INTRODUCTION

Functional exercise programs have proven to be useful in the field of physical therapy and rehabilitation and are aimed at improving joint stability, neuromuscular control, and muscular strength and endurance for injured persons (1, 6, 14, 16, 24, 25). Functional exercise programs for the rehabilitation of athletes typically include a combination of 4 types of exercises to help return the individual to pain-free function and prevent injury recurrence. These 4 exercise domains include (a) spinal stabilization exercises done to enhance spinal stability during movement, (b) balance and proprioception exercises done to improve neuromuscular control, (c) flexibility exercises done to regain full range of motion at a joint, and (d) resistance exercises done for functional strength development. Based on its success in rehabilitation, the concept of functional training has been applied to develop training programs for the improvement of athletic performance in various applied fitness settings. To date, however, there has been little or no research studying the efficacy of a functional training program including all 4 types of exercises in the improvement of sport performance.

Playing golf does not require high levels of physical fitness, which is 1 possible reason for its popularity among older individuals. However, the golf swing is a complex movement pattern that puts various joints of the body under stress, and golf participation has been shown to be responsible for injuries to the lower back, wrist, elbow, and other joints of the older golfer and can result in a high risk of injury recurrence (10, 11, 15). Because of this, the importance of proper conditioning for the golfer cannot be underestimated, because continued participation in golf can be a very important form of exercise for older adults and carry with it substantial health benefits (20). Additionally, regular exercise training including resistance exercises and balance exercises has consistently been shown to improve physical function and reduce fall risk in older adults (7, 20). A review of recent golf-related fitness research revealed that club head speed in golfers of various ages can be improved by weight training, flexibility, and plyometric exercise programming (8, 9, 12, 26, 27). However, to date, researchers have not studied the effects of a training program that includes the systematic combination of flexibility, core stability, balance, and resistance exercises on sport performance of any type, including golf.

Golf is a sport where the application of a functional training program may be of particular benefit because a mechanically sound golf swing requires a combination of flexibility, muscular strength, and balance. Researchers have shown the important role of the shoulder and torso musculature in the execution of the swing (13, 21). Recently, Okuda et al. (19) studied the biomechanical and physical characteristics of a prominent Japanese touring professional’s swing. Data were collected by surface electromyography (EMG), video, and force plates to identify muscle activity throughout the body, vertical ground reaction forces (VGRF), and weight transfer characteristics at different stages of the golf swing. Consistent with Milburn (17) and Burden et al. (3), the EMG results indicated that the muscles of the legs initiated the downswing before the upper body reached the top of the swing to allow for maximal club head speed at impact. This movement pattern creates simultaneous opposing directions of movement in the upper and lower body and produces significant torque on the axial skeleton. Additionally, VGRF data revealed that a rapid weight shift from the trailing foot to the target foot takes place during the downswing and that VGRF increases to more than 180% of the golfer’s body weight at impact (19).
These robust weight transfer dynamics and torque of the axial skeleton during the swing emphasize the importance of the physical capabilities of the golfer and suggest that training programs to improve golf performance should incorporate the 4 domains of functional exercise to ensure optimal performance and prevent injury to the older golfer. A golfer with better conditioning in these areas would be more able to make a full follow-through while maintaining balance and a stable axis of rotation to allow the muscles of the trunk and periphery to produce the powerful muscular contractions associated with the downswing. Thus, it was the purpose of this investigation to study the effects of an 8-week progressive functional training program on club head speed in older male golfers. The researchers hypothesized that the functional training program would significantly improve club head speed and functional fitness.

**METHODS**

**Experimental Approach to the Problem**

Study subjects were randomly assigned to either an exercise group \((N = 11)\) or a control group \((N = 7)\). A larger portion of the sample was placed into the exercise group to allow for unforeseen subject attrition; however, none occurred. Subjects in the exercise group completed an 8-week exercise program, whereas control group subjects were instructed to continue their current level of physical activity for the duration of the study. Other than the training program designed for the study, exercise group subjects were instructed not to begin any other new physical activities for the duration of the study. In addition, to decrease any possibility of changes in skill confounding the results of the swing speed test, all subjects were instructed not to take any golf lessons during the course of the program. Data were collected in the week before the start of the exercise program and again the week after the program's conclusion.

**Subjects**

Subjects were members of a private golf club in a large city on the west coast of the United States. Volunteers were recruited through newsletter announcements, e-mail messages, and postings at various locations in the clubhouse. Before being enrolled in the study, interested subjects were interviewed by the researchers to ensure that they met the eligibility requirements that included being between the ages of 60 and 80 years, averaging more than 40 rounds of golf per year, and being free of any uncontrolled cardiovascular or metabolic disease. After eligibility screening, 18 male recreational golfers \((mean \pm SD \text{ age: } 70.7 \pm 7.1 \text{ years})\) gave informed consent approved by the university's Institutional Review Board and were enrolled in the study. They were randomly assigned to either an exercise group \((N = 11)\) or control group \((N = 7)\). All subjects were required to obtain written physician clearance to participate in the study.

**Procedures**

When assessing a golfer's performance, it is important to realize that golf is a sport where performance can be affected by many variables. A golfer who is more skilled or hits the ball a longer distance than another golfer will not always post a better score. Factors such as weather conditions, equipment, course knowledge, and mental focus can have a significant effect on performance, and these factors are difficult, if not impossible, to control. Thus, the best objective measure of the physical capability of a golfer is the measurement of maximal swing speed. Maximal swing speed is directly proportional to the distance a golf ball will travel and is influenced solely by the body's ability to apply force to the ball. The majority of the literature that pertains to the effect of conditioning on golf performance analyzed maximal swing speed as a dependent variable \((2, 8, 9, 26, 27)\).

**Club Head Speed Assessment**

For all subjects, maximal swing speed of a driver was measured on a SwingMate radar measuring device (Belterronics, Mississauga, Ontario, Canada). The SwingMate can calculate swing speed in 1.6 km·hr\(^{-1}\) increments \((1.0 \text{ mph})\) and can range from 32.2 \((20.0 \text{ mph})\) to 225.3 km·hr\(^{-1}\) \((140.0 \text{ mph})\). Measurement error for the SwingMate is \(\pm 0.8 \text{ km·hr}^{-1}\) \((0.5 \text{ mph})\). The device was checked for accuracy against a computerized launch monitor (Golf Achiever; Focaltron Corporation, Sunnyvale, CA) before testing.

Swing speed testing was measured in both exercise and control group subjects and was performed at an indoor golf facility with a large net, Astroturf mat, regulation golf balls, and rubber tees of various heights to accommodate the preference of each participant. The participant was allowed to warm up with an iron until he felt comfortable to swing a driver and was allowed to make several swings with his driver. This warm-up was designed to familiarize the participant with the testing station and to reduce any pretest anxiety. The participant was instructed to hit 5 balls by taking full swings with his own driver, imagining that he was on a comfortable driving hole on his home golf course. The participant was not allowed to view his swing speed results between trials. An intraclass correlation coefficient (ICC R) was generated to evaluate the reliability of the 5 swing speed measurements and yielded a value of 0.971, indicating excellent trial-to-trial reliability. The highest swing speed for each subject was used in data analysis.

**Functional Fitness Assessment**

The Senior Fitness Test (SFT) battery was administered to subjects in the exercise group. The SFT has been used extensively and has been shown to be a valid and reliable indicator of fitness in various community-dwelling older populations \((4, 22)\). However, the SFT has never been used to assess outcomes after a functional training program such as the program used in this study. Thus, it was of interest to the investigators to determine if the SFT would detect changes in fitness in response to a functional training program such as this. The following SFT assessments were made: 30-second chair stand test (CHAIR) for lower body muscle strength; arm curl test (ARM) for upper body muscle strength; 2-minute step test (STEP) for cardiovascular endurance; chair sit and reach (SR FLEX) for lower body flexibility; back scratch test (BS FLEX) for upper body flexibility; and 8-ft timed up-and-go test (TUG) for agility and dynamic balance. Testing procedures, including providing practice trials, were matched directly to the protocols listed in the assessment manual \((23)\). Subjects were tested in a carpeted general use recreation room with adequate space and lighting to ensure optimal performance.

**Training Program Design**

The framework for this 8-week progressive functional training program was adapted from the National Acade-
This periodized model presents a systematic progression of exercises to enhance fitness and performance. The first phase of the model has the primary goal of enhancing spinal stabilization and developing neuromuscular control during functional movements. The second phase of the model has the primary goal of developing peripheral muscle strength. The final phase of the model has the primary goal of enhancing speed of movement and muscle power. These phases are intended to progress sequentially and build on the previous phases to ensure optimal performance and injury prevention. Exercises for this research project were developed to be consistent with the first phase of the Optimum Performance Training Model and included flexibility, spinal stabilization, balance, and resistance exercises to enhance performance, improve neuromuscular control, and prevent injury. Rotational (i.e., transverse plane) movements were included frequently and were intended to mimic the golf swing for sport specificity.

Exercise classes were offered daily, and subjects were required to attend three 90-minute training sessions per week during the 8-week program. This volume of training is consistent with most other golf fitness studies and represents an adequate training period to see adaptations in both fitness and performance (26, 27). Throughout the program the exercises were systematically progressed to accommodate improvements in exercise performance. All training sessions were led by the lead researcher, a certified fitness professional, and assisted by trained undergraduate exercise science students. Careful attention was given to proper exercise technique, and subjects were provided visual and tactile feedback to correctly perform the exercises.

Each session began with 5 minutes of dynamic exercises to music to increase muscle blood flow. Exercises included marching, squats, lunges, arm circles, overhead reaches, and trunk rotations. Static stretches for major muscle groups followed the 5-minute warm-up and were performed as a 10-minute cool-down at the end of the session. Static stretches were held for 15–30 seconds each and were performed for the following muscle groups: calves, hamstrings, quadriceps, hip flexors, gluteals, latissimus dorsi, rhomboids, pectorals, deltoids, triceps, levator scapulae, and scalenes.

The remainder of each training session involved 3 different domains of exercise: core stabilization, static and dynamic balance, and muscular strength. Exercises in each domain were performed in a circuit fashion to complete the session in 90 minutes. Table 1 details the core stabilization exercises performed weekly during the training program. Table 2 details the balance exercises performed weekly during the training program. Table 3 details the strength exercise progressions performed weekly during the 8-week training program. During the last 2 weeks of the training program, rotational power exercises were also included. These were delayed until the end of the exercise program to ensure that adequate core stability and neuromuscular control had been established so that the subjects could safely perform the exercises with...
proper form. Power exercises included rotational medicine ball throws, wood chops, and simulated golf swings with elastic cables anchored to a fixed object. Figures 1–4 show various exercises used during the training program. Subjects that were not able to complete an exercise progression safely and with proper form continued with the previous exercise until they showed that they could perform the progression correctly.

Statistical Analyses
Subsequent to the collection of data, data entry was verified by comparing a printout of data entry to the original data sheets. The following data were represented as dependent variables: maximal club head speed in km·hr\(^{-1}\) (CHS), number of chair stands performed in 30 seconds (CHAIR), number of arm curls performed in 30 seconds (ARM), number of steps performed in 2 minutes (STEPS), sit and reach flexibility in centimeters (S FLEX), back scratch flexibility in centimeters (BS FLEX), and up-and-go time in seconds (TUG). Analysis of covariance (ANCOVA) was performed to determine group pretest to posttest differences between exercise and control groups for club head speed measurement. Pretest measurement was used as the covariate to account for any initial differences that may have existed between groups. Additionally, paired \( t \)-tests were performed to determine pretest to posttest differences in exercise group SFT variables. All measures were considered significant at \( p \leq 0.05 \).

RESULTS
Club head speed for the exercise group increased from 127.3 ± 19.3 km·hr\(^{-1}\) (79.1 ± 11.9 mph) before the 8-week conditioning program to 133.6 ± 21.6 km·hr\(^{-1}\) (83.0 ± 13.4 mph) after the conditioning program. This represents a 4.9% increase in CHS. Club head speed for the control group showed a slight decrease from 135.9 (84.5 mph) to 135.0 km·hr\(^{-1}\) (83.9 mph). Club head speed changes for both groups are represented in Figure 5. The ANCOVA comparing CHS for treatment and control was significant (\( F = 15.53; p = 0.01 \)).

Results of the \( t \)-tests for the SFT measurements were mixed. Improvement in the exercise group for CHAIR, STEP, SR FLEX, and TUG were significant, with \( p \leq 0.05 \). However, there were no significant differences between pretest and posttest for ARM or BS FLEX. Table 4 contains group data for all SFT variables.

DISCUSSION
Consistent with the hypothesis, subjects in the exercise group of this study significantly increased their club head speed by an average of 5.3 km·hr\(^{-1}\) (3.9 mph) after the 8-week conditioning program. This result has both statistical significance and practical importance. A 5.3-km·hr\(^{-1}\) improvement in driver swing speed will result in approximately 10–15 more meters of carry distance off the tee, and likely more roll distance as well. This will typically result in the need for 1–2 fewer clubs to be hit into a green. For example, on a 400-m par-4 hole, a drive hit 250 m will leave the golfer with a 6-iron into the green from 150 m. However, if the drive is hit 265 m, likely only an 8-iron will be needed from 135 m. The use of an 8-iron over a 6-iron has several performance benefits. It will result in a higher shot that has less sidespin, has more backspin, flies straighter, and lands softer. Provided the golfer strikes the ball well during a full round of golf, he/she likely will score better when hitting shorter irons into greens.

This significant improvement in club head speed was similar to the success that other conditioning programs have had in the improvement of golf performance. In 1998, Hetu et al. (9) studied the effect of an 8-week program of circuit resistance training, static stretching, and plyometric medicine ball throws on the club head speed of 17 middle-aged golfers (52.4 ± 6.7 [SD] years). After the program, club head speed increased significantly by 4.8 km·hr\(^{-1}\) (3.0 mph).

Westcott and Parziale (27) conducted 2 studies to assess the importance of flexibility and strength training on club head speed. The first study investigated a combined circuit resistance training and flexibility training program and its effect on club head speed in 17 middle-aged golfers (mean age, 57.8 years). The results showed significant improvements in muscle strength and flexibility measurements. Club head speed increased significantly by 8.1 km·hr\(^{-1}\) (5.0 mph). A small control group of 5 persons showed no improvements in any performance measure during the 8-week program. In the same publication, Westcott and Parziale reported the findings of a second 8-week study done to determine the effect of circuit resistance training alone on club head speed in 31 middle-aged subjects (mean age, 51.7 years). The results showed that the subjects improved significantly in muscular strength; however, all flexibility measurements remained the same after the weight-training program. Club head speed increased significantly, but by only 4.8 km·hr\(^{-1}\) (3.0 mph).

### Table 2. Balance progressions during the training program.

<table>
<thead>
<tr>
<th>Wk 1</th>
<th>Seated balance on stability ball with good posture 4 reps 15-s hold</th>
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</thead>
<tbody>
<tr>
<td>Wk 2</td>
<td>Seated rotations on stability ball with good posture 2 reps 30-s each direction</td>
</tr>
<tr>
<td>Wk 3</td>
<td>Single leg balance with/without upper body support 4 reps/leg 10-s hold</td>
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<tr>
<td>Wk 4</td>
<td>Single leg balance, single leg frontal plane reach 4 reps 10-s hold per leg</td>
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<tr>
<td>Wk 5</td>
<td>Single leg balance, single leg frontal plane reach 4 reps 10-s hold per leg</td>
</tr>
<tr>
<td>Wk 6</td>
<td>Single leg, opposite arm touchdown 2 × 12</td>
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<tr>
<td>Wk 7</td>
<td>Single leg, opposite arm touchdown 2 × 12</td>
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<tr>
<td>Wk 8</td>
<td>Single leg windmill with shoulder rotation 2 × 12</td>
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</tbody>
</table>
TABLE 3. Strength progressions during the training program.

<table>
<thead>
<tr>
<th>Wk</th>
<th>Chest</th>
<th>Shoulders</th>
<th>Back</th>
<th>Arms</th>
<th>Legs</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Wall push-up</td>
<td>Single leg scaption</td>
<td>Single leg cobra</td>
<td>Triceps extension and single leg biceps curl</td>
<td>Wall squat on stability ball</td>
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<tr>
<td>1</td>
<td>1 x 15</td>
<td>1 x 15</td>
<td>1 x 15</td>
<td>1 x 15</td>
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<tr>
<td></td>
<td>Lateral raises</td>
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<td></td>
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<tr>
<td>2</td>
<td>2 x 15</td>
<td></td>
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<td></td>
<td>Single leg diagonal raise</td>
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<tr>
<td>3</td>
<td>Close grip push-up</td>
<td>2 x 12</td>
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<td></td>
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<tr>
<td></td>
<td>Wall push-up</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Wide grip push-up</td>
<td>2 x 15</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Wide grip push-up</td>
<td>3 x 12</td>
<td></td>
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<tr>
<td></td>
<td>Chest press on stability ball</td>
<td>3 x 12</td>
<td></td>
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<td></td>
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<tr>
<td>5</td>
<td>Rotating shoulder raise on stability ball</td>
<td>3 x 12</td>
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<tr>
<td></td>
<td>Standing rotating shoulder raise</td>
<td>3 x 12</td>
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<tr>
<td>6</td>
<td>Single arm chest press on stability ball</td>
<td>3 x 8</td>
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<tr>
<td></td>
<td>Reverse fly on stability ball</td>
<td>3 x 8</td>
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<tr>
<td>7</td>
<td>Chest fly on stability ball</td>
<td>3 x 8</td>
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<td></td>
<td>Wood chops</td>
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<tr>
<td></td>
<td>Squat to rotating shoulder press</td>
<td>3 x 8</td>
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</table>

The authors concluded that flexibility and weight training together have a greater influence on club head speed than either one alone (27). Additionally, Jones (12) determined that an 8-week stretching program using proprioceptive neuromuscular facilitation techniques resulted in an 8.90 km·hr⁻¹ (5.5 mph) increase in club head speed in 16 middle-aged golfers (51.9 ± 4.9 years).

The previously noted investigations all studied a population approximately 20 years younger than that used in this investigation, and the study designs were not without methodological limitations. Only 1 study used a control group and that included less than one-half of the subjects in the exercise group. More recently, Thompson and Osness (26) studied the effect of an 8-week circuit resistance training and flexibility program in 31 older male golfers (65.1 ± 6.2 years). Nineteen subjects were assigned to an exercise group, which completed 24 exercise sessions over the 8-week period, whereas another 12 subjects functioned as nonexercising controls. Club head speed in the exercise group increased 3.6 km·hr⁻¹ (2.1 mph), a significant improvement compared with the control group.

Although the improvement in club head speed in this
any plyometric/power exercise until the last 2 weeks of the program in an attempt to ensure that our subjects had established adequate neuromuscular control and stabilization strength in their core musculature before executing rotational exercises at maximal speed. As the Optimal Performance Training Model progresses to later phases, the development of muscular power and maximal strength becomes of primary importance. It has been shown in younger golfers that rotational power exercises can improve club head speed (8). Thus, it is possible that a training program of longer duration that included a greater emphasis on the development of rotational power would have resulted in an even greater increase in club head speed. Additionally, power training in older adults has been implicated in fall prevention and injury reduction (7, 18, 20). Therefore, it is recommended that future fitness research studying older golfers increase the duration of an intervention such as ours to include more golf-specific power exercises in the latter stages of the exercise program to assess whether performance and health benefits occur. Additionally, the application of a functional training program such as this one may be appropriate for general fitness programming with community-dwelling older adults and reduce risk for falling. Further research should be done to study the efficacy of such a training program in various older populations.
FUNCTIONAL TRAINING FOR OLDER MALE GOLFERS

PRACTICAL APPLICATIONS

Although integrated periodized training models such as the Optimal Performance Training Model are prevalent in strength and conditioning programs for various athletic populations, such a model had never been used to provide the framework for a research study until now. The results of this study lend strong support to its effectiveness in improving golf performance in older golfers.

It is reasonable to believe that athletes of any age and in other sports could benefit from exercise programs similar to this that emphasize multiplanar exercises in a proprioceptively enriched environment. Many of our selected exercises, which were chosen to be appropriate for older, deconditioned golfers, could be significantly progressed in difficulty to accommodate even the most accomplished and/or youngerathletes. However, careful attention must be given to the initial assessment of flexibility, spinal stabilization, balance, and functional strength to properly initiate and progress the training program. Additionally, because the primary goal of periodized training is to ensure that the athlete peaks during the competitive season, such a program should be constructed well in advance and progress through all relevant phases (i.e., development of maximum strength and power) in preparation for competition.

It is also important to note that such a periodized training model has applications outside of the athletic domain. This training program was effective at improving several dimensions of functional fitness in the study sample. Community-dwelling and institutionalized older adults, whose balance and strength deficits greatly increase their risk for falls, can benefit from exercise programs such as this that integrate multiple components of fitness. Careful preparticipation health screenings, quality exercise leadership, and slow but regular exercise progressions should be used and will contribute to beneficial functional outcomes.

REFERENCES


Acknowledgments

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