson, Button, Chaouachi & Behmm, 2012; Vandervoort, 2009; Weerapong, 2005). Stretching can help release connective tissue bonds in resting musculotendinous units and between the myofasical tissues that can lead to a lessened range of motion (Narici & Maganaris, 2007). Lastly, the rehearsal of sport-specific coordinated movement patterns is commonly found in a warm up routine (e.g., shooting at the hoop in basketball, or swinging a golf club) when flexibility would enhance performance (Vandervoort, 2009). In addition to flexibility, neuromuscular connections are enhanced through warm up. This could occur by waking up the reticular activating system (RAS), or stimulating the motor pattern in the brain (McArdle et al., 2015).

Active-dynamic and static stretching are two well-known types of activities that are utilized in warm up for flexibility in physical performance. Athletes commonly engage in static stretching during a warm up period prior to practice or competition. It has
been believed by many that static stretching provides increased range of motion that will lead to reduced injury and/or performance improvement (Gergley, 2009). Interestingly, however, research has provided evidence that use of static stretching before exercise does not actually have the benefit of reduced incident of injury (Gergley, 2009; McMillian et al., 2006). Additionally, a significant decrease in performance, specifically power and speed, with the use of static stretching has been shown (Bishop & Middleton, 2013; McMillian et al., 2006; Shrier, 2004). Although there is a reason to increase flexibility, static stretching can decrease force transmission rates in the short-term and has even been found to be detrimental to performance when compared to dynamic stretching during a warm up (Gergley, 2009; McMillian et al., 2006; Tilley & Macfarlane, 2012).

Various studies have demonstrated that active dynamic stretching following the general warm up may improve physical performance as opposed to static stretching, especially for complex movements (Gergley, 2009; McMillian et al., 2006; Tilley & Macfarlane, 2012). Most dynamic warm ups include continuous and progressive movements. For example, calisthenics are commonly paired with change in direction movements and running drills (McMillian et al., 2006). Performance tests that include explosive force production have been positively established through the completion of dynamic warm ups (Bishop, 2013; Fletcher & Jones, 2004; McMillian et al., 2006; Taylor, Sheppard, Lee, & Plummer, 2009). Dynamic warm up protocols, if performed long enough, may raise temperatures similar to a traditional cardiovascular component of warm up, which enhance appropriate motor control as they require the muscles to contract in sequence, affecting the central programming of the muscle contraction/coordination (Bishop, 2013; McMillian et al., 2006).
Dynamic warm up routines are becoming more commonly utilized over the traditional cardiovascular component of the warm up followed by static stretching routines due to time savings and the possibility of improving short-term force production (Bishop, 2013). Despite the research and benefits of a dynamic warm up, there remains a controversy between the two. This may be due to coaches and athletes wanting increased static flexibility for performance, lack of knowledge, habit, or because there are a variety of different warm ups that can be used to achieve the same outcome.

Functional resistance training is another form of warm up that is utilized for preparation of physical activity, aimed to better the coordination between the muscular and nervous systems as well as the force-producing capabilities of muscles for an activity or task (Tilley & Macfarlane, 2012). Several studies have utilized resistance training as warm up through the use of a Theraband® (Page et al., 1993; Tilley & Macfarlane, 2012). Functional resistance training can cause adaptive changes within the nervous system that lead to better muscle coordination because of muscle activation (Sale, 2002). This can lead to both increased peak force and greater net force within the direction of the movement (McMillian et al., 2006; Sale, 2002).

Although there are various types of warm up protocols, the optimal warm up protocol for golf remains unclear. The golf swing is unique in the characteristics it encompasses such as being multi-segmental, rotational and a closed chain movement (Gordon, Moir, & Davis, 2009). The golf swing needs to be highly coordinated, requiring strength, explosive power, flexibly and balance, (Gordon et al., 2009) all movements which could be in opposition if the warm up is unable to be adequate for all. But what is the best way for golfers to obtain these requirements? Sufficient levels of range of
movement in a golf swing are well documented, as well as levels of flexibility in joints and tissues for optimal golf performance (Tilley & Macfarlane, 2012).

Research has suggested the importance of musculoskeletal structure flexibility for a golf swing; however, passive stretching prior to activity has immediate effects that have been associated with immediate decline in performance in sports, including golf (Tilley & Macfarlane, 2012). On the other hand, an improvement in golf swing performance has been shown when static stretching is eliminated and active dynamic stretching is incorporated into the warm up in competitive golfers (Gergley, 2009). Resistance training has been shown to cause adaptive changes when active dynamic stretching is incorporated into the warm up and static stretching is eliminated, which may lead to greater force production (Sale, 2002). Although these methods have been generally suggested, little research has been conducted on golf performance and the immediate effect of functional resistance training during a warm up routine.

Currently, the optimal warm up procedure routine to improve performance of a maximal golf drive is not clear, however, research does recommend active-dynamic stretching as opposed to static stretching during warm up. Currently, there have been no studies conducted using recreational golfers to research functional resistance exercises used towards immediate performance of golf through muscle activation. Because golf is such an increasingly popular activity for the general population, recreational golfers could benefit from an understanding of what specific warm up may enhance performance. The purpose of this study therefore was to assess the effects of different warm up protocols in recreational golfers on immediate golf performance of a maximal
golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF).

**Hypotheses**

H₀: There would be no significant difference in the golf performance factors of participants between no warm up (control), the active dynamic warm up, and a functional resistance Theraband® warm up protocol. The alpha level was set at p < 0.05.

Ha: There would be a significant, positive difference in golf performance factors of the participants following the functional resistance Theraband® warm up and the active dynamic warm up protocol compared to the no warm up (control) protocol.

**Operational Definitions**

All club movement measures were accomplished using the Flightscope® XI (EDH, Orlando, Florida). These measurements were averaged over the participant’s 10 maximal drives, excluding non-consistent ball strikes (outliers).

**Club head speed (mph):** A measure, in miles per hour, of how fast the club head of the golf club traveled at the point it impacted the golf ball.

**Maximal driving distance (yd):** A measure, in yards, of how far the golf ball traveled.

**Smash factor:** The ratio between the ball speed and the club speed. It provided information about the centeredness of impact and the solidity of the shot, an important factor related to performance. The Flightscope® calculated this information.
Consistent ball strike: Refers to the participant’s ability to strike the ball at impact in the desired manner. This was assessed by subjective feedback from the participant following each shot. The participant said, “yes” for solid contact or “no” for poor contact.

Delimitations

The sample population for this study was delimited to 17 adult (18 – 65 years old) recreational golfers (females n=6, males n=11). For the purpose of this study, golfers who play at least eight rounds of golf a year and have an average 18 hole score between 80 and 140 or an average 9 hole score between 40 and 70 were considered recreational golfers.

Significance of study

Currently, the optimal warm up protocol prior to golf in order to improve maximal drive performance is not clear. However, research evidence does suggest that an active dynamic warm up is more beneficial than static stretching in elite golfers (Gergley, 2009; McMillian et al., 2006; Tilley & Macfarlane, 2012). At present, no studies had been conducted to research functional resistance exercises on immediate golf performance of recreational golfers.

Summary

This introduction presented the importance and specific information regarding warm up/stretching, the different types, and their applications. This section also addresses warm up in regards to the game of golf. The purpose statement, hypotheses, delimitations, operational definitions, and significance are all explained thoroughly in this chapter.
Chapter 2

Literature Review

Introduction

The purpose of this study was to assess the effects of different warm up protocols in recreational golfers on immediate golf performance of a maximal golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF). In this review, previous work is presented that has led to the current evidence on proper warm up protocols and the need for proper warm up prior to activity. The current evidence on active-dynamic stretching, static stretching and functional resistance training with Theraband® use on performance was evaluated. Emerging studies are presented that have found significant results with different types of combined warm ups and explore these different types of warm up programs.

General Warm Up

Warm up generally fits into one of two categories: 1. General warm up using body movements or neuromuscular actions of the upcoming activity. An example would be aerobic activity. 2. Specific warm up applying larger muscles and rhythmic movements that provide a rehearsal of skill in the activity. Examples include swinging, throwing and shooting (McArdle et al., 2010). The general purpose of warm up is to increase muscle and tendon suppleness, to simulate blood flow to the periphery, to increase body temperature, and to enhance free, coordinated movement (Bishop & Middleton, 2013; McArdle, Katch, & Katch, 2010; McMillian, Moore, Halter, & Taylor, 2006; Smith, 1994; Tilley & Macfarlane, 2012; Vandervoort, 2009; Weerapong, 2005).
The majority of research has used activity as the method of warm up (Gastin, 2001; Hajoglou et al., 2005; Robergs et al., 1991). In each case, performance in either a continuous moderate activity (Hajoglou et al., 2005) or acute high intensity activity (Gastin, 2001; Robergs et al., 1991) was improved following warm up. Studies that incorporated an aerobic warm up component found significant improvements with golf related skills, specifically club head speed (Fradkin, Finch, 2003; Lephart, Smoliga, Myers, Sell, & Tsia, 2007; Smith, Callister, & Lubans, 2011; Thompson, Cobb, & Blackwell, 2007). Active warm up changes temperature at the muscle through metabolic heat production, which also causes cardiovascular changes including blood flow by dilation to aid in heat removal, and improved oxygen kinetics for transport (Bohr effect) between the blood and muscle cells (Hajoglou et al., 2005; McArdle et al., 2010; Robergs et al., 1991).

The muscle temperature is quickly elevated because 70% of the metabolic process is lost as heat, which has the effect of about a 2° C elevation in core temperature within five minutes (McArdle et al., 2010). To get rid of the heat, the circulatory system adapts through increased blood flow through the muscles to draw the heat, then vasodilation at the skin to remove the heat through conduction and sweating (Hajoglou et al., 2005; McArdle et al., 2010; Robergs et al., 1991). The temperature elevation at the muscle improves the muscle mechanics (Gastin, 2001; Hajoglou et al., 2005; McArdle et al., 2010; Robergs et al., 1991) and the increased blood flow also aids in removing lactate more quickly, which allows the muscle to work at a higher intensity for longer (Gastin, 2001). These findings suggest positive physiologic and performance effects from warm up prior to activity.
As part of a warm up strategy, a stretching routine has typically been recommended for activities that require flexibility (Narici & Maganaris, 2007; Samson et al., 2012; Vandervoort, 2009). Stretching is known to help release connective tissue bonds that reside in resting musculotendinous units between the myofacial tissues, which can also be limiting for the desirable range of motion in joints (Narici & Maganaris, 2007). Traditional warm up methods regularly included a static stretching component, however it has been questioned whether static stretching in warm up has a detrimental effect on power and force production (Bishop & Middleton, 2013; Fletcher & Anness, 2007; Samuel, Holcomb, Guadagnioli, Rubley, & Wallmann, 2008; Sayers, Farley, Fuller, Jubenville, & Caputo, 2008; Young & Behm, 2003).

Researchers have suggested that there is a two-fold argument for incorporating static stretching in warm up (Bishop & Middleton, 2013). First, to improve static flexibility for sports where a performer is required to be at the limits of static range of motion. Second, due to an athlete’s perceived psychological needs for increase static flexibility levels, or due to feelings of being uneasy/unprepared prior to competition without performing static stretching (Bishop & Middleton, 2013). In that situation, static stretching likely creates alterations in musculotendinous stiffness or altered reflex sensitivity and decreased muscle activation and therefore impact upon the rate of force transmission (Avela, Kyrolainen, & Komi, 1999; Bishop & Middleton, 2013; Kookonen, Nelson, & Cornwell, 1998; Knudson, Bennett, Corn, Leick, & Smith, 2001).

On the other hand, active-dynamic stretching has been shown to improve physical performance when opposed to static stretching in various studies (Gergley, 2009; McMillian et al., 2006; Tilley & Macfarlane, 2012). Most dynamic warm ups include
progressive and continuing motions that are sport specific (McMillian et al., 2006).

Performance tests have shown positive benefits with the use of dynamic warm ups, specifically with explosive force production performance (Bishop, 2013; Fletcher & Jones, 2004; McMillian et al., 2006; Taylor, Sheppard, Lee, & Plummer, 2009). If performed long enough, dynamic warm up protocols may provide the temperature-related mechanisms similar to traditional cardiovascular components of a warm up, which provide appropriate motor control as they affect the central programming of the muscle by contracting in sequence, affecting the muscle coordination (Bishop, 2013; McMillian et al., 2006). These include decreased stiffness of the muscles and joints; increased transmission rate of nerve impulses; changes in the force velocity relationship; and increased glycogenolysis and high-energy phosphate degradation (Bishop & Middleton, 2013).

The most consistent recommendation suggests that the ideal warm up program should include active-dynamic stretching over static or passive stretching (Bishop & Middleton, 2013; Gergley, 2009; McMillian et al., 2006; Sale, 2002). Active warm up, such as a dynamic warm up, might improve short-term performance. In addition to temperature-related changes, a study done by Sale (2002) discusses a neuromuscular phenomena, post activation potentiation, that may be activated by dynamic warm ups and could possibly enhance agility and power performance through an increase in muscle twitch force and rate of force development after conditioning contractile activity (Sale, 2002).

Despite the contradicting evidence, pre-exercise stretching warm up routines are still commonly practiced (McMillian et al., 2006). Because of this, warm up protocols
may reflect the different experiences of coaches, trainers, and athletes where they tend to
do and recommend what they have always done. In addition to stretching, it is also
common practice in warm up to rehearse the specific patterns of coordinated movement
involved in the sport, for example shooting at the hoop in basketball, or swinging a
baseball bat or golf club before hitting, etc. (Vandervoort, 2009). For example, when
practicing the rehearsal of golf swings to be used on the course, facilitation of
coordinated motor pathways occurs. The golf drive on a tee-box is a great example of
this. Most golfers use their driver, which is their longest club, and try to swing with high
club head speed for maximum driving distance, making it valuable to have already
rehearsed the desired movements and made any adjustments (Vandervoort, 2009).

Golf Specific Warm Up

Research suggests an appropriate warm up for golf should include a period of
aerobic exercise to increase core temperature, followed by stretching of the muscles
(Fradkin et al., 2003; Hedrick, 1992; McMillian et al., 2006). After the core is warmed
up, then all additional components are specific to the sport or activity. Because golf is a
skill sport, additional warm ups are used to enhance the performance of skills such as
club head speed, distance, accuracy, and consistent ball contact. Research on golf warm
up has included both stretching and club swing progressions (Fradkin et al., 2003;
Gergley, 2009; Tilley & Macfarlane, 2012). Stretching is included in most warm ups with
the intention of increasing joint range of motion, especially because the golf swing
consists of a magnitude of rotation, which is paramount for optimal swing mechanics to
be learned, improved, and performed (Gergley, 2009).
Although warm up is widely recommended to enhance performance, just like any other sport, the extent to which warm up are utilized or the knowledge of possible warm up benefits are unknown. This may be due to the golfers’ status. It has been found that only a small portion of recreational golfers perform appropriate warm up exercises (Fradkin, Finch, & Sherman, 2001). Because the golf swing requires a high amount of coordination, strength, power, flexibility and balance (Tilley & Macfarlane, 2012), competitive golfers have been able to maximize more of these unique physical characteristics, as well as combine them to score better. Elite golfers have been shown to possess more of these characteristics than amateur golfers and are utilized as subjects more often in the warm up studies reviewed.

It has not been reported whether more competitive golfers warm up regularly, but research on the benefits of warm up using competitive golfers as subjects have all demonstrated performance benefits (Gergley, 2009; McMillian et al., 2006; Moran, McGrath, Marshall & Wallace, 2009; Tilley & Macfarlane, 2012) Therefore, it could be assumed competitive golfers are more likely than amateur golfers to warm up prior to play, not only because they are used more often in the research available but because all competitive and elite athletes try to do what is best to enhance their performance.

Golf requires a high level of skill to score well. Being able to strike the ball consistently with greater club head speed should increase driving distance and accuracy, both components of the game that will likely lead to lower scores. Research on the warm up for golf skills has consistently shown benefits to performance measures of driving distance, smash factor, and club head speed (Fradkin et al., 2001; Fradkin, Finch, et al. 2003; Fradkin, Sherman, et al. 2003; Gergley, 2009; Lephart et al., 2007; Moran et al.,
2009; Tilley & Macfarlane, 2012; Vandervoort, 2009). However, the controversy remains as to what form the warm up should take.

Just as has been seen with power sports, static stretching is controversial in golf performance (Gergley, 2009; Rosenbaum & Henning, 1995; Shrier, 2004). For example, significant decreases in club head speed, distance, accuracy, and consistent ball contact was found after static stretching following warm up (Tilley & Macfarlane, 2012), as well as no significant difference comparing a static stretching warm up to no warm up at all (McMillian et al., 2009). It is strongly suggested to avoid a total-body passive static stretching routine prior to play. Instead, a gradual, active-dynamic golf swing progression is advised.

As mentioned previously, the negative implications of static stretching on the musculotendinous unit apply to golf as well (Gergley, 2009). Because of this, there is a decrease in force created by the Golgi Tendon Organ (GTO) reflex relaxation, which may result in a low force production for a movement during performance (Rosenbaum & Henning, 1995). It has also been suggested that repeated static stretching will either inhibit a spindle reflex due to fatigue of the muscle (Kokkenen et al., 1988) or possibly disrupt the motor pattern which reduces coordination and/or force production (Gergley, 2009).

Static stretching exercises have commonly been used, prior to practice or competition, during the warm up phase in golf with the thought that increased range of motion will lead to reduced injury rates and/or improved performance (Gergley, 2009). While increasing flexibility in a warm up is important, static stretching appears to be counterproductive in force transmission rate and may be detrimental to performance
(Bishop & Middleton, 2013). While static stretching remains controversial, recent golf specific studies show that active dynamic warm up programs can be combined with other types of exercise, such as the use of Theraband® exercises in a functional resistance warm up, to show significant positive results in immediate golf performance (Tilley & Macfarlane, 2012; Page et al., 1993).

Functional resistance training is another form of warm up that is utilized for preparation of physical activity. Multiple studies have utilized resistance training and warm up through the use of a Theraband® (Page et al., 1993; Tilley & Macfarlane, 2012). Using resistance training with a Theraband® can lead to adaptive changes in the nervous system, allowing an athlete to fully activate prime movers, both short and long term, in certain movements and to aid in the coordination of all relevant muscles activating (Tilley & Macfarlane, 2012). These changes have been shown to lead to increased peak force and affecting a greater net force in the intended direction of movement, as measured using electromyography (McMillian et al., 2006; Sale, 2002). It should also be noted that both in acute and chronic conditions, range of motion was improved using the Theraband® (McMillian et al., 2006; Sale, 2002; Tilley & Macfarlane, 2012).

Functional resistance training aids in enhancing the relationship between the muscular and nervous systems, as well as muscle groups or motor patterns force-producing capabilities for a certain task (Bryant, 1999; Tilley & Macfarlane, 2012). It has been suggested that the activation of functional movements and motor patterns in the golf swing during a functional resistance warm up, may lead to improvements in maximal golf drive performance (Tilley & Macfarlane, 2012). With experienced golfers, it has been found that using a Theraband® to perform a functional resistance warm-up program had a
statistically significant increase in maximal driving distance, consistent ball strike, and smash factor during the performance of a maximal golf drive compared to other warm up programs (Tilley and Macfarlane, 2012). It should be noted that only male subjects were utilized in current research literature.

Using a series of golf swings with progressive increase in range of motion and vigor as a part of an active-dynamic warm up has been recommended and utilized in several studies (Fradkin et al., 2001; Tilley & Macfarlane, 2012; Gergley, 2009; Fradkin, Sherman, et al., 2003). In a study done by Tilley & Macfarlane (2012), there were significant positive improvement in golf performance factors when a golf swing progression, active-dynamic warm up was combined with a weights warm up. This may be due to the fact that with more lofted clubs (wedges and higher lofted irons) the golf swing is more consistent than lower irons, woods, and drivers. As the shaft of the club gets longer, the swing mechanics should remain the same, thus the golfer may need to adjust stance or other components to continue to hit consistently and accurately. In order to utilize a golf-related active dynamic warm-up, researchers have used the same progression with different golf clubs (Gergley, 2009; Tilley & Macfarlane, 2012). This progression included, ten practice swings with a 1.13-kg weighted club (Momentus), three full-swing shots with sand wedge, 8-iron, 4-iron, fairway/metal wood, and driver.

Technology has changed the assessment of golf performance. Performance factors have been obtained through the use of golf specific equipment such as high-speed cameras, videotape footage, laser range finders, and radar technologies (Gergley, 2009; Fradkin, Sherman, et al., 2003; Tilley & Macfarlane, 2012). Many golf professionals and research studies have utilized Flightscope® radar technology. Flightscope® has the ability
to measure ball data such as carry distance, total distance, roll distance, ball speed, lateral deviation and also club data such as club head speed and smash factor. Within the studies, information related to performance factors was collected via the Flightscope® for parameters including maximum club head speed (MCHS), maximum driving distance (MDD), smash factor (SF) and driving accuracy (DA) (Gergley, 2009; Tilley & Macfarlane, 2012). The performance factors measured were important pieces of information taken from the swing data, relating to the forces, control, and outcome of a golf swing.

The need for further investigation looking at the latent effects of the warm up programs in golf has been called for in previous studies. Overall, the consensus through the reviewed studies discusses that an adequate warm up to maximize golf performance should be investigated further.

**Summary**

This review presents the most current literature in the area of warm up importance and the effects on golf performance, along with the specific facets that attribute to that. It is evident that this area of research needs to be investigated further and many questions still remain unanswered about what type of warm up, specific to golf, is the absolute best for performance in recreational golfers.
Chapter 3

Methods

Introduction

The purpose of this study was to assess the effects of different warm up protocols in recreational golfers on immediate golf performance of a maximal golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF). This chapter provides a description of the methodology that was used to test the hypotheses for the current study. More specifically, this chapter provides a background of the participants, information on the instrumentation used, an overview of the procedures, and a description of the statistical analyses that was performed.

Participants

This study was delimited to male and female recreational golfers between the ages of 18 and 65. The participants were recruited through a variety of methods including word of mouth and referrals from Qualchan Golf Course. Participants completed a medical questionnaire relating to golf to determine if they met the study criteria of having no current injuries and the recreational golfer requirements. For the purpose of this study, golfers who play at least eight rounds of golf a year and have an average 18 hole score between 80 and 140 or an average 9 hole score between 40 and 70 were considered recreational golfers.

Instrumentation

Golf performance factors were collected via the Flightscope® XI (FlightScope (Pty) Ltd. Orlando, FL) for each shot including maximum club head speed (MCHS), maximal driving distance (MDD) and smash factor (SF). The study took place on the
driving range at Qualchan Golf Course. Participants used their own golf clubs and gear for the study. A red Theraband® (light resistance) was used for the functional resistance Theraband® warm up in order to properly provide resistance for muscles to activate while avoiding stiffening of the muscle tendon unit (MTU). This hopefully allowed the participants to avoid high levels of exertion prior to the maximal effort golf drive that could possibly occur with the use of a stronger resistance Theraband® (Tilley & Macfarlane, 2012; Page et al., 1993; Fletcher & Hartwell, 2004).

Procedure

This study was approved through the Institutional Review Board (IRB) at Eastern Washington University. Once the study was approved through the IRB, participants were recruited by word of mouth and referrals from Qualchan Golf Course to participate in the study. Prior to participation, informational emails were sent out for all potential participants to go over informed consent and purpose of the study before deciding whether they wanted to participate. Participants completed informed consent and medical questionnaire and were able to ask questions prior to data collection of the first session.

Important aspects of collecting the most accurate golf performance data were for the participants to not engage in intense physical activity, lift heavy weights, or stretch immediately prior to testing. Participants used the same equipment all testing days (golf clubs and Qualchan’s driving range golf balls). Lastly, the participants tried to obtain a consistent golf swing. This means the participants did not undertake in lessons or alter their swing technique in between testing sessions. It was assumed that all participants followed these protocols to produce the most valid results possible.
The participants attended Qualchan Golf Course on three separate, non-consecutive days with a maximum of three days in between each session. There were identical set ups for the warm up exercises, as well as data collection for each participant. Three different warm up protocols: (1) no warm up, (2) active dynamic warm up, and (3) functional resistance Theraband® warm up were performed by all participants prior to gathering performance measurements. The participants randomly selected a warm up protocol on the first two sessions, drawn out of a hat by the participant. The participants then carried out the selected warm up protocol during that session and completed the other warm up protocols the following two sessions.

Following each warm up routine, each participant immediately went through their normal pre-shot golf routine, just as they would for an actual golf shot. This included what the participant usually does when addressing each golf shot, (ex: practice swings) but did not include stretching. Following this, the participant hit 10 maximal effort golf drives while data analysis using Flightscope® radar technology occurred. Participants had one-minute rest intervals between each shot. This hopefully allowed participants time to regain focus and any mental preparation needed for the next golf drive. Following each shot, the participant was asked about the ball strike consistency. The participant either answered, “yes” for solid contact or “no” for poor contact. This CBS measure was a subjective assessment to gauge the accuracy of the golf shot.

In the ‘no warm up’ protocol, the participant proceeded to their normal pre-shot routine and completed the maximum effort drives as explained above. In the ‘active dynamic warm up’ protocol, the participant completed the active-dynamic golf swing
progression (adapted from Gergley, 2009 and Tilley & Macfarlane, 2012) that consists of:

1. Ten practice swings with any club
2. Three full-swing shots with sand wedge
3. Three full-swing shots with 8-iron
4. Three full-swing shots with 5-iron
5. Three full-swing shots with fairway wood/hybrid
6. Three full-swing shots with driver

Then the participant immediately proceeded to their normal pre-shot routine and completed the maximum effort drives as explained above.

In the ‘functional resistance Theraband® warm up’ protocol, the participant completed the functional resistance warm up using a Theraband® and then immediately proceeded to their normal pre-shot routine and complete the maximum effort drives as explained above. The functional resistance Theraband® warm up (as used by Tilley & Macfarlane, 2012) consisted of the following with each exercise: 10 reps x 2 sets (See Appendix 3 for figures):

1. Theraband® (red) with bilateral rotational trunk movement in standing
2. Theraband® (red) with bilateral standing lunge and rotational trunk movement
3. Theraband® (red) right arm cross chest adduction and internal rotation with body rotation
4. Theraband® (red) left arm external rotation and shoulder abduction with rotation
5. Theraband® (red) with wood chop from right and left trunk rotation
Information related to performance factors were collected via the Flightscope® for parameters including MCHS, MDD, and SF. These parameters were utilized in previous studies and are highly related to performance of a maximal golf drive (Gergley, 2009; Tilley & Macfarlane, 2012).

**Statistical Analysis**

Data was collected from Flightscope® and was later entered into a Microsoft Excel file before being imported into SPSS for analysis. Statistical analysis was performed using SPSS version 20 (SPSS Inc., Chicago, IL). Data was screened for outliers as well as checked for normality. Any non-consistent ball strike was considered an outlier and was not included in the statistical analysis. To examine the differences of the golf performance, three one-way repeated measured (within subjects) ANOVA were utilized between the three different warm up protocols with 2-tailed testing. Pairwise comparisons between the three different warm up protocols were also analyzed. Alpha levels were set at $p \leq 0.05$ *a priori* for all statistical tests.

**Summary**

This chapter provided detailed descriptions of the methodology used for the current study. This included a background of the participants, instrumentation information, an in-depth detail of procedures, and an overview of the statistical analyses that was performed.
Chapter 4

Results

Introduction

The purpose of this study was to assess the effects of different warm up protocols in recreational golfers on immediate golf performance of a maximal golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF). This chapter provides a summary of results of the statistical analysis described in the previous chapter.

Descriptive Statistics

In the current study, 17 participants were used (women n = 6, men n = 11).

Descriptive statistics for the participants are displayed in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>44.9 ± 4.9</td>
<td>42</td>
</tr>
<tr>
<td>Handicap (USGA)(^a)</td>
<td>25.4 ± 1.4</td>
<td>27</td>
</tr>
<tr>
<td>Rounds of golf (per/y)</td>
<td>37.5 ± 10.6</td>
<td>37</td>
</tr>
</tbody>
</table>

\(^a\) A golfer’s handicap index is the average number of strokes over par from the most recent rounds of 9 or 18 holes played. The handicap averages from above are in accordance with the United States Golf Association (USGA). A lower handicap index is an indicator of a more skilled player.

Repeated Measures ANOVA

Three, one-way repeated measures ANOVA were calculated comparing the golf performance factors (MCHS, MDD and SF) between the three protocols: no warm up, the active dynamic warm up, and a functional resistance Theraband\(^\circledR\) warm up. No significant
effect was found \((F(2,32) = .483, p > .05)\). No significant difference exists between MCHS and the three warm up protocols \((p = .621)\). No significant effect was found \((F(2,32) = .1.265, p > .05)\). No significant difference exists between MDD and the three warm up protocols \((p = .296)\). No significant effect was found \((F(2,32) = .853, p > .05)\). No significant difference exists between SF and the three warm up protocols \((p = .436)\). Results are displayed in Table 2.

Table 2

**ANOVA statistics from sample population \((Mean \pm SD)\)**

<table>
<thead>
<tr>
<th>Warm up type</th>
<th>Performance Factors</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Club Head Speed (Miles/hr)</td>
<td>Maximal Driving Distance (Yards)</td>
<td>Smash Factor (Ball speed/ club head speed)</td>
</tr>
<tr>
<td>Active-dynamic</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Theraband®</td>
<td>91.19 ± 15.89</td>
<td>204.88 ± 40.28</td>
<td>1.42 ± .05</td>
</tr>
<tr>
<td>No warm up</td>
<td>90.38 ± 15.95</td>
<td>213.56 ± 42.01</td>
<td>1.43 ± .05</td>
</tr>
</tbody>
</table>

**Summary**

Regardless of the warm up type, there was no significant difference between the golf performance factors of maximum club head speed, maximal driving distance, or smash factor. This chapter provided a summary of results of the statistical analysis from the current study.
Chapter 5

Discussion

Introduction

The purpose of this study was to assess the effects of different warm up protocols in recreational golfers on immediate golf performance of a maximal golf drive by measuring maximum club head speed (MCHS), maximal driving distance (MDD), and smash factor (SF). The following chapter discusses the results of the current study as they relate to the current literature.

Summary of Results

A total of 17 recreational golfer participants (females n = 6, males n = 11) were used in the analysis. The results revealed no significant different in MCHS, MDD, or SF between the no warm up protocol, active dynamic warm up protocol, or the Theraband® warm up protocol.

Current Literature

There has been no previous research on performance of different warm ups on acute golf drive performance using recreational golfers. However, one study conducted by Tilley & Macfarlane (2012), looked at similar warm ups and performance factors using elite golfers. Unlike the current study, their results showed statistically significant difference for MDD (p=0.042) and SF (p=0.004) between the three warm up protocols: an active dynamic, an active dynamic with functional resistance Theraband®, and active dynamic with weights warm up protocols. They found that the active dynamic with functional resistance Theraband® warm up showed the most significant improvements with the golf performance factors.
Literature suggests that Theraband® warm up and training could be related (Lephart et al., 2007; Thompson et al., 2007; Tilley & Macfarlane, 2012). A major goal of functional resistance training is to aid in the relationship between the muscular and the nervous system to produce muscle or motor pattern force for a task (Bryant, 1999; Tilley & Macfarlane, 2012). The researchers believed that the certain performance factors that showed improvement with the functional resistance Theraband® warm up may have been due to the activation of functional movement and motor patterns that are involved in a golf swing (Tilley & Macfarlane, 2012). Since the present study did not find significant differences, a possible explanation could be that the elite golfers may have already had good motor patterns and did not need training over a long period of time compared to what recreational golfers may need.

Another study used recreational golfers, training them to use a specific warm up before play, resulted in significant improvements in club head speed (Fradikin, Sherman, et al., 2003). They performed a warm up consisting of brief exercises, static stretching, and air swings with the golf club over a five week period. The results showed that the experimental group club head speeds improved by 12.8% between weeks one and two, and 24% between weeks 1 and 7 (Fradikin, Sherman, et al., 2003). Half of the improvement from the study came in the first two weeks. In another recreational golfer study, done by Lepart et al. (2007), golfers performed a golf-specific conditioning program 3-4 times per week for 8 weeks. The researchers found improvements in strength, flexibility, and balance, which may result in increased club head velocity, ball velocity, and driving distance (Lephart et al., 2007).
Research has shown that dynamic warm up protocols, if performed long enough, may provide the temperature-related mechanisms similar to traditional cardiovascular components of a warm up, which provide appropriate motor control as they require the muscles to contract in sequence affecting the central programming of the muscle contraction/coordination (Bishop, 2013; McMillian et al., 2006). It is likely that the warm ups used in the present study were not long enough, nor stressed the cardiovascular system enough to increase temperature in the participants. Especially in the male participants, using only the Red Theraband® would provide minimum resistance and the movement was not repeated enough times to generate significant heat.

**Limitations**

A limiting factor may have been the relatively small sample size of 17 participants. However, the major limitation that comes to mind within the structure of the current study is the population. The current study used recreational golfers, whereas other similar studies used elite golfers or specific ages and found statistical significance. Although it is important to research recreational golfers, there is less consistency with the golf drive with this population. This consistency is very important when measuring the specific golf performance factors in order to find differences between the different warm ups. Based off of many inconsistent golf drives recorded and discarded due to being outliers, using recreational golfers is not the best population to use when measuring golf performance factors that are sensitive to consistency and accuracy.
Suggestions for Future Research

- A recommendation for future studies would be to include a cardiovascular component to the warm up protocols or to check for core temperature of the participants.

- A recommendation for future studies would be use different Theraband® for males and females for appropriate resistance and analyze them separately, requiring a larger sample size.

- A recommendation for future studies would be to follow a recreational golfer through an 18 hole round of golf to see how long it takes for the golfer to actually "warm up" and have improved performance factors.

- A recommendation for future studies would be to have a large enough sample size to group the participants by handicap when analyzing the data to see if there are any statistical differences with a comparison by sex vs. handicap, having an equal number of males and females.

Summary

This chapter discussed the results of the current study as they relate to the current literature. Although no significant results were found in the current study, the body of knowledge of literature can still grow from the information and encourage future research.
References


Bishop, D., & Middleton, G. (2013). Effects of static stretching following a dynamic warm-up on speed, agility and power. *Journal of Human Sport & Exercise, 8*(2), 391.


Appendix 1: Informed Consent

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**Informed Consent Form**

DIFFERENT WARM UP PROTOCOLS ON IMMEDIATE GOLF DRIVE PERFORMANCE IN RECREATIONAL GOLFERS

**Purpose & Benefits**
The proposed study seeks to examine the effects of three different warm up protocols on immediate golf performance of a maximal golf drive in recreational golfers. At present the optimal warm up procedure prior to golf to improve immediate performance during a maximal drive is unclear. The proposed study may benefit recreational golfers with knowledge of an optimal warm up that may enhance performance. Also, this study may help expand the body of literature review on different warm up effects and possible benefits on immediate golf performance.

**Procedures**
Participants intended for recruitment are recreational golfers between the ages of eighteen and sixty-five. Study procedures will be verbally discussed in detail with potential participants in an informational meeting, and an opportunity for questions will be provided. Golfers choosing to voluntarily participate in the study will be provided with an informed consent document and a questionnaire regarding medical and golf experience related information. After consent and questionnaire are obtained, the primary investigator will conduct information sessions that describe the different warm up protocols that will be performed. Step-by-step details, procedures, and visual examples will be provided to participants to ensure they understand how their testing sessions will work. The duration of the proposed study is a maximum of 6 weeks, and all participants will be required to perform each of the three warm up protocols and 10 maximal drives on three non-consecutive days at Qualchan Golf Course. Random selection will be used to assign the warm up protocol that will be performed for each participant at the testing sessions.

**Risk, Stress, Discomfort**
Risk, stress, and discomfort are minimal. The risks involved don’t extend risks ordinarily encountered during physical activity, golf, or warm up exercise sessions. The risks involved in the study include possible muscle soreness and muscular injury to the participants during the warm up protocols, the maximum effort golf drives or following after.

**Inquiries**
Any questions about the procedures used in this study are encouraged. If you have any concerns, questions, or would like more information please contact Wendy Repovich or Emily Travis prior to signing the informed consent form. We can be reached at (509)-359-7960; wrepovich@ewu.edu and (509 499-8865 emilytravis@eagles.ewu.edu respectively.
Other Information
You are requested to not engage in intense physical activity or lift heavy weights immediately prior to testing. You must use the same equipment both testing days (golf clubs and golf balls). Lastly, you must try to obtain a consistent golf swing while you are taking part in the study. If you have any concerns about your rights as a participant in this research or any complaints you wish to make, you may contact Ruth Galm, Human Protection Administrator, (509) 359-6567 or rgalm@ewu.edu.

Signature of Principal Investigator __________________________       Date ___________

Subject Statement
My participation in this study is completely voluntary. I am free to refuse participation and to stop at any point in this study. I understand the study procedures that I will perform, and the possible risks that go along with the testing and training. Knowing all of the risks and discomforts, and being allowed to ask questions that have been answered to my satisfaction, I consent to take part in this study. I am not waiving my legal rights by signing this form. I understand I will receive a signed copy of this consent form.

Signature of Participant ___________________________
Appendix 2: Medical Questionnaire

Golf Related Medical Questionnaire.

Name: ____________________________________
Date: ________________________________
Date of birth _____________   Height: _______   Weight : _______
Handicap: ________________
If no handicap, average score for 9 holes: _____ or 18 holes: _____

How many golf rounds a year on average do you play? _____

Do you smoke?  Yes      No                      Do you have diabetes?   Yes      No
Do you have any chronic diseases? Yes      No     If yes, please state the diagnosis: ________________
Do you take regular medication for injury or illness? Yes      No
If you answered yes, what is the name of the medication? _______________________________________

Do you have any current physical injuries?    Yes    No      Has this injury kept you from playing or practicing? Yes    No      For how long (days/weeks)? ______
What is the injury/injuries? Please list:
(e.g. right shoulder, left elbow, low back pain).

Have you had treatment for this injury? Yes      No
Are you currently taking any medication for this injury? Yes      No      If so, what is it?

With respect to any exercise you are currently undertaking (excluding playing or practicing golf):
Are you currently undertaking exercise? Yes      No
If so, what does your exercising involve? (Please check all appropriate boxes)
Strength training          Flexibility exercises          Cardiovascular exercises
Other (please list): ________________________________________________________

Thank you for taking the time to complete this questionnaire.
Appendix 2: CBS Data Collection Sheet

Consistent Ball Strike Data Collection Sheet

**Participant ID:**

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WARM UP TYPE:

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<th>3</th>
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</tbody>
</table>
Appendix 4: Theraband® warm up exercise figures

Theraband® warm up exercise figures

1. Theraband® (red) with bilateral rotational trunk movement in standing

2. Theraband® (red) with bilateral standing lunge and rotational trunk movement
3. Theraband® (red) right arm cross chest adduction and internal rotation with body rotation

4. Theraband® (red) left arm external rotation and shoulder abduction with rotation

5. Theraband® (red) with wood chop from right and left trunk rotation
CURRICULUM VITAE
Emily Travis

Education:
M.S., Eastern Washington University, Physical Education-Exercise Science, 2015
B.A., B.A., Whitworth University, Health Sciences, Kinesiology, 2013

Employment History:
09/2014/15 - Present: University Recreational Center management, Eastern Washington University (Cheney, WA)
09/2014-11/2015: Youth sport coach, Orange head sports (Spokane, WA)
06/2014-08/2014: Pro shop costumer service representative, Liberty Lake Golf Course (Liberty Lake, WA)
09/2013-05/2014: Physical Therapy Aide, Physical Therapy Associates (Spokane, WA)
2011-2013: Golf course caddie, Coeur D’Alene Resort Golf Course (Coeur D’Alene, ID)
2011-2012: Scotford Fitness Center management, Whitworth University (Spokane, WA)
09/2011-12/2011: Fitness/Wellness Coach, Scotford Fitness Center (Spokane, WA))
2009-2012: Basketball camp instructor, Stars Basketball & Whitworth University (Spokane, WA)
06/2010-08/2010: Pro Shop Costumer service representative, Coeur D’Alene Resort Golf Course (Coeur D’Alene, ID)

Teaching Experience:
2014/2015- Eastern Washington University
EXSC 490- Senior Capstone in Exercise Science- Supervised a student research project and assisted with the paper (Pedometer accuracy testing with IPhone). Assisted with lab instruction and demonstrations. Assisted with grading.
EXSC 460- Physiology of Exercise- Graded assignments and exams, moderated in-class discussions, presented a class lecture (environmental exercise physiology), taught a lab session and demonstrations (Wingate Testing).
2013- Whitworth University
HS 365W- Evidence Based Health Science – Supervised student research projects. Assisted with lab. Assisted with grading.
2012 – Whitworth University
HS 326- Physiology of Exercise- Assisted in grading assignments, set-up, administer, breakdown of practical exams. Assisted with lab testing demonstrations (VO2 max and Wingate).
2011 – Whitworth University
HS 220- Anatomy Lab- Assisted with set-up, administration, breakdown of practical exams, prepared cadaver and other lab specimens, maintained inventory of supplies and equipment. Assisted in Grading.
Publications/Presentations:
2015: Presented at the Eastern Washington State University’s Graduate Symposium
Thesis: Effects of different warm up protocols on immediate golf drive
performance in recreational golfers
2012: ACSM northwest undergraduate research award
2012: Presented at the ACSM northwest conference (Couer d'Alene, Idaho)
Travis, E. R.; Watt, e.; Brandt, k. (2012). Effect of two week Wingate training on
two mile run performance

Academic/Research Interests:
Adolescent and community obesity prevention strategies
Prevention and treatment of chronic diseases through physical activity
Golf performance (through warming up or other methods)
High intensity interval Wingate training effects on anaerobic and aerobic performance

Service Experience:
06/2013-09/2013: U-District Physical Therapy - (Liberty Lake, WA) Kids summer
sports camp.
09/2011: Opening of Robinson Science Building, Whitworth University – (Spokane,
WA) demonstrated the research and teaching capabilities of the human
performance lab to alumni parents and guests.
11/2012: Christ Kitchen - (Spokane, WA) Volunteered and assisted with production
of foods/bible study.

Awards/Honors:
2010 – 2011: Legacy Scholarship recipient, Whitworth University
2010 – 2011: Enhanced Talent-Writing Scholarship recipient, Whitworth University
2010 – 2011: Dept. School-Kinesiology Scholarship recipient, Whitworth University