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Resistance training for performance and injury prevention in golf

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This introductory resistance training program is designed to minimize injury risk, improve golf swing speed and the overall fitness of recreational golfers. This article aims to introduce to the Chiropractor the basic concepts sport specific resistance training, periodization models of resistance training and proposes a year round conditioning resistance training program specific to golf. The exercises have been chosen based on the best biomechanical evidence to minimize injury risk and on the research supporting the use of movement specific training adaptations. Upper body strength exercises are performed standing to develop both trunk and hip stabilizing musculature and the primary movement of the golf swing.
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KEY WORDS: golf, injury, exercise, strength training, stability.

Le programme introductif d'entraînement contre résistance est conçu pour diminuer les risques de blessure, améliorer la vitesse de l'élan de golf et la santé physique générale des golffeurs amateurs. Cet article a pour but d'introduire au chiropraticien, les concepts de base particuliers, reliés à l'entraînement sportif contre résistance, aux modèles de périodisation d'entraînement contre résistance et propose un entraînement de conditionnement contre résistance, axé particulièrement sur le golf. Ces exercices ont été choisis selon les meilleurs critères biomécaniques pour réduire les risques de blessure, ainsi que d'après la recherche qui soutient des adaptations d'entraînement, utiisant un mouvement particulier. Les exercices pour raffermir la partie du corps supérieure sont exécutés debout pour développer, à la fois le tronc et la hanche, pour stabiliser la musculature et les mouvements principaux de l'élan de golf.
(JACC 2006; 50(1):27–42)

MOTS CLÉS : golf, blessure, exercice, entraînement de la force, stabilité.

Introduction

This paper outlines a simple 3 phase resistance training program designed for golfers with minimal strength training experience. The program can also be used as an introduction to strength training for elite golfers wishing to advance to a more rigorous and periodized strength and conditioning program. The program aims to prevent musculoskeletal injuries, improve the strength and power of the golf swing and increase the general fitness of participants. For ease of description, the conditioning program will be split into two different components: 1. Injury Prevention and 2. Strength and Power Training. The two exercise components are not mutually exclusive. Exercises performed in the injury prevention component

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may improve the golf swing and exercises performed during the strength and power component may reduce the risk of injury.

An attempt has been made to select exercises based on the best available biomechanical and strength and conditioning research. However, research in many areas is lacking and suggestions for program construction are still necessary. Where research is lacking, exercises were included based on the published suggestions of leading researchers within the biomechanics and strength and conditioning field. It should also be noted that these are not the only possible exercises that may improve golf performance and decrease injury risk. Additionally, while the construction of the conditioning program is based on the available literature gaps in our current knowledge ultimately makes much of the program still the opinion of the author based on my interpretation of the literature. Future longitudinal research comparing different training regimes for golf performance would be of benefit.

Injury Prevention

The injury prevention program focuses on developing muscle endurance and motor control to provide muscular stability for the lumbar and shoulder regions. It should be noted that research is lacking that prospectively evaluates the efficacy of these exercise programs in preventing injuries. Rather, the rationale for the inclusion of these exercises is supported by the available biomechanical evidence and cross sectional epidemiological evidence (i.e. greater hip abduction strength is correlated with fewer knee injuries). Exercise inclusion is supported by the exercise's efficacy in achieving muscular activation (determined via electromyographic studies), minimization of excessive or asymmetrical spinal loading or theorized sub-optimal muscular recruitment (i.e. high levels of upper trapezius recruitment during exercises designed to train serratus anterior) and the expert opinion of leading researchers. Details of the exercise inclusion rationale will be provided in the following sections.

Training to Improve Spinal Stability and Prevent Low Back Injuries

Trunk extensors, flexors, rotators and lateral bend agonists are active through all portions of the golf swing.[1] Due to the muscular demands of the golf swing and the prevalence of injury in the lumbar spine, training the trunk musculature may improve performance and decrease injury risk. Adequate spinal stability is the amount of trunk muscle co-contraction necessary to reinforce the spine to prevent segmental buckling. This ability to stabilize the spine is considered necessary in the prevention of low back injuries.[2,3] Spinal stability is not provided by one specific muscle but rather via the coordinated efforts of the flexor, extensor and lateral bending trunk musculature[4] (rectus abdominis, external oblique, internal oblique, tranverse abominis, erector spinae, quadratus lumborum and latissimus dorsi). Because only a minimal level of trunk muscle contraction appears necessary to stabilize the spine, the strength of these muscles appears less important than the endurance capabilities of the muscular stabilizing system. Spinal extensor endurance has been shown to be correlated with decreases in injury risk for the low back.[5] Poor trunk muscular endurance as well as aberrant flexor/extensor endurance ratios has also been correlated with a history of low back injury.[6] Therefore, the aim of this exercise program is to improve the endurance and strength of trunk muscles to facilitate their ability to stabilize the spine in neutral and non-neutral positions and improve their ability to produce force during the golf swing.

Many exercises can stress the trunk muscular system and require muscle activation levels which result in increased strength and endurance. However, a justification and requirement for the inclusion of exercises in this spinal stability program is that the exercises are safe and do not increase the risk of injury with elevated spinal compressive and shear loads. Many commonly prescribed trunk muscle exercises for rehabilitation and performance may actually predispose one to injury due to the high compressive and shear loads imparted on the lumbar spine caused by excessive muscular co-contraction and extreme ranges of motion.[7] The exercises (Figures 1–4, description in Table 2; curl up, bird dog, side bridge and front support) chosen for this program currently have the most research supporting their ability to adequately activate the trunk musculature without exceeding cautious injury thresholds for compressive and shear loading.[8] The exercises are sufficient to adequately stress all trunk muscles responsible for maintaining a strong and stable spine.

The exercises should be performed on the days that the athlete is not performing their strength and power resistance exercises. An attempt to maintain a moderately neu-

Table 1 Injury prevention exercises designed to train muscles responsible for trunk stability.

Exercise	*Description*
Curl Up	Golfer lies on back with one knee bent 90 degrees and the second leg straight. Hands should be placed under the low back to prevent spinal flexion. Golfer "curls" their shoulders 2 inches off the surface. The neck should should stay in a neutral position. Strain should be experienced in the abdominal region. The golfer should focus on curling the ribcage toward their pelvis.
Bird Dog	Golfer starts on hands and knees. From this four point kneeling position the golfer should extend one leg parallel to the floor, hold for 3 seconds and return to the starting position. Repeat with other leg. Additionally, the opposite arm can also be raised. The golfer must maintain control of the spine and minimize twisting and excessive movement.
Side Support	Golfer starts in side lying position and raises their torso off the floor. Their weight should be supported by their knee and their forearm. To increase difficultly support the weight from the forearm and the golfers lateral feet.
Front Support	Rolling from the side support position the golfer maintains a neutral spine and supports their weight on their forearms and the balls of both feet.

Figure 1 Curl up.

Figure 3 Side Support.

Figure 2 Bird Dog.

Figure 4 Front Support.

Table 2 Exercises to prevent shoulder injury through enhancing shoulder control.

Exercise	*Exercise Description*
Lower Trap Arm Raise	While lying face down the participant lifts their arm to a position 45 degrees lateral to and at the level of their head. The arm should be in line with the lower trapezius fibres. This exercise trains the trapezius, deltoid, external rotator cuff and rhomboids.
External Rotation –teres minor –infraspinatus	Using a dumbbell with their arm abducted and elbow flexed, the participant should eccentrically lower the dumbbell (internally rotate) and then raise the dumbbell to the starting position via external shoulder rotation. This exercise trains the external rotator cuff. Athletes should focus on keeping their shoulder blades back and down.
Push Up Plus	The athlete begins in push up position and allows their shoulder blades to "roll together". The participant, while maintaining a neutral spine, attempts to push themselves up further by pushing the shoulder blades farther apart (Scapular Protraction). This exercise has been shown to maximize serratus anterior & subscapularis activity while minimizing upper trapezius activation. The external rotator cuff is also active.

tral spine posture should occur. For the isometric bridge exercises (front and side bridge) athletes should hold each position for 3–5 seconds then "roll" into the next bridge position while maintaining a neutral spine. When the athlete performs the bird dog or curl up exercise and has lifted their leg or chest, respectively, they should hold this position for 3–5 seconds. The athlete should choose a repetition level which results in fatigue and the inability to perform the exercises with correct form.

Defining these exercises as spine/core stability exercises does not mean that the strength and power training exercises are not core stability exercises. The term core stability in terms of exercise prescription is overused to the point of becoming meaningless. When trunk muscles must be co-activated to stabilize the spine then that exercise is by definition a core stability exercise. For example, the loaded squat is an excellent example of a core stability exercise – anterior, lateral and posterior trunk muscles are active to ensure that the spine does not buckle. All of the exercises in the strength and power training component will require bilateral agonist-antagonist co-activation to produce movement and stabilize the spine. It is the aim of the 4 previous exercises to condition the trunk muscles to facilitate this role and improve their endurance to provide stability during everyday activities. An argument can also be made that these injury prevention exercises may not be necessary if a participant has no back pain and has adequately functioning low back muscles. These exercises are included based on a least harm principle. While it is uncertain whether they might decrease the injury risk for a participant they are not likely to increase their risk of injury.

Training to improve shoulder joint control and prevent shoulder injury

Adequate control of the scapula has been suggested to be necessary in the prevention and treatment of shoulder injuries.[9] Aberrant scapular movement is referred to as scapular dyskinesis which is the result of incorrect muscular coupling between primary scapular stabilizers (serratus anterior, upper, mid and lower trapezius, rhomboids and rotator cuff muscles).[10] Dysfunction in the firing pattern of the trapezius musculature has been noted in patients with rotator cuff impingement.[11,12] Scapular stabilizers are active during all throwing movements, golf included, and therefore conditioning of these muscles may be necessary to improve performance and decrease injury risk.[13]

Rubin and Kibler[13] describe three roles of the scapula in normal function. First, the scapula provides an anatomic and kinematic link between the trunk and the arm. Second, the scapula provides a stable socket for the articulation of the humeral head. Third, scapular control attempts to create adequate space for the clearance of the

rotator cuff during arm elevation via posterior tilting and upward rotation. Details of optimal scapular control cannot be explored in this paper; rather this paper will demonstrate some of the exercises which can train the muscles required to provide scapular stability. An excellent review of scapular function can be found in Rubin and Kibler.[13]

Based on the roles of the scapula delineated by Rubin and Kibler[13] and Cools et al[14] the aim of scapular stability program is to perform exercises which satisfy the following criteria:

1. Train the serratus anterior (SA), while minimizing upper trapezius activity, to increase SA strength, therefore decreasing scapular winging and increasing upward rotation and posterior tipping of the scapula, while minimizing the abnormal scapula rotation associated with increased upper trapezius activity.[15,16]
2. Train the subscapularis muscle because of its role in positioning the humeral head in the glenoid fossa,[9] and its elevated activity during the golf swing.[17,18]
3. Train the scapulothoracic muscles (trapezius, levator scapula, serratus anterior, rhomboids) to control the scapula via retraction, protraction, elevation and depression to provide a stable socket for the humeral head and allow for an optimally positioned scapula for stability.[19,20]
4. Train external rotators to position the humeral head within the glenoid fossa and be optimally conditioned for the requirements of the golf swing.[18]

This scapular stability and strength program also provides a conditioning stimulus for the muscles of the upper limb and thorax. These exercises should be performed 2 times per week on separate days than the strength and power exercises. Two sets of 10–12 repetitions should occur for each exercise. Weights should increase with improvement in strength and endurance. It should be emphasized that these exercises are not the only exercises that can influence and improve shoulder control. These exercises were chosen because they are simple, can be easily implemented and train all the muscles responsible for shoulder joint control. Chiropractors may wish to modify or replace exercises provided they meet the previous requirements. The primary suggested exercises are the Lower Trapezius arm raise, standing shoulder external rotation and push up plus (Figures 5–9, described in table 2). Other possible exercises are low rows, scapular punches, scaption and scapular protraction exercises.

Strength and Power Training

The aim of resistance exercise is to improve the strength of the golfer and their ability to generate power during the golf swing to increase club head speed. Before explaining the resistance training program a brief introduction to resistance training concepts is warranted. The following paragraphs establish a basis for exercise inclusion in the conditioning program.

Strength can be defined as the maximal force that a muscle or muscle group can generate at a specific velocity. Resistance training designed to increase strength typically involves moving weight at a relatively slow pace (2 seconds for each eccentric and concentric portion of the movement) and at a repetition level of less than 12. Total sets per exercise typically range from 1 to 3-elite athletes may perform a significant amount more. Six or less repetitions per set corresponds to approximately 80% of the athlete's one repetition maximum and is the current recommendation for building absolute strength from the National Strength and Conditioning Association.[21] Higher repetition levels (10–12 per set) correspond to the development of muscular hypertrophy. Some research suggests that strength gains are both velocity and movement specific meaning that the largest training effects (increases in force development) occur during tasks which are most similar to the movement and velocity that an athlete performed while training.[22,23] In practice, this suggests that exercises for golf should be similar to the actual golf swing in some manner (i.e. same muscles recruited, similar kinematics, similar velocity of muscle contraction etc). Building a base of strength is a necessary requirement before athletes can begin to train for muscular power. To satisfy the demands of specificity, the current resistance training program includes exercises which recruit the large muscle groups used during the golf swing and are similar to the movement mechanics of the golf swing. However, it is difficult to mimic the exact golf swing with resistance exercises because the addition and application of the weight changes the speed of movement and some of the movement kinematics. Lacking perfect kinematic specificity, some exercises can be performed in

Figure 5 Lower Trapezius Arm Raise.

Figure 6 External Rotation Start.

a manner similar to components of the swing. The exercises performed with resistance cable are executed with the athlete accentuating the production of force from the trunk and incorporating the weight shift from the back leg to the front leg. Essentially, exercises using cable resistance can be semi-specific to the movements of the golf swing. Additional exercises may not be similar to the swing kinematics but are still semi-specific because they train the muscles responsible for creating force and power during the golf swing. The exercises composing the program presented in this article are a combination of cable resistance exercises which are semi-specific to the movement kinematics of the swing and traditional bench or ground based strength training exercises responsible for producing force and power.

Figure 7 External Rotation Finish.

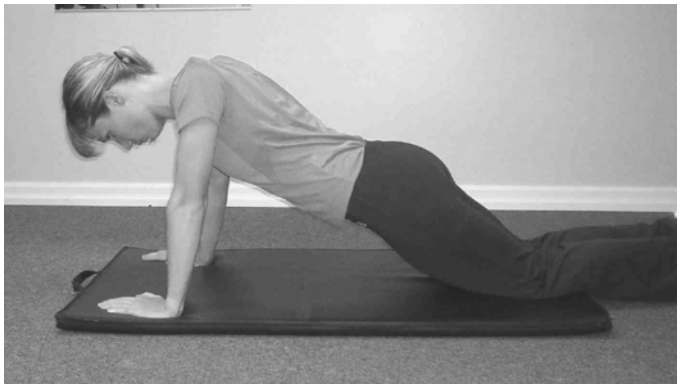

Figure 8 Push Up Plus Start.

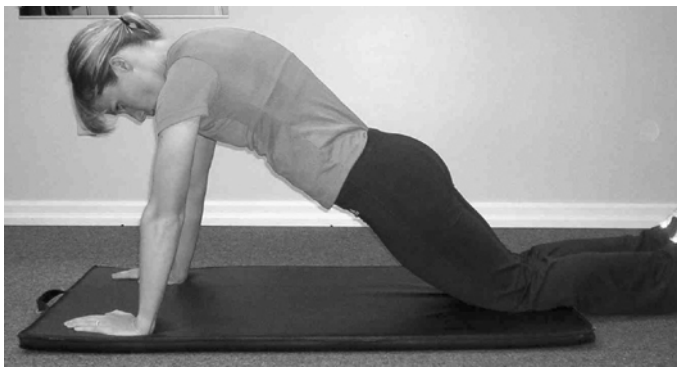

Figure 9 Push Up Plus Finish.

One aim of the golf swing is to generate as much club head speed as possible. To generate these high speeds muscular power must be generated at a high velocity with little resistance to be overcome (only the body's inertia and clubhead mass). *Power* is defined as the rate of work or the product of force and velocity of the movement. Because both force and velocity are components of producing power it is recommended that power production be improved via two methods; heavy resistance training and explosive exercises.[24,25] The first requires improving the ability of the athlete to generate high force via resistance training using high loads (>80% of 1RM) with the intent to maximally accelerate the load. An example is the use of the power clean or the clean and jerk by sprinters. The second method aims to increase the explosiveness of an athlete by developing their ability to generate force at high velocity. Athletes typically choose a weight corresponding to 30–60% of 1RM and attempt to accelerate the weight maximally. A common example is sprinters performing weighted squat jumps or sprints with a weighted sled attached to their waist. It was stated earlier that some research supports that strength gains are specific to the velocity at which the athlete trains. Adhering strictly to the velocity specificity maxim would lead to the conclusion that golfers should only train at high speeds and therefore with minimum resistance. However, the *intent* to maximally accelerate a load is an important stimulus responsible for increases in force and speed.[23] Therefore, training with high levels of force at low speeds can still increase an athlete's ability to generate power at high velocities.[25,26] This is exemplified in the training programs for sprinters which incorporate high resistance training and low resistance-high velocity training to produce improvements in sprinting performance.[27] Due to this research the golf resistance program incorporates both high force and high speed resistance training exercises. A recent study has demonstrated the effectiveness of a resistance training program combining a movement specific plyometric medicine ball toss (fast eccentric muscle actions immediately followed by fast concentric actions) program with a general strength training program in improving golf performance (club head speed, ball distance).[28]

In light of the research demonstrating the importance of specificity in strength development and the methods of developing muscular power the exercises chosen for the resistance program satisfy at least one of the following criteria:

1. Exercises are multi-joint movements, recruit the primary movers of the golf swing and require trunk and hip muscle activation to provide movement and stability.
2. Exercises performed are similar to the movement of the golf swing (i.e. weight shift, torso rotation, muscles recruited).
3. An intention to perform exercises at higher speeds can occur without altering the movements similar to the swing.
4. Exercises are relatively safe in regards to minimizing trunk loading by avoiding awkward postures.

Since safety was a concern in the selection of these exercises a trade off between performance and cautious tissue loading is necessary. High level athletes (gymnasts, wrestlers, Olympic weightlifters) often train extreme ranges of motion, under high loads which exceed acceptable limits for most people. Theoretically, to satisfy the velocity and movement specificity demands of the golf swing, a training exercise would require the golfer to assume elevated levels of trunk rotation and full shoulder rotation and adduction while producing high levels of muscular force. This combination of high force and extreme range of motion is highly related to low back injury in work place and tissue biomechanics studies[29] and may not improve performance sufficiently to warrant the risk. To satisfy the movement specificity demands of our training goal, the range of motion of the exercises is limited to the middle portion of the trunk movement during the swing. The middle portion corresponds to the half way back position during the swing and the early follow through. While debatable, high velocity training and plyometrics may also be related to an increased risk of injury in the uninitiated athlete. To decrease this risk but still gain the advantages of high velocity training, exercises performed at higher speeds should be incorporated after the athlete has developed a base of strength and developed sufficient mastery of the exercises. Again, this range of motion is limited to the middle range of trunk rotation and lead arm shoulder adduction.

Table 3 Weekly schedule of workouts for Introductory Cycle.

Day One	*Day Two*	*Day Three*
Deadlift	Cable Punch	Deadlift
Dumbbell Bench Press	Cable Pull	Dumbbell Bench Press
Seated Row	Weighted Swing	Seated Row
Rear Deltoid Raises	Reverse Scaption	Rear Deltoid Raises
Scaption	Posterior Deltoid Abduction	Scaption
	Swing Fan	
Trunk Series	Trunk Series	Trunk Series
Shoulder Series	Shoulder Series	Shoulder Series

Resistance Training Exercise Descriptions and Periodization

This resistance training program combines traditional strength and power exercises with non-traditional cable resistance exercises semi-specific to the movement kinematics of the golf swing. Please note that the inclusion of these exercises do not exclude other exercises that may be similar to the golf swing and improve performance. Nor is their sufficient scientific proof to imply that a general strength program, without cable resistance exercises, will not improve golf performance. The largest assumption is that the addition of non-traditional cable resistance exercises are similar in kinematics to the golf swing resulting in greater strength and power gains being carried over to golf performance. The exercise selection is predicated on the belief that typical bench based exercises (bench press, two arm seated row, bicep curls) do not adequately train the hip stabilizing musculature (gluteus medius/minimus, gluteus maximus) or the "core" musculature in a functional manner sufficiently to allow a carry over of force production to the golf swing. Additionally, traditional exercises may train the primary mover but they do not train the primary mover in a manner similar to the golf swing. Because traditional exercises do have benefits in improving general muscular strength and can be performed in a short time period they have not been entirely removed from the resistance training program.

Periodization

Periodization of a resistance training program changes program variables (volume, speed of movement, exercises performed, intensity) in an attempt to train different muscular characteristics (hypertrophy, absolute strength, power). It is based on the idea that the body continually adapts to changes in stimulus and habituates to a constant stimulus. Periodization can occur over the long term (e.g. 1 year linear periodization model) or the short term (2 week undulating periodization model). A linear model may see an athlete initially train for hypertrophy for 2 months, then absolute muscle strength for two months, then muscular power for 2 months and finally begin a maintenance phase. An undulating model would have an athlete train for hypertrophy, absolute strength and power on different days during a 10–14 day period. Both methods have been shown to be effective in improving strength gains compared with a non-periodized resistance program.[30]

The golf resistance program presented here combines both periodization methods. Three cycles of resistance training will occur. The introductory cycle (10 weeks duration) will focus on general strength and muscle hypertrophy. The 2nd cycle (10 weeks) will emphasize power and absolute strength development with high force and high velocity exercises. The 3rd cycle follows an undulating periodization scheme to maintain and increase power and strength.

Cycle One: Introductory Hypertrophy and Strength Phase

This phase is a 3 day/week introduction to strength training and is geared toward gaining the strength necessary to incorporate power exercises in the upcoming cycle. The exercises should be performed at a concentric: eccentric ratio of 2:2 seconds with controlled slow movements. All

Table 4 Exercise Descriptions for Semi-Specific Strength Strength, Power and Explosive/Ballistic Exercises.

Exercise	*Description*
Cable Punch	This exercised is performed standing with the legs slightly bent, staggered and body weight on the balls of the feet. While keeping an athletic posture the golfer begins with the cable held lateral to and slightly in front of their chest. The golfer than presses their hand forward in line with the cable. The exercise creates an isometric torque about the lumbar spine which the golfer must resist while actively contracting the primary movers (pectoralis major and triceps brachii). The golfer can also make a slight twisting motion similar to throwing a punch or a football. In addition to training the primary movers this exercise requires a great deal of trunk muscle activity. The twisting motion is similar to the rotation occurring during the golf swing.
Lawnmower Pull	With the knees bent between 45 and 90 degrees and the feet staggered (left leg forward if pulling with the right arm) the golfer faces the weight stack and pulls the cable toward the chest like a one arm row. During the pulling action the knees should extend and the golfer should now be upright. A small amount of trunk twist should also occur during this movement.
Weighted Golf Swing	The golfer grips the rope attachment with two arms and mimics a slow and shortened golf swing. The arms should travel less than 30 cm. The golfer must focus on the trunk starting the movement and the proper weight shift from the trailing leg to the lead leg. This exercise is not designed to allow for a swinging of the arms, rather a small movement of the trunk twisting combined with a small amount of arm movement should occur.
Reverse Scaption:	Using the trailing arm (the right arm for a right handed swinging golfer) the athlete grasps elastic tubing or the cable with their arm abducted and external rotated. This position should be similar to the midrange position of the downswing. From this position the athlete should adduct their arm as if attempting to swing. The elbow should not cross the midline of the body and should finish “tucked” against the athlete right side.
Medicine Ball Toss	The golfer simply assumes a golf stance, swings the ball back similar to the back swing but not more than halfway back and then swings forward releasing the ball while attempting to mimic the proper golf movement.
Deadlift	This exercise is designed to train the leg muscles and the posterior trunk muscles. It should also be noted that all abdominal muscles are recruited and this is therefore an excellent “core” exercises. Golfers should focus on allowing the buttocks to feel as if they are being pushed backwards. Body weight is on the heels similar to the golf address position. This exercise is added because it is an excellent all around exercise and is similar to the address position for all swings of the club.

one arm exercises should be performed bilaterally. The golfer-athlete should perform 2–3 sets of 10–12 repetitions of each exercise. A rest between sets of 1–2 minutes should occur. Golfers should attempt to mimic the weight shift that occurs during the golf swing and focus on proper golf form where applicable. Table 3 details the exercises performed each day of the week. Table 4 describes the non-traditional semi-specific resistance exercises and Figures 10–18 illustrates some of the exercises.

Cycle Two: Strength and Power Development

In Cycle two the golfer-athlete aims to improve their power and strength production. In this stage the athlete will train three days per week. Each day will either be de-

Figure 10 Start of Cable Punch.

Figure 11 Finish of Cable Punch.

voted to strength and hypertrophy development (a "light" day 10–12 repetitions/set), power development using explosive exercises and light loads (30–60% max) and power development using "heavy" loads and an intention to maximally accelerate the weight (less than 6 repetitions/set). Simply, there is a light day, an explosive day and a heavy day. Power, strength and hypertrophy is desirable for all muscles and all exercises, however; different exercises are performed on day 1 and day 3 meaning some exercises are subjected to different loading parameters. To rectify this imbalance the golfer athlete must rotate which exercises are performed on light days and which are performed on heavy days. This is done using a microcycle of two weeks duration. The first week requires that day one be the "light day" and day three be the "heavy day". This should be reversed for week two in the microcycle; day one using heavy loads and day three using lighter weights. Table 5 outlines the two week micro cycle for Cycle Two.

For both the explosive training and the high force day the rest time between sets should increase to 3 minutes. The concentric portion of the exercises should occur as rapidly as possible however, the eccentric portion should not be violently fast. The typical backswing is not fast, therefore, for safety, the eccentric portion should be slightly slower than their backswing. Immediately following the eccentric portion the athlete should rapidly contract concentrically, maintaining proper golf form for

Figure 12 Lawnmower Pull start.

Figure 13 Lawnmower Pull finish.

Table 5 Two week micro cycle for Cycle Two.

Day One	*Day Two (Explosive)*	*Day Three*
Dumbbell Bench Press	Cable Punch	Deadlift
Cable Pull	Cable Pull	Cable Punch
Weighted Swing	Reverse Scaption	Seated Row
Squats	Posterior Deltoid Abduction	Weighted Swing
Rear Deltoid Raises	Medicine Ball Toss	Rear Deltoid Raises
Scaption	Swing Fan	Scaption
Trunk Series	Trunk Series	Trunk Series
Shoulder Series	Shoulder Series	Shoulder Series
During Week 1 of the 2-week micro-cycle the exercises on Day One are performed using less than 6 repetitions per set and 3 minutes of rest between sets (a “Heavy” day). The exercises of Day 3 are performed using higher repetitions with less weight and no intention to maximally accelerate the weight. The amount of weight lifted and the acceleration profile is reversed in Week 2 for Days One and Three.		

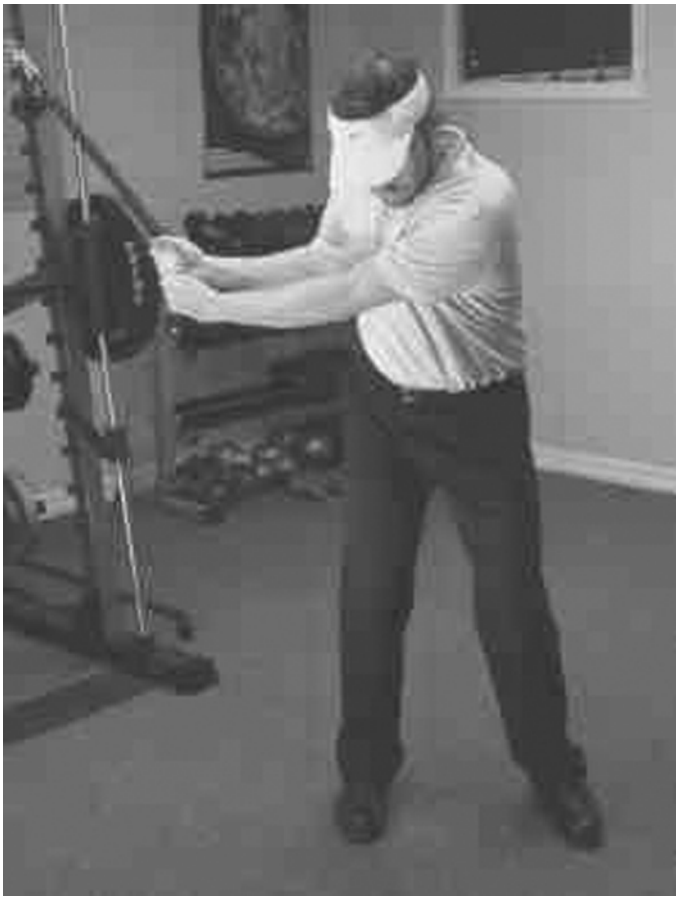

Figure 14 Weighted Golf Swing Start.

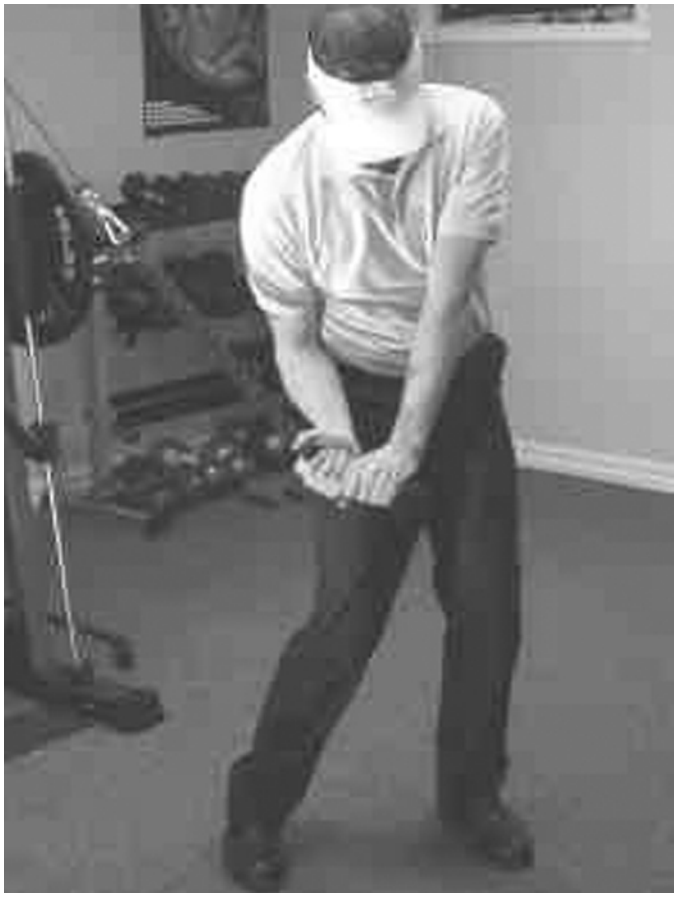

Figure 15 Weighted Golf Swing finish.

the golf semi-specific exercises. During explosive training the weight should be heavy enough that it is not accelerated so rapidly as to exceed the force of gravity to the extent that the cable becomes slack. If the Chiropractor wishes to incorporate higher velocity movements then elastic tubing can be used. The deadlift should be excluded from the power exercises. It should be performed in the same manner as described in the exercise description section. If the chiropractor has sufficient training in strength training then the deadlift can be replaced with the Power Clean or Snatch if the athlete wishes to train this movement for power.

Cycle Three: Undulating Periodization Phase (Hypertrophy, Strength, Power, Speed)

The program presented here is a 14 day cycle, consisting of 3 different routines for week 1 and 3 different routines for week 2. Strength, hypertrophy, power, ballistic speed and balance are being maintained and developed over the course of the 14 day cycle. This phase incorporates more high speed training where the golfer athlete uses elastic tubing rather than cable or free weights on the ballistic training days. Additionally, a SwingFan is incorporated into this day of training. The swing fan is a golf club with fins attached to the end which provides air resistance through out the swing. This allows the golfer to swing at high velocities against a resistance greater than what is provided by a club. Table 6 and 7 outlines week 1 and 2 of this phase.

Figure 16 Reverse Scaption.

Figure 17 Medicine Ball Toss.

Table 6 Week one of undulating periodization.

Day 1 (Hypertrophy)	*Day 2: Ballistic Exercise*	*Day 3 (Power)*
1-Arm Chest Press (3x10) Seated Row (3x10) Weighted Swing (2x10) Scaption (2x10) Medicine ball toss (2x10) Squat & Shoulder Press (2x10) Bridge Series *regular pace	–Underweight swings –Swing Fan swings –1 leg squats progressing to lateral leaps. –Reverse Scaption with tubing –Cross body pull with lead arm 2 sets of 10 for each exercise. 2–3 minutes rest between sets. Bridge Series	Deadlift (3x6) 1-arm Pull with twist (3x6) Reverse Scaption (2x6) 1 arm shoulder adduction with cable (2x6) Medicine ball toss (2x10) Dumbbell Bench Press (2x6) Bridge Series *Attempt to move fast

Figure 18 Deadlift.

Flexibility Training for Injury Prevention and Golf Performance

This is a complicated and much debated issue exacerbated by a lack of research investigating the influence of stretching on injury prevention in golf and performance improvement of the golf swing. While little research exists to suggest that increasing flexibility decreases the injury risk in some sporting events, no research has investigated whether stretching can decrease the injury risk during golf. The greatest drawbacks to a stretching program are that stretching prior to performance may decrease force production,[31,32] stretching may have no injury preventative effects[33,34,35] and specific stretches, specifically, lumbar flexion, extension and rotation may load the spinal tissues to such an extent that injury may be more likely to occur.[36,8] An argument in favour of stretching suggests that a certain degree of range of motion and flexibility is required to perform the golf swing, stretching has anecdotal support from many injury treatment and strength professionals, there is no epidemiological evidence suggesting that stretching increases the risk of injury and that stretching may be relatively safe compared with the biomechanical demands of the golf swing, considering that range of motion during stretches are more controlled than the ballistic range of motion which occurs during the actual performance of a golf swing.

The aim of a flexibility program is to increase active range of motion and ultimately increase performance. Unfortunately, the relationship between range of motion and golf performance is unknown. While stretching has been shown to increase range of motion via an increase in stretch tolerance,[37] it is unknown whether increases in ROM results in increased clubhead speed. Anecdotally, limited ranges of motion may be associated with a decrease in clubhead speed due to the decreased size of the swing arc and time to produce clubhead speed. Since static stretching decreases the muscles ability to generate force immediately after a stretching protocol[31,32] a cautious recommendation for stretching would be to include golf specific stretching after a workout.

A preliminary recommendation for the incorporation of stretching exercises into a conditioning program may be based on a least harm assumption and clinical wisdom. Stretches which do not actively mimic the necessary golf movement and may result in higher than acceptable tissue loads should be avoided, i.e. forward spinal bend and extension stretches. Stretches designed to increase range of motion that appear relatively innocuous (upper and lower limb stretches while maintaining a neutral spine angle) and those stretches that mimic the golf swing (trunk and hip rotation) should be advocated. Further support for advocating a trunk twisting stretch that may improve shoulder and hip turn during the back swing is seen in a case study where the rotational range of motion of the trunk during the golf swing exceeds that of the

Table 7 Week two of undulating periodization.

Day 4 (Strength)	*Day 5: Ballistic Exercise*	*Day 6 (Power)*
1-Arm Chest Press (3x6) Seated Row (3x6) Weighted Swing (2x6) –Scaption (2x10) –Dumbbell fly (2x6) –Medicine Ball Toss Squat & Shoulder Press (2x10) *Regular Pace Bridge Series	–Underweight swings –Swing Fan swings –1 leg squats progressing to lateral leaps. –Reverse Scaption with tubing –Cross body pull with lead arm 2 sets of 10 for each exercise. 2–3 minutes rest between sets.	Deadlift (3x 10–12) 1-arm Pull with twist (3x12) Weighted swing (2x12) –1 arm shoulder adduction with cable (2x12) –Medicine Ball Toss Dumbbell Bench Press (2x12) *Attempt to move fast Bridge Series

passive range of motion during a trunk twist suggesting the golf swing is a greater risk than the stretch itself in terms of passive tissue strain.[38] If stretches are recommended by the Chiropractor then they should be performed after the strength training session or as an individual session. Athletes are encouraged to warm up rather than stretch before golfing or working out.

Conclusion

This conditioning program aims to prevent injury and improve force and power generation during the golf swing to ultimately improve club head speed. The strength training program is designed under the assumption that the exercises are similar to the movements of the golf swing; therefore, greater strength and power gains will be transferred to the swing when compared with traditional strength exercises. It must be stressed that the exercises recommended are not the only possible exercises that may benefit a golfer. The Chiropractor is left to their individual discretion in choosing exercises but may still benefit from the inclusion criteria detailed in this program.

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