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ARTICLE

Effectiveness of a Six-Week Strength and Functional Training Program on Golf Performance

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The purpose of the study was to evaluate the effects of six weeks of strength/functional training on muscular strength and golf performance, measured by club-head speed. Ten participants (age = 21.4 ± 2.3 yrs) were randomly assigned to an experimental group performing 6 weeks of strength/functional training or a control group that followed their regular activity/golf routine. Club-head speed was measured as an indicator of golf performance. A 2 × 2 ANOVA with repeated measures on swing speed revealed significant ($p < .05$) differences between the groups for swing speed before training (Experimental: 50.87 ± 3.62 m/s., Control: 47.21 ± 1.56 m/s). No changes in swing speed were observed as a result of resistance training. Significant ($p < .05$) differences were noted for bench press and leg press after the training program. No significant ($p > .05$) differences were noted for vertical jump or sit-and-reach. Participants realized improvements in strength during their participation but these did not translate to increased golf performance as measured by swing speed.

Keywords: club head speed, resistance training, adaptations

The sport of golf continues to increase in popularity worldwide (Hetu, Christie & Faigenbaum, 1998). According to several recent surveys, there are 26.4 million

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active golfers in the United States, which represents a ten percent increase since 1995, and ranks tenth among all sports and recreation activities in active participation (Doan, Newton, Kwon, & Kraemer, 2006). Golf is played by people of all ages, abilities, and physical fitness levels (Doan et al., 2006; Hetu & Christie, 1998). With this rise in popularity there has been a parallel interest in studying factors associated with improving golf performance. To date a clear relationship between neuromuscular fitness and golf performance has not been established. Previous studies have not investigated the relationship of general strength training exercise in highly skilled golfers.

According to Fletcher and Hartwell (2004), physical fitness is viewed as a key component for optimum athletic performance. Different sports and people of all skill levels use strength training as a process to elevate athletic performance. Previous research has identified the complexity of the golf swing motion and the necessary activation of a majority of large muscles in the body to successfully complete this motion (Doan et al., 2006, Fletcher & Hartwell, 2004, Thompson, Cobb, & Blackwell, 2007).

Golf was previously considered a sport of technique and strategy rather than of physical fitness (Hetu & Christie, 1998). However, recent research reveals that strength, power, and flexibility training can increase club head speed and driving distance (Doan et al., 2006). One study found that resistance training focused on hip and shoulder rotation increased maximum hip rotation speed, which improved golf performance (Burden, Grimshaw, & Wallace, 1998). Researchers observed the characteristics of highly skilled golfers, and determined that golfers with the most strength, flexibility, range of motion, and balance possessed higher skill levels (Sell, Tsai, Smoliga, Myers, & Lephart, 2007). To date many issues associated with physical training have not been specifically addressed in relation to golf performance.

Several studies have examined the effects of different resistance training programs and their effect on golf performance. Fletcher and Hartwell (2004) examined the combined effects of resistance and plyometric training and found a 1.5% increase in club head speed and 4.3% increase in driving distance for the training group. Hetu et al. (1998) studied the effects of an 8-week conditioning program focusing on flexibility, plyometric training, and muscular strength on measures of physical fitness and golf performance. The authors reported increases in flexibility, strength, and club head speed among the experimental group after completion of the program. Another study found that among older golfers, an eight week functional training program increased club head speed by 4.9% and caused some improvements in strength and flexibility (Thompson, Cobb, & Blackwell, 2007). Fradkin, Sherman, and Finch (2004) reported that a seven-week golf specific warm-up program improved club head speed. A study investigating the effects of an 8-week introductory strength training program among golfers with no previous strength training experience found significant increases in strength, flexibility, club head speed, and driving power (Westscott, Dolan, & Cavicchi, 1996). A recent study investigating the effects of a strength, flexibility, and power program on NCAA golfers found increases in strength, flexibility, and club head speed for the experimental group after completing the eleven-week program (Doan et al., 2006). In summary, several studies have reported that strength, flexibility, and range of motion are directly related to club head speed and driving distance, which is thought to result in increased performance (Doan et al., 2006; Fletcher

& Hartwell, 2004; Fradkin et al., 2004; Hetu & Christie, 1998; Lephart, Smoliga, Myers, Sell, & Tsai, 2007; Sell et al., 2007; Thompson et al., 2007; Westscott et al., 1996). These studies have reported that participation in a variety of different strength, flexibility, and plyometric training programs has a positive influence on golf performance. However, only one of these studies (Doan et al., 2006) examined participants that may be considered highly skilled golfers.

The purpose of this study was to determine the effects of a combined resistance and functional training program on highly skilled amateur golfers after a 6-week training period, and how those effects influenced performance as assessed by measuring club head speed. It was hypothesized strength and functional training would result in an increase in golf performance by increasing club head speed.

Methods

Participants who were enrolled in the Professional Golf Management program at Mississippi State University participated in this study. All methods were approved by the Institutional Review Board and all participants provided informed consent before participation. This study was designed as a pre-post study to assess the influence of general strength training in an experimental group compared with a control group. Participants were randomly assigned to a control group or an experimental group after reporting for the initial day of assessment. All participants received a complete description of the experimental procedures before providing written informed consent and were aware of their right to withdraw from the experiment at any time without prejudice.

The participants ($N = 10$) were male volunteers (mean age = 21.4 ± 2.3 yrs) who received no remuneration for their participation. All participants reported playing golf a minimum of 4 days per week. No participants reported actively engaging in strength training for the eight weeks before participation in this study. The small sample size was used because researchers were primarily interested in measuring the dependent variables among golfers with a predetermined level of golf expertise. As a condition of enrollment in the program students must maintain a handicap of 8 or lower. There were no differences in mean handicaps noted between groups. Although previous studies examining the relationship between golf performance and a strength training program were generally 8 weeks in length (Doan et al., 2006; Fletcher & Hartwell, 2004; Fradkin et al., 2004; Hetu & Christie, 1998; Lephart, Smoliga, Myers, Sell, & Tsai, 2007; Sell et al., 2007; Thompson et al., 2007; Westscott et al., 1996), the current study chose to examine a training schedule of 6 weeks, as previous studies have found an increase in muscular strength following a six week training program (Lamont, Cramer, Bemben, Shehab, Anderson, & Bemben, 2011; Potdevin, Alberty, Chevutschi, Pelayo, & Sidney, 2011; Randell, Cronin, Keogh, Gill, & Pedersen, 2011; Vila-Chã, C., Falla, D., & Farina, D., 2010). Five participants were randomly assigned to the control group and five participants were randomly assigned to the experimental group. Participants in the experimental group were asked to come to the campus recreational facility for an orientation session to familiarize themselves with the specific lifts and exercises they would be performing throughout the duration of the study. This session was conducted to help prevent injury and to minimize any learning effects that could have resulted

from the process of training. During the orientation session, the participants were instructed on the proper form for each exercise. In addition, participants were instructed on how to perform the prescribed warm-up and post workout stretch routine. Participants were provided the opportunity to practice each movement under the supervision of the researchers. Exercise descriptions were also provided in a training manual so the participant could refer to it to review instruction on technique and how to perform each exercise during training.

In the days following the orientation session, experimental group participants completed strength, flexibility, and golf performance pretesting. Participants completed the required training sessions without direct supervision from the researchers. Following completion of the six week training period all performance assessments were completed again. All participants were instructed to maintain their usual personal and dietary habits during the study. In addition, control group participants were instructed to carry out their normal daily activity routines throughout the duration of the study. The control group was only pre and post tested during the same weeks on the golf performance tests.

The experimental group participants were tested using a one-repetition maximum bench press protocol as a measure of upper body strength, one-repetition maximum leg press exercise as a measure of lower body strength, and a vertical jump test as a measure of explosive strength. All strength tests were conducted in accordance with the American College of Sports Medicine criteria. Flexibility was measured by administering a sit and reach test.

All training sessions completed by the experimental group were performed in a campus recreational facility with qualified fitness instructors present. Participants verbally reported any difficulties with failing to complete the exercise protocol to the researchers. In addition, if the participants had questions specific to any exercise requirement they would verbally or electronically communicate with the researchers. The exercise program consisted of free weight, pin selected machine exercises, cable machine exercises and medicine ball work. Participants were instructed the workout protocol should take 60–75 minutes to complete but were not instructed to complete it within a predetermined time period. For a complete list of exercises please see Table 1. It is important to note that participants in the current study completed a general strength and functional training program designed to increase upper and lower body strength, flexibility, and overall fitness. The exercises performed were not specifically designed to improve golf performance, but to increase general strength and flexibility.

A standardized dynamic warm-up was used to begin each training session. The dynamic warm-up consisted of a series of movement patterns designed to raise the heart rate and increase dynamic flexibility and range of motion before each workout. These movements were designed to help prime the body for exercise by increasing mobility and dynamic flexibility within the same range of motion as the specific lifts and exercises performed in the second portion of each training session. A static stretch routine was performed at the end of each training session. The stretch routine included a series of stretches designed to help maintain range of motion in all muscle groups and joints targeted during each training session.

All participants were instructed to complete 3 sets of 25 repetitions for sit-ups and 3 sets of 15 repetitions for back hyperextensions during each session. For the following exercises participants were instructed to complete 3 sets of 8 repetitions

Table 1 The exercises which were included in the experimental groups prescribed training program. Participants were provided the program with specific sets and repetitions for each week. The participants completed between 2 and 4 sets and between 6 and 12 repetitions for each exercise depending on the weekly program.

Lower Body Exercises	Upper Body Exercises	Total Body Exercises
Back Hyper	Bench Press	Standing Cable Twist
Leg Press	Dumbbell Rows	Cable Wood Chop
Leg Curl	Shoulder Complex	
Reverse Lunge	Dumbbell Incline Bench Press	
Bulgarian Lunge	Lat Pulldown	
Walking Lunge	Double Curls	
Dumbbell Forward Lunge	Dumbbell Bench Press	
Smith Squat	Dumbbell Upright Row to Curl to Press	
	Double Lat Pulldowns	
	Horizontal Pull-Ups	

during each training session. In addition, the participants were instructed to increase their resistance by 20% at the start of each training week following the second week of training. Participants completed standing cable twists, cable chop wood, back hyperextensions, leg press, bench press, dumbbell rows, leg curls, shoulder complex, reverse lunge, Bulgarian lunge, dumbbell forward lunge, walking lunge, dumbbell incline bench press, lat pulldowns, double curls, dumbbell bench press, dumbbell upright row to curl to press, double lat pulldowns, smith squat, and horizontal pull-ups. Golf performance was assessed for all participants using a Vector Pro 200 system launch monitor system which measures club head speed and ball launch with a dual camera microlens functionality (Accusport, Inc.; Winston-Salem, NC). Additional measures can be assessed using the Vector Pro 200 system (i.e., ball spin and degree of ball launch) however; for the current study only club head speed was assessed. The participants were allowed to swing the club before testing; however they were not allowed to strike a ball. The participants were instructed to perform the same warm-up as they would when approaching hitting a tee shot. Participants then hit the golf ball off of a driving range mat with elevated rubber tee into a net in the testing facility.

A 2 Condition (Experimental, Control) × 2 Swing Speed (Pre, Post) ANOVA with repeated measures on the swing speed was used to analyze the data and determine pre and post *swing speed* differences between the experimental and control groups. All significance testing was completed using an alpha level of 0.05. Partial Eta Squared effect sizes and power were calculated for all comparisons.

Four paired samples *t* tests were performed for pre-post changes on one-repetition bench press maximum, one-repetition leg press maximum, vertical jump, and sit and reach tests. Significance testing for *t* tests was completed using an alpha level of 0.05.

Results

ANOVA revealed significant differences ($p < .05$; $F_{1,8} = 7.37$) between the experimental group and the control group for club head speed. The experimental group had a greater swing speed than the control group and maintained their superior swing speed following the resistance training. Partial Eta squared obtained .480 for this comparison and observed power was .664.

The experimental group pre-test mean swing speed was 50.87 ± 3.62 m/s. The swing speed following strength training in the experimental group decreased to 48.91 ± 1.48 m/s. The control group pre-test mean swing speed was 47.21 ± 1.56 m/s. The mean of the post-test swing speed was 46.31 ± 0.67 m/s. There were no significant ($p > .05$; $F_{1,8} = 4.15$) differences observed for either the experimental group or the control group between pre and post-test swing speeds. Partial Eta squared obtained .342 for this comparison and observed power was .434. These nonsignificant changes in swing speed were represented by the experimental group reducing their swing speed by 3.9%, and the control group reducing their swing speed by 1.9%. These changes should be considered in future research on strength training and swing speed (Figure 1).

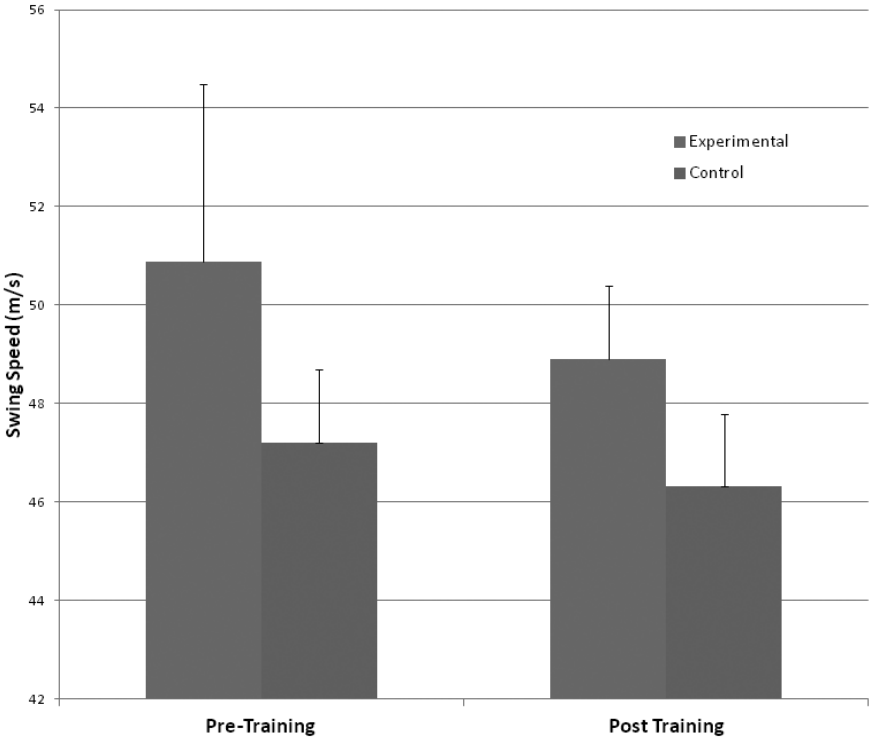

Figure 1 — Observed swing speeds (m/s) in the experimental and control groups during pre-training measurement and following the training period.

Four paired samples *t* tests were performed, one for each of the dependent fitness measures. Pre and post resistance training measures were compared for each of the four exercises in the experimental group. One-repetition maximum bench press performance increased significantly ($p < .05$) in the post test condition. Pre-test bench press was 82.08 ± 9.38 kg and increased to 89.34 ± 10.34 kg during the post weight training assessment. Leg press increased significantly ($p < .05$) in experimental group participants from 94.81 ± 16.62–103.86 ± 18.44 kg. The vertical jump of the experimental group participants showed a nonsignificant ($p > .05$) change from a pre-test value of 85.9 ± 8.2 cm to 87.5 ± 9.7 cm. Results for the sit-and-reach test were not significantly different ($p > .05$). The pre-test mean was 41.15 ± 2.04 cm and the posttest mean was 43.67 ± 7.87 cm.

Discussion

The primary finding in this investigation was the 6-week strength and functional training program resulted in no significant changes in club head speed for the experimental group when compared with the control group. The experimental group did demonstrate an increase in 1-RM bench press and leg press. There were no changes in the vertical jump or sit and reach tests. In the current study, increases in upper body and lower body strength did not result in an increase in club head speed. This finding of no significant change in club head speed after completion of a strength training program is a different finding from previous studies (Doan et al., 2006; Fletcher & Hartwell, 2004; Fradkin et al., 2004; Hetu & Christie, 1998; Lephart, Smoliga, Myers, Sell, & Tsai, 2007; Sell et al., 2007; Thompson et al., 2007; Westscott et al., 1996), and the possible reasons for this finding and implications will be discussed further.

Since the participants in the current study demonstrated increases in muscular strength after completion of the 6-week training program, it is reasonable to conclude that significant gains in upper and lower body strength were made. However, these increases in strength did not result in an increase in club head speed. Based on participants reports of prior strength training experience it is likely that these strength changes were a result of neural adaptations to the training stimulus similar to that found previously (Carroll, Riek, & Carson, 2001), which may occur without changes to the muscle itself (Enoka, 1997). It has been reported that resistance training may cause adaptations that lead to an increase in motor unit synchrony (Carroll et al., 2001), and research has shown this motor unit synchronization can cause larger variability in force during simple isometric tasks (Halliday, Conway, Farmer, & Rosenberg, 1999; Yao, Fuglevand, & Enoka, 2000). It is possible that strength training can cause adaptations that diminish neuromuscular control during some types of movement (Carroll et al., 2001). In addition, while the 6-week training program did not result in changes in club head speed, it may have resulted in other changes to the golf swing, such as in increase or decrease in swing variability or changes to the kinematics of the golf swing. Future research is needed to test this theory and further elucidate issues associated with training and golf performance. Specifically, different resistance training methodologies should be investigated.

In the current study a different training program was implemented than in previous studies. In the current study, the participants completed a general strength and

functional training program designed to increase upper and lower body strength, flexibility, and overall fitness. The exercises performed were nongolf specific but targeted general strength and flexibility which may have an effect on golf performance. This type of training program was chosen over a golf-specific training program because most golfers do not have access to certified strength coaches that can design a golf specific training program, but do have access to general fitness specialist that can design a training program to improve general strength, flexibility, and overall fitness. The previous studies (Doan et al., 2006; Fletcher & Hartwell, 2004; Fradkin et al., 2004; Hetu & Christie, 1998; Lephart, Smoliga, Myers, Sell, & Tsai, 2007; Sell et al., 2007; Thompson et al., 2007; Westscott et al., 1996) all used different methodologies to assess the effects of a strength/functional training program on golf performance. Two of these studies used golf specific exercises (Fradkin et al., 2004; Lephart et al., 2007) and found an increase in club head speed. Other studies used a general strength and conditioning program (Doan et al., 2006; Hetu & Christie 1998; Thompson et al., 2007) and found increases in club head speed, while Fletcher and Hartwell (2004) found that a combination of weight and plyometric training resulted in increases in club head speed and driving distance.

Another key difference between the current study and previous studies were the participants. Three of the studies used participants over the age of 45, with the average ages being 47.2 years (Lephart et al., 2007), 52.4 years (Hetu & Christie 1998) and 70 years (Thompson et al., 2007). Only one previous study investigated a group of participants similar to the current study. Doan et al. (2006) tested varsity golfers with an average handicap of eight, while the current study tested college students enrolled in a professional golf management program with an average age of 21 years and a handicap of eight or lower. Due to changes that occur with both the muscular system and the neurological system with aging, it is to be expected that participants belonging to different age groups would respond differently to training programs. In light of these methodological differences, it is difficult to make direct comparisons between the studies. Lastly, it is possible the selected sample was too small and thus not reflective of the population mean. Future studies should use larger samples with similar participants of the same golf expertise or include larger samples of more representative golfers from the general population of golfers.

In closing, a 6-week strength and functional training program caused no significant changes in club head speed among highly skilled, college-aged golfers. While the participants did demonstrate changes in muscular strength, this did not result in changes in club head speed. A general strength training program may result in changes in muscular strength without adversely affecting golf performance; however, a golf specific training program may be more suitable for increasing club head speed than a general strength training program among college aged golfers. As club head speed is a common and accessible measure of golf performance, this was used as the dependent measure. It is possible the observed increases in strength resulted in an alteration in swing mechanics that was not captured in this study. Future studies should not only use a measure of golf performance but also use a measure like motion capture which would allow swing variability or quality to be analyzed.

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