Golf

Play It Safe

Play Better

(And Prevent Injuries, Too)

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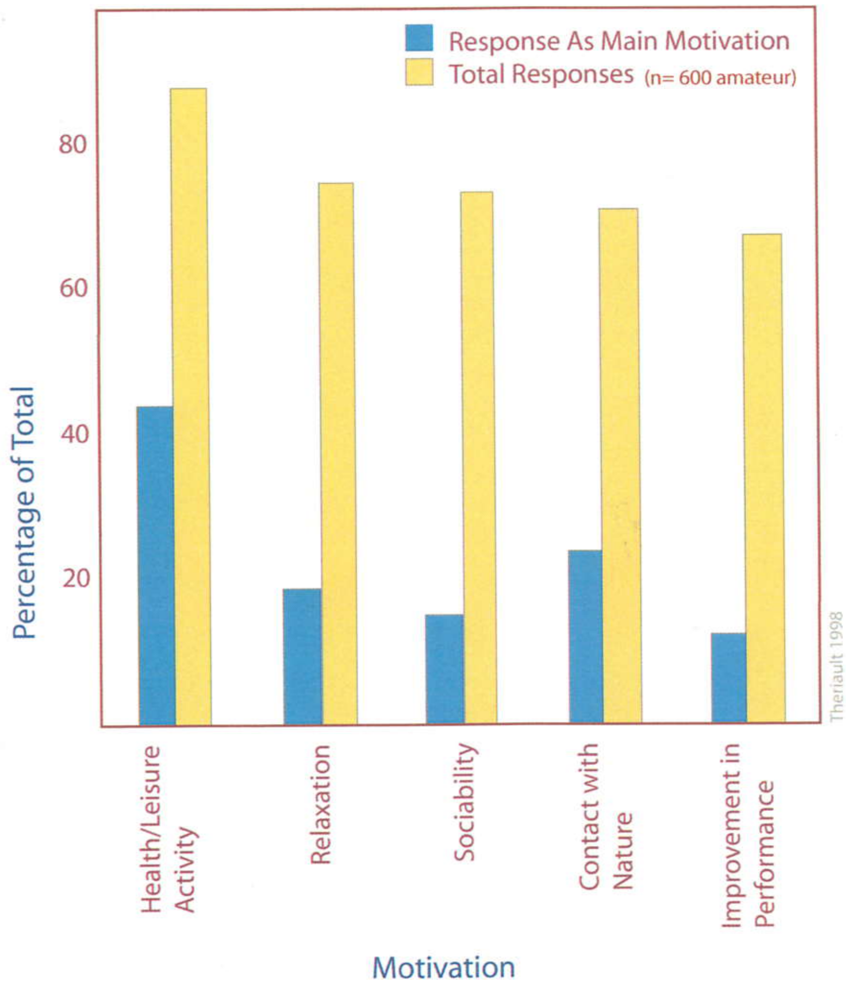
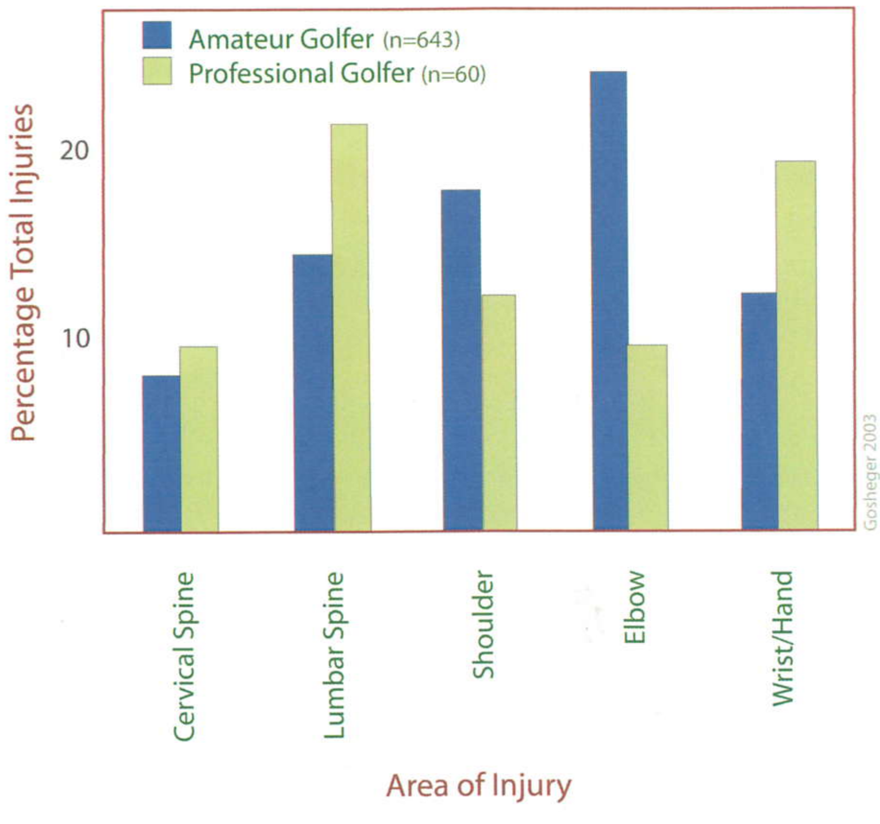
Motivations of Amateur Golfers For Playing Golf



Prevalence of Injuries in Amateur And Professional Golfers



The most common injuries in the amateur group were elbow injuries, followed by shoulder and back injuries.

In the professional group the back was the most affected region, followed by the wrist and shoulder.

(Gosheger 2003)

Causes Of Injuries In Golf

Overuse

(Professional 80%)

Back - 92%

<u>Excessive Play</u>

Shoulder - 92%

Elbow - 99%

Technical Errors

(Recreational 62-72%)

Physical Fitness

No Pre-Game Warm-up

Gosheger 2003

Back Pain Risk In Golf

Professionals: 24%
Amateurs: 16%

A history of previous back pain more than once carries a relative risk of 10x the risk of one or less incidences. Risk is strongly influenced by the nature and severity of previous back pain.

Poor swing mechanics have been shown to develop a greater torque in the lumbar spine.

Loss of internal hip toration on either side. Golfers who have more hip external rotation than internal rotation are more likely to develop low back pain.

Reducing Risk

Flexibility, strength and articular stability of the trunk and spinal structures may be considered as, potentially, the most restrictive variables for performance and the most important determinant for risk of injury. (Vad 2004)

Ball Address

Upper body forward flexion instead of at the hips: Over-stretchs the spine and increases muscular tension during the backswing.

Overextended, straight arms (especially the left) or locked elbows, excessive tension in forearms (too tight a grip): Reduces effectiveness in creating speed in the downswing and can induce elbow and wrist injuries at ball impact.

Too wide a stance: Greater strain on the spine as it reduces the ease of trunk rotation.

A grip without interlocking hands or too loose a grip: Danger of dropping the club causing a loss of precise ball impact and injury of the elbow, wrist or hand through ground impact.

End of Backswing

An overly long backswing: Trunk overrotation injury or throw the golfer off balance leading to ground impact injuries. Increases stress in the left thumb and right wrist.

Excess arm/shoulder elevation on the backswing, with left arm crossing above left shoulder: Impinges on the tendons and bursa at the top of the shoulder joint and requires good stabilization from the rotator cuff muscles.

Leftward spinal tilt, instead of being perpendicular to the ground during the rightward weight shift: Increases the chance of an opposite spinal curve (reverse C) posture at the end of the follow-through.

The rightward weight shift abnormally collected on the outside of the right foot: Loss of balance and right ankle sprain.

Decreased right hip rotation range: Overloads low back, resulting in injury.

Downswing

Acceleration

Trunk rotation too vigorous during downswing: Thoracic and abdominal muscular strains.

Leftward weight shift: Substantial compressive forces on the left leg (hip, knee, ankle and foot) which are hazardous to individuals with osteoarthritis.

Grip is too tight, or the elbows overextended or are held too tightly: Lateral and medial epichondylitis (inflammatory elbow conditions).

Excessive wrist flexion/extension in the downswing, hitting the ground: Serious hand and wrist injuries.

Ball Impact

Grip is too tight, or the elbows are held too tightly or are overextended: Lateral and medial epichondylitis (inflammatory elbow conditions).

Excessive wrist flexion/extension in the downswing, hitting the ground: Serious hand and wrist injuries.

Early Follow Through

Late Follow Through

Follow through too vigorous: Shoulder ligaments and rotator cuff muscles experience excessive mechanical stress (tension or compression).

Deceleration of the follow through is too brisk: Injury to the hips, dorsolumbar spine or shoulder (excessive eccentric loading).

An overly powerful drive, inducing a reversed C lordotic spinal curvature: abdnormally high stresses on the dorsolumbar vertebral bodies, especially on the posterior joints.

Off-balance weight shift or slip: Ankle or foot sprain as well as knee injury.

Decreased left hip rotation range: Overloads low back, resulting in injury.

Theriault 1998

Avoiding Golf Related Injuries

Optimum performance must not be achieved at the expense of safety or injury.

1. Improve Technique

2. Avoid End Range

3. Maintain Spine Position In Neutral

4. Improve Physical Conditioning To Avoid Fatigue

Adapted from: The 'foursome' for optimizing performance in golf. (Lindsay 2000)

Warm-Up

10 minute warm-up before play:
Increases club head speed by 3-6 m/s (12%).
Equates to a 4 shot drop in handicap.

10 minute warm-up 5 days a week for 5 weeks:
Increases club head speed by 7-10 m/s (24%).
Equates to a 7 shot drop in handicap.

Golfers who don't warm-up for 10 minutes, on the average, had 2.5 times more injuries than golfer who do warm up for 10 minutes.

The average handicap of golfers who warmed up more than 10 minutes was better than those who didn't. (14.3 versus 22.0)

A Period Of Aerobic Exercise To Increase Body Temperature.

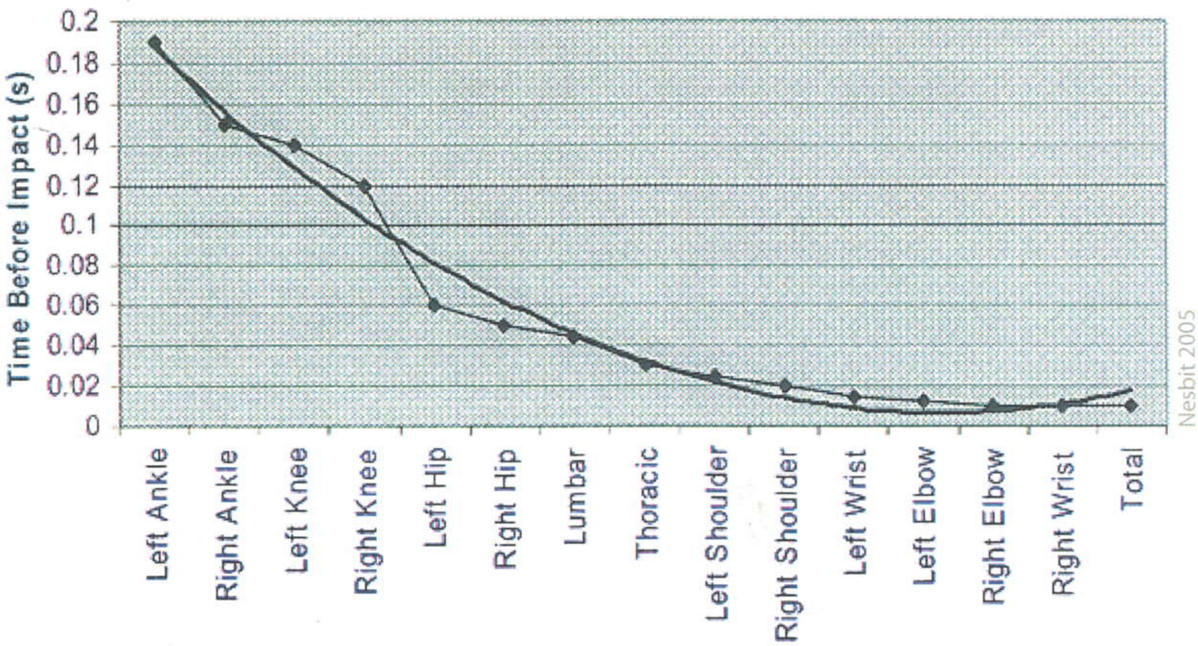
Gradually Increasing Active Stretch Of The Leg And Upper Body.

Hands, Wrists, Forearms And Shoulders; Trunk; Calf, Hamstrings And Quads

A Series Of Golf Swings That Gradually Increase In Range Of Motion And Vigor

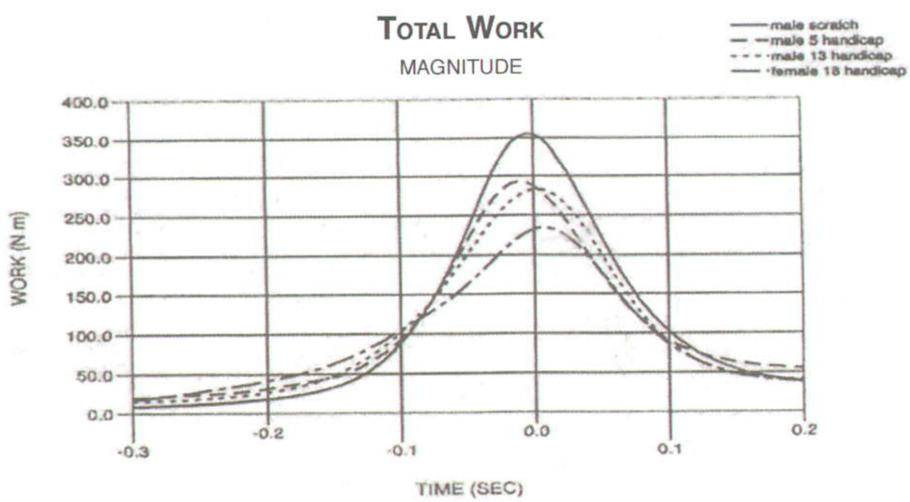
Endurance Conditioning For Stabilization

Timing Of Peak Work Of A Male Scratch Handicap Golfer



The golf swing does not require maximum strength: coordination, timing, speed, power and stabilization are the keys to improving your golf swing.

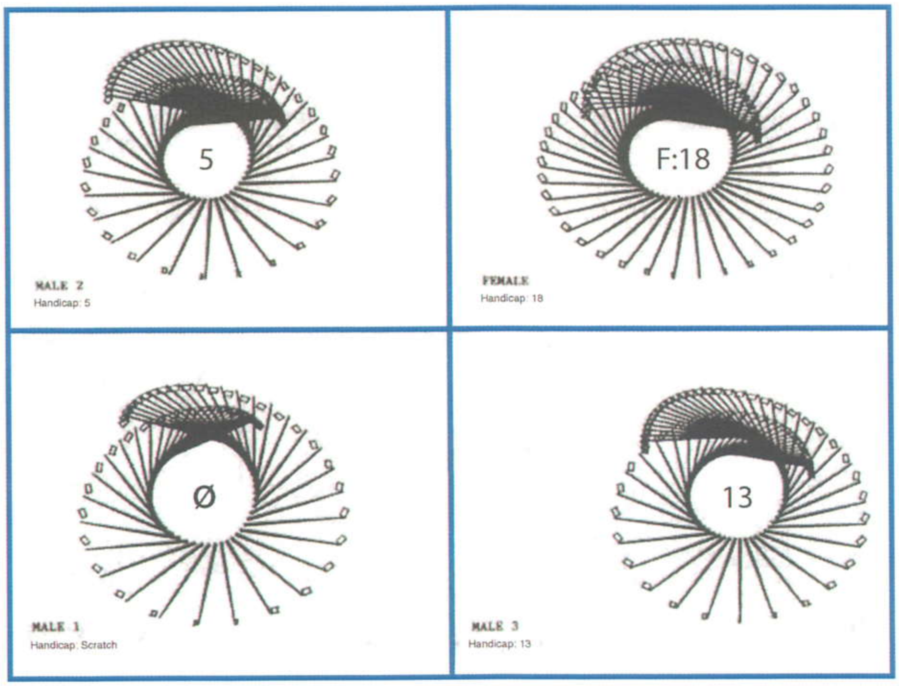
Coordination, Flexibility, Strength and Power



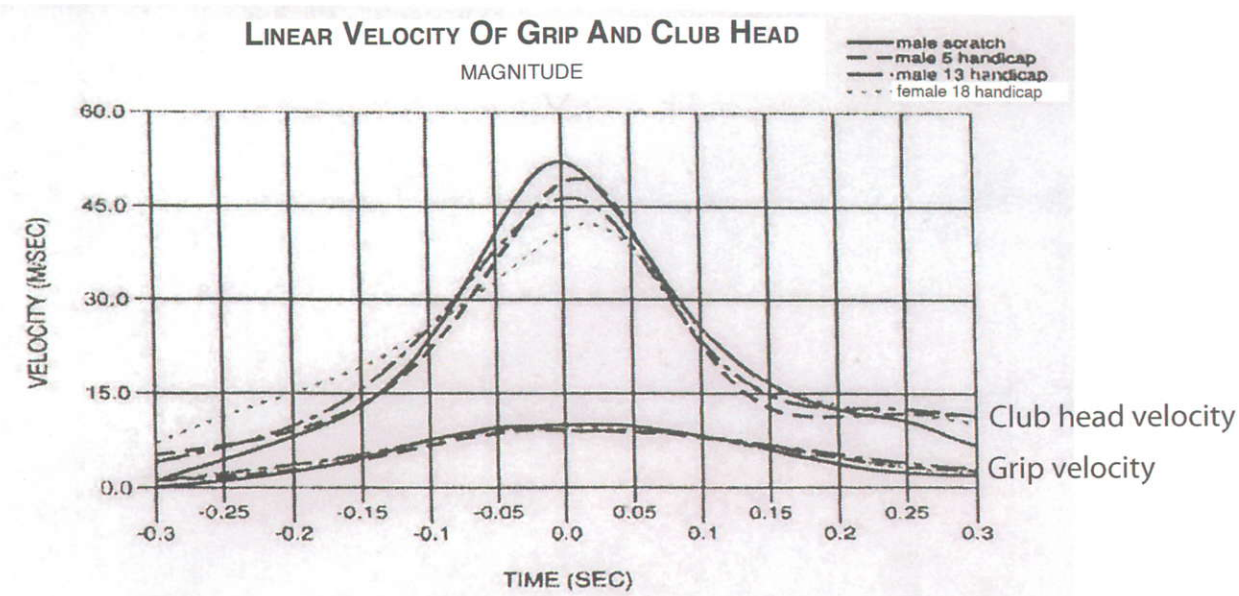
Maximum efficiency of the golf swing results from the precise timing required to simultaneously coordinate the swing motion, wrist uncocking, wrist roll, swing plane stabilization, and shaft unflexing to cause the peak velocity to occur at impact (Nesbit 2006).

Swing With Proper Technique, Tempo And Balance

Front Superimposed View Of Subject Swings.



Club Head Speed Is Different From Hand Speed



Golf - Play It Safe

Developing a Pre-Game Warm-Up and Conditioning Program For Golf

Background

Participation in the sport of golf has risen considerably in recent years. The most notable increase in participation has been individuals between the ages of 50 and 59 years. This group accounts for approximately 25% of the golfing population but plays 50% of the total number of annual rounds. (Lindsay 2000) The profile of a weekend or amateur player varies and their availability for golf may depend on a work schedule. A recent study of 528 amateur golfers demonstrated that they played an average of 3 days and 15 hours per week. (Table 1) It is interesting to note that 88.7% of the group practicing golf as a recreational activity were motivated by the health and leisure aspect; 44.7% reported this aspect to be the main motivation, contact with the natural environment was the main motivation for 24.2%, while improvement in performance was the chief motive for only 12.9% of these individuals. These observations help to demonstrate that, besides the pleasure of practicing the sport itself, the golfer also seeks to gain health benefits from contact with the natural environment, and the physical exercise and energy expenditure related to walking. (Theriault 1996)

Table 1 Main motivations of 600 amateur golfers for playing golf[8]

Motivation	Golfers giving this response (%)	Golfers giving this response as the main motivation (%)
Health/leisure activity/energy expenditure	88.7	44.7
Relaxation	76.1	18.9
Sociability	73.8	15.5
Contact with natural environment	71.5	24.2
Improvement in performance	67.7	12.9

Theriault 1998

Cardiovascular Demands

A golfer may walk between 5 and 6.2 miles to complete an 18-hole course. For a person who weighs 150 pounds, this represents an energy expenditure varying from 600 to 1000 Kcal, or maybe more depending on the geography of the golf course. (Theriault 1998) Studies have shown that women can reach a peak of abut 80% of their maximum heart rate while walking some uphill fairways. For men the peak can be 70% of their maximum heart rate. Carrying golf clubs has been shown to cause a 10% increase in Kcal/min expended compared with normal walking.(Lindsay 2000)

Musculoskeletal Demands

The golf swing is a very demanding and complex dynamic movement involving powerful muscle contractions. The generation of work in the golf swing comes primarily from the back (lumbar and thoracics) and hip joints generating 69 – 72% of the total body work for the swing. This core body work is generated by high torques (much higher in the right hip than left hip) over the entire range of motion of the hip joints, and moderate but consistent torques applied over the considerable twisting range of motion of the spine. (Nesbit 2005)

In terms of spinal stress, the golf swing produces a complex loading pattern involving shear, compression and axial torsional loads with rapid change in direction of these forces. The spinal compression loads equaled approximately 8 times body weight in both amateurs and professionals. The lead hip experienced a much greater rotational torque than the trail hip during the downswing. While the magnitude of forces on the knee during a golf swing were at least equal to those generated from running or side-cutting motions. (Gatt 1998)

Table 2
Injuries in Amateurs and Professional Golfers by Anatomic Region[a]

Injured area	Amateurs (N = 643) N	(%)	Professionals (N = 60) N	(%)	Total (N = 703) N	(%)
Head	31	(5.9)	12	(10.9)	43	(6.8)
Cervical spine	45	(8.5)	11	(10.0)	56	(8.8)
Thoracic spine	5	(1.0)	3	(2.7)	8	(1.3)
Lumbar spine	80	(15.2)	24	(21.8)	104	(16.3)
Spine total	130	(24.7)	38	(34.5)	168	(26.4)
Ribs	9	(1.7)	3	(2.7)	12	(1.9)
Shoulder	98	(18.6)	14	(12.7)	112	(17.6)
Elbow	131	(24.9)	11	(10.0)	142	(22.3)
Wrist/hand	68	(12.9)	22	(20.0)	90	(14.1)
Upper extremity total	297	(56.4)	47	(42.7)	344	(54.0)
Hip	15	(2.9)	3	(2.7)	18	(2.8)
Knee	17	(3.2)	6	(5.5)	23	(3.6)
Ankle/foot	28	(5.3)	1	(0.9)	29	(4.6)
Lower extremity total	60	(11.4)	10	(9.1)	70	(11.0)
Total injuries	527		110		637	

[a] Some golfers reported multiple injuries.

Gosheger 2003

Prevalence of Injuries

Overuse and technical deficiencies in the golf swing are clearly the leading causes of injuries in the golfer. Recreational golfers injure themselves more often because of technical deficiencies (62 -72%) whereas professional golfers more often sustain injuries due to overuse (79.9). (Theriault 1998)

Anatomic Distribution: The most common injuries in the professional group were back injuries, followed by wrist and shoulder injuries. In the amateur group the elbow was the most affected region, followed by the back and shoulder. (Gosheger 2003)

Mechanism of Injury:The top four main causes of golf injuries are: overuse, technical errors during the swing, physical fitness deficiencies, and no pre-game warm up. Overuse and technical deficiencies in the golf swing are clearly the leading causes: recreation golfers injure themselves more often because of technical deficiencies (63% - 77%), whereas professional golfers more often sustain injuries due to overuse (80%). Overuse injuries were blamed for: the back (92.3% of injuries) excessive play was blamed; shoulder (92%); Knee (95.7%); and elbow (98.6%). (Gosheger 2003) When compared to professional golfers, amateur golfers attain higher force levels in the low back in side bending, forward bending, and rotation. This is often because of amateurs' desire to hit the ball as vigorously as the professionals but without the same technical refinement. (Theriault 1998) Golfers with low back pain tended to flex their spines more when addressing the ball and exhibited greater lateral flexion on the backswing. Pain-free golfers had twice as much trunk flexion velocity on the downswing than golfers with pain. (Lindsay 2002) See Figures 1,2,and 3 for a discription of swing related causes of injuries.

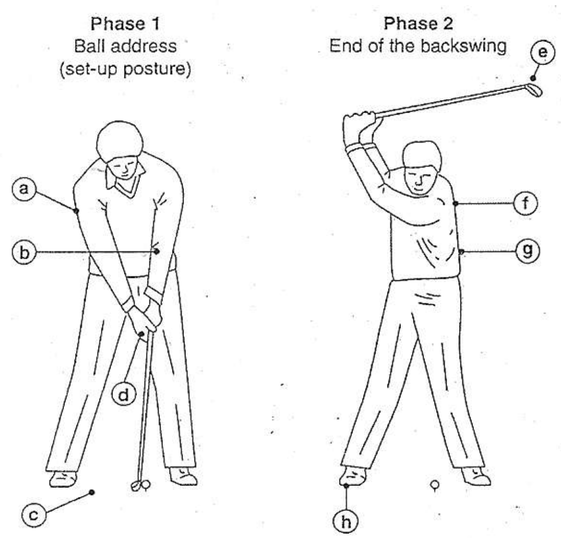


Fig. 1. Injuries associated with phases 1 and 2 of the golf swing.. (a) Upper body anterior flexion at the dorsolumbar spine instead of at the hips increases the risk of vertebral hypermobility and abnormal muscular tension during the backswing. (b) Over-extended, straight arms (especially the left) or locked elbows and abnormally high muscular tension in the forearms (too tight a grip) reduces the effectiveness in creating speed in the downswing and can induce elbow and wrist injuries at ball impact. (c) Too wide a stance puts greater strain on the spine as it reduces the ease of trunk rotation. (d) A grip without inter-locking hands or too loose a grip increases the danger of drop-ping the club causing a loss of precise ball impact and injury of the elbow, wrist or hand through ground impact. (e) An overly long backswing may cause trunk overrotation injury or throw the golfer off balance leading to ground impact injuries, as described in (d). Excess backswing also increases stress in the left thumb and right wrist. (f) Excess arm/shoulder elevation on the back-swing, with the left arm crossing the left shoulder, impinges on the subacromial tissues (tendons, bursa) and requires good stabilisation from the rotator cuff muscles. (g) Leftward spinal tilt, instead of being perpendicular to the ground, during the right-ward weight shift increases the chance of an opposite spinal curve (reverse C) posture at the end of the follow through. (h) The rightward weight shift abnormally collected on the outside of the right foot can cause a loss of balance and right ankle sprain.

Theriault 1998

Age: None of the age groups showed a significant difference in overall injury prevalence or distribution. (Gosheger 2003)

Stretching and Warming up: In a study of 570 golfers 81.0% did not warm up for more than 10 minutes. Whereas 18.9% took more than 10 minutes to do so. Those who warmed up for 10 minutes or less reported they had 2.5 times the amount of injuries per player of those who took more than 10 minutes to warm up. Furthermore, the average handicap of golfers who warmed up more than 10 minutes was better than in the other group (14.3 versus 22.0). (Gosheger 2003)

Playing time: The number of injuries to the back, shoulder, wrist, and hand increased with the amount of time spent on the golf course or the driving range. There were significantly more injuries in golfers who played four of more rounds a weak and in those who hit at least 200 balls in 1 week. (Gosheger 2003)

Carrying a bag: Golfers who carry their bags on a regular basis suffer significantly more injuries to the lower back and the shoulder and ankle. (Gosheger 2003)

Previous Injuries: Golfers who reported any previous chronic musculoskeletal problems were more prone to injury than those who considered themselves healthy. (Gosheger 2003) In fact, for the novice golfer, a history of previous back pain more than once carried a relative risk of almost 10 times the risk of one or less incidences of previous back pain. The recurrence of back pain was strongly influenced by the nature and severity of previous back pain. The more frequent and severe the previous back pain, the more liable the subject was to experience a reoccurrence of their back pain. (Burdorf 1996)

Distribution of Injuries During a Golfing Season: More that 50% of all injuries in amateur golfers occurred midseason and predominantly affected the upper limbs. At the beginning of the season about one-third of the injures were sustained, and were distributed equally between the spine and upper limb segments. (Theriault 1998)

Injuries Associated With The Golf Swing

For each phase of the swing, zones of the human body undergo biomechanical stresses likely to provoke injuries. Injuries to the musculoskeletal structures are caused either by excess tension, twisting of the tissues

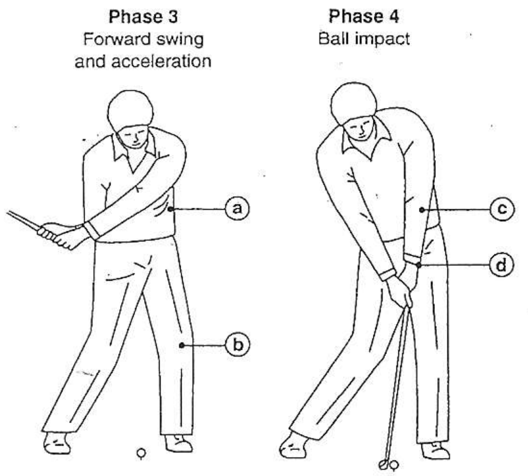


Fig. 2. Injuries associated with phases 3 and 4 of the golf swing. (a) Thoracic and abdominal muscular strains can occur after vigorous trunk rotation on the downswing. (b) The leftward weight shift can create substantial compressive forces on the left leg (hip, knee, ankle and foot) which are hazardous to individuals with osteoarthritis. (c) Lateral or medial epicondylitis (golfer's elbow) can be sustained at impact if the grip is too tight or the elbows are held too tightly or are overextended. (d) Excessive wrist flexion/extension in the downswing, or hitting the ground after losing balance, can cause serious hand and wrist injuries.

Theriault 1998

or the stress of the physical impact of hitting the ball. The risk of injuries in the downswing occur in the zones of greatest muscular activity (abdominal, pectoral, and back). There is also risk for injury to the elbows, wrists and hands of any of these structures are held too stiffly, if the wrists move excessively or if the downward club trajectory is poor (solidly hits the ground, e.g. a tree root). (Theriault 1998) The risk for injuries also occurs at the ends of range, the back swing and follow through, where tensions are high. At the top of the backswing the wrists, left shoulder, and trunk are coiled up and the tension increases slightly as the downswing begins. At the end of the follow-through stresses can occur in excessively rotated trunk and shoulders.

Back: The most important lever in achieving maximum speed during the golf swing, and therefore the distance covered by the ball, is probably that determining the trunk rotational capacity. Flexibility, strength and articular stability of the trunk and spinal structures may therefore be considered as, potentially, the most restrictive variables for performance and the most important determinant for risk of injuries. The modern swing is suspected of being a major source of injury suffered by golfers. This is likely due to the twisting motion of the lumbar spine a the top of the backswing, with subsequent derotation and hyperextension through the downswing and follow-through. Amateur golfers, who exhibit poor swing mechanics, have been shown to develop a greater torque in the lumbar spine than professional golfers. Low back pain has also been attributed to loss of internal hip rotation on either side. Golfers who have more hip external rotation than internal rotation are more likely to develop low back pain. (Vad 2004)

Wrist: The range of motion required of the wrist in the golf swing exceeds the functional range of motion requirements of the wrist. Perhaps it is the catapulting function of the left wrist at impact, as well as the increased range of motion of both wrists, which make

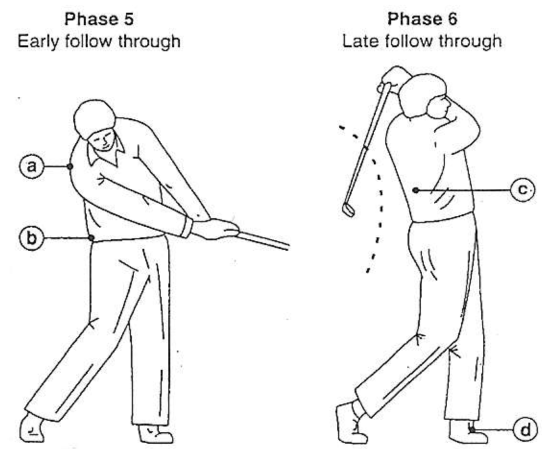


Fig. 3. Injuries associated with phases 5 and 6 of the golf swing. (a) Shoulder ligaments and rotator cuff muscles can experience excessive mechanical stress (tension or compression) in a vigorous follow through. (b) Injury to the hips or dorsolumbar spine can occur if the deceleration of the follow through is too brisk. (c) An overly powerful drive, inducing a reversed C lordotic spinal curvature, can induce abnormally high stresses on the dorsolumbar vertebral bodies, especially on the posterior joints. (d) An off-balance weight shift or slip can cause an ankle or foot sprain as well as knee injury.

Theriault 1998

the wrists of the golfer vulnerable to injury. (Murray 1996)

Elbow: Repetitive play and practice over a protracted period of time can lead to complaints of pain on the inside of the right arm and the outside of the left arm in dominant right-handed golfers. Other causes include: gripping too tight, elbows held too tightly or overextended, or hitting the ground. (Kohn 1996)

Shoulder: Golf is not a strenuous arm activity in that it does not require extremes of shoulder strength or ranges of motion. The shoulder accounts for 24 – 28% of the total body work. (Nesbit 2005: Work) However, the golf swing is a rapid movement and the muscles about the shoulder girdle must fire in synchrony to provide a coordinated, harmonious movement to protect the shoulder complex. The specific timing of each muscle reinforces their significant roles; each muscle plays its part at a given moment in order to assure rhythmic movement.(Pink 1990) Some muscles of stabilization for the shoulder are susceptible to fatigue, namely the serratus anterior, resulting in slower and longer accommodation times, lead to compensation by secondary muscle groups and altered mechanics which, in turn, causes overload and injury.(Kao 1995) An injury in any of the muscles of the shoulder could easily throw off this balance, promoting complete disruption of the normal swing.

During the back swing, the lead shoulder reaches across the body causing a stretch through the back of the shoulder and can result in jamming the top of the arm into the roof of the shoulder, impinging the tendons of the rotator cuff. Furthermore, because of the stretch placed on the lead shoulder injuries are three times more likely to occur there than the trailing shoulder. (Kin 2004)

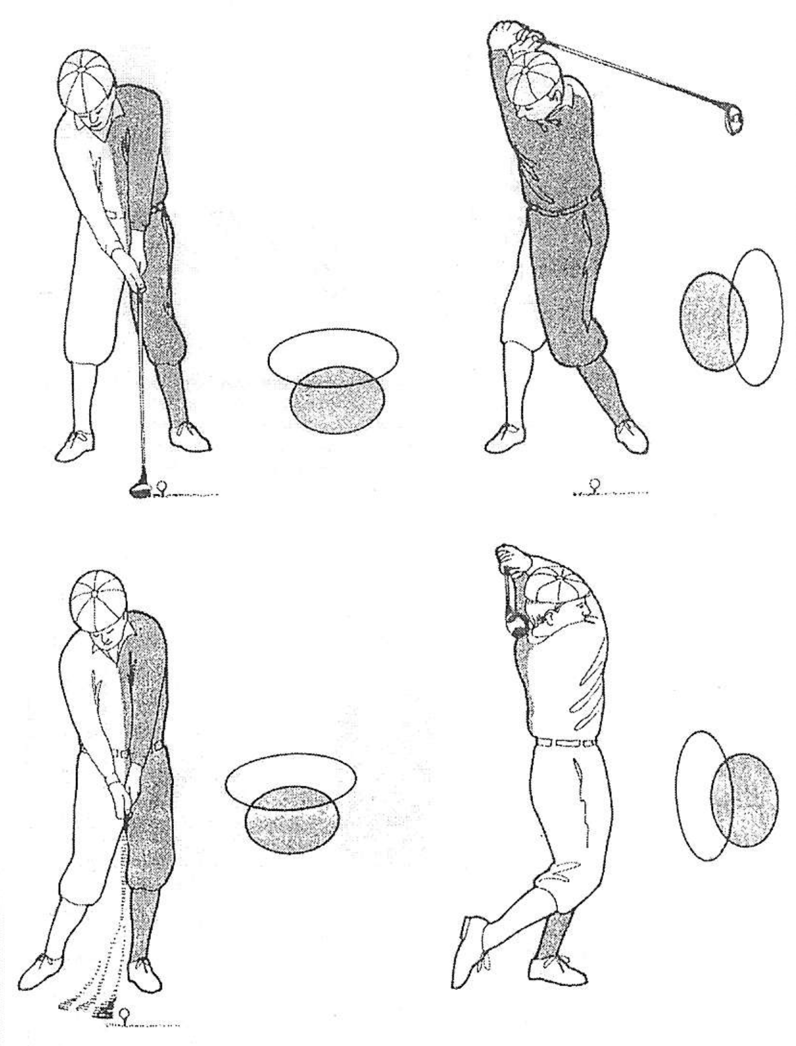


Figure 4 The classic swing. This swing uses a relatively flat swing plane with a large hip and shoulder turn. The follow-through is characterized by a straight up and down "I" position. (The shaded oval represents the position of the hips; the unshaded oval, the shoulders.) (*From* Hosea TM, Gatt CJ, Gertner E: Biomechanic analysis of the golfer's back. *In* Stover CN, McCarroll JR, Mallon WJ (eds): Feeling Up to Par: Medicine from Tee to Green. Philadelphia, FA Davis, 1994, p 99; with permission.)

Hosea 1996

Classic Versus Modern Swing

The "classic" swing, originated in Scotland, was refined in the United States to best utilize the hickory shaft. It differs from the "modern" swing in several respects, which are important when considering their effects on the lower back. The classic technique utilizes a backswing with a flatter swing plane and a large pelvis and shoulder turn, with the pelvic rotation almost as much as the shoulders. That is, with less trunk rotation. On the follow-through, the golfer finishes in a relaxed upright "I" Position.

The modern swing relies on a tightly coiled body to store power for maximum club head acceleration at impact. It also utilizes a large shoulder turn, but unlike its predecessor, the modern swing restricts the pelvic turn, to build torque in the back and shoulders. The follow-through is characterized by the hyperextended back ("reverse C" position) with the right shoulder lower than the left and the hands held height over the head. The modern swing uses all parts of the body to generate a more powerful but stressful swing. This modern swing technique is suspected of being the major source of injury suffered by both professional and amateur golfers. This most likely develops secondary to the rotation of the lumbar spine at the top of the backswing, with the subsequent uncoiling and hyperextension through the downswing and follow-through. (Hosea 1996)

A swing that attenuates excessive ranges of motion will result in less injuries and better control. Utilizing a shorter back swing (reduced by 22°) has no significant effect on stroke accuracy or club head velocity. (32.2 m/s and 33.8 M/s: short and full backswing, respectively). Importantly, studies show there is a 12%-19% reduction in the activation of the muscles of the back and trunk. (Bulbulian 2001) Bending from the hips and keeping the back straight (not bending forward in the low back), keeping the spine perpendicular to the ground throughout the swing, and finishing the swing upright and facing forward will have profound effects on eliminating stress and overload of your back and spine.(Adlington 1996)

The Senior Golfer

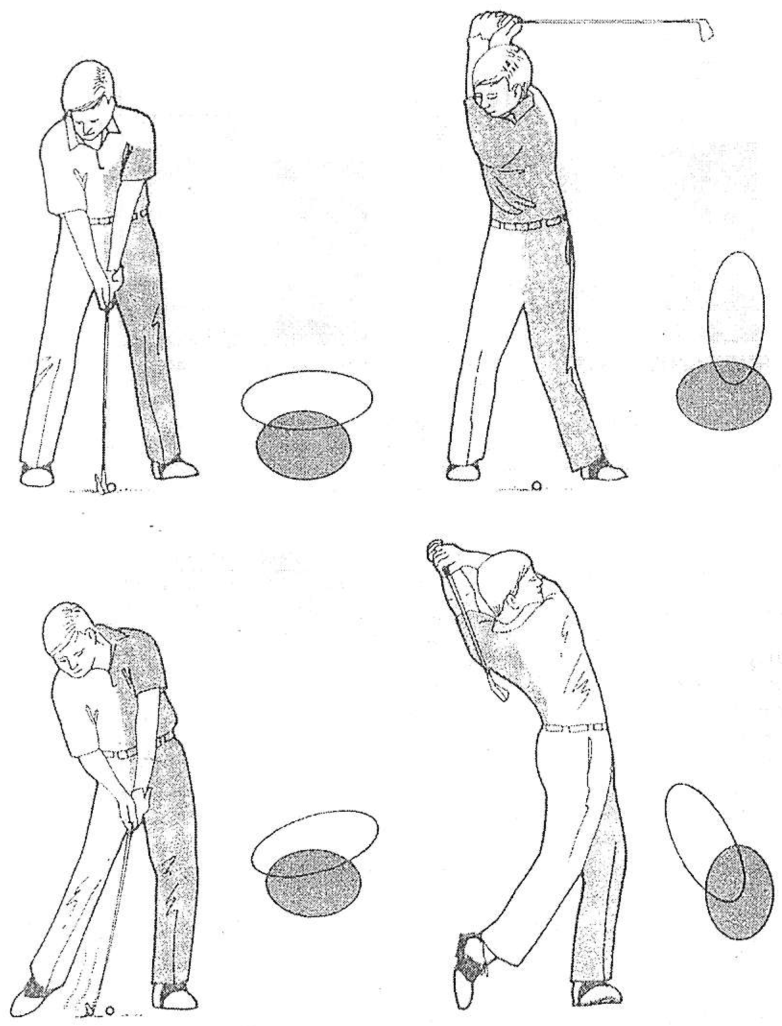


Figure 5 The modern swing. This swing emphasizes a large shoulder turn with a restricted hip turn, thus increasing the torque affecting the back. The finish is characterized by a reverse "C" position. (*From* Hosea TM, Gatt CJ, Gertner E: Biomechanic analysis of the golfer's back. *In* Stover CN, McCarroll JR, Mallon WJ (eds): Feeling Up to Par: Medicine from Tee to Green. Philadelphia, FA Davis, 1994, p 100; with permission.)

Hosea 1996

As we have seen, there are many risk factors associated with golf, such as aptitude, frequency of play and experience. The senior golfer (over the age of 50) is susceptible to additional factors related to declines in strength, flexibility, and coordination as well as increased body fat. Aging decreases the body's reserve capacity and reduces the ability of the individual to adapt effectively to stress. Not only does this lead to an increased risk of injury, but the severity of injury and consequent rehabilitation time required may also be increased in older athletes. (Lindsay 2000)

Strength: The loss of muscle mass and function has minimal changes through middle age, but accelerates after 60 to cause increasing problems for older adults. This loss stems from changes in the nervous system and also an atrophy of the fast-twitch fibers (type 2 fibers (strength). There is evidence that Type 2 convert to Type 1 (endurance) in the process.) within the muscle. Atrophy of type 2 fibers may well be related to the more sedentary lifestyle of older persons that seldom requires the forceful activation of these fibers. Therefore, compared to young adults, aged persons need to recruit a larger percentage of a smaller muscle mass to achieve a given force, and this can lead to earlier fatigue during exercise. Older adults who remain active exhibit only moderate losses in skeletal muscle mass and strength compared with sedentary people. Studies have shown that with the proper training strength, flexibility, and clubhead speed can improve with an appropriate program. Exercises should be designed that reinforce and simulate the golf swing which include coordination, endurance, strength, and speed. (Lindsay 2000)

Endurance: On a relative basis, older adults have similar muscular endurance (dominance of Type 1 fibers: slow twitch, endurance) capacity to young adults. However, older persons take longer to recover from a strenuous bout of fatiguing muscular exercise than young people. Age related changes affecting muscular endurance may be related to changes in fiber type with age (predominantly type 2 converting to type 1), changes in fiber size and number, muscle blood flow and capillarity, and changes in muscle metabolism. When a muscle fatigues it reacts slower, and takes longer to accommodate to changes in load. Fatigue develops faster in the abdominal muscles than the back. In the golf swing this is seen with increased trunk rotation and side bending. This effect is significantly greater in people with back pain. (Lindsay 2000)

Endurance, not strength, directly influence the development and occurrence of chronic low back pain. (McGill 2004) Training for back and trunk should emphasize endurance, and this should precede strengthening efforts in a gradual, progressive exercise program, since studies suggest that endurance has a much greater prophylactic value than strength. As long as the intensity and duration of the endurance training are adequate, elderly skeletal muscle can adapt in a fashion similar to that of young skeletal muscle. (Lindsay 2000)

Flexibility: Significant reductions in active and passive range of motion have been reported in comparisons of joint flexibility between young and older adults. However, studies show that in as little as eight weeks senior golfers can improve flexibility and club head speed without an increase in spinal torque. (Lindsay 2000)

Speed of Movement: Motor performance becomes slower and less consistent with age. Nerve conduction slows which has a detrimental effect on coordination. There is a loss of Type II fibers (fast-twitch, strength) and an increase in Type I fibers (slow-twitch, endurance) which would explain the slower speed of movement characteristic with older individuals. However, speed of movement and power development can be improved in older adults with specific training exercises. With proper training Type I fivers will convert to tpe II, improving strengtha and speed. Therefore, training should include resisted movement patterns that mimic the swing. Such as using a specially weighted golf club or a golf grip and elastic tubing, plyometric routines which emphasize arm and trunk rotational exercises, and balance. (Lindsay 2000)

Cardiorespiratory System: Between the ages of 30 and 70 cardiac output declines an average of about 30% due to decreases in heart muscle mass and contractility. Regular physical activity is associated with a decreased incidence of coronary heart disease and increased longevity. Mild to moderate exercise such as walking can be effective in increasing aerobic capacity, especially in elderly persons, and can also be beneficial in lowering blood pressure in hypertensive patients. Walking exercise during golf participation appeared to significantly reduce low-density lipoprotein cholesterol levels and improved the ratio of total cholesterol to high-density lipoprotein cholesterol. Finally, it is important to note that these types of health benefits would be negated by riding in a power cart. (Lindsay 2000)

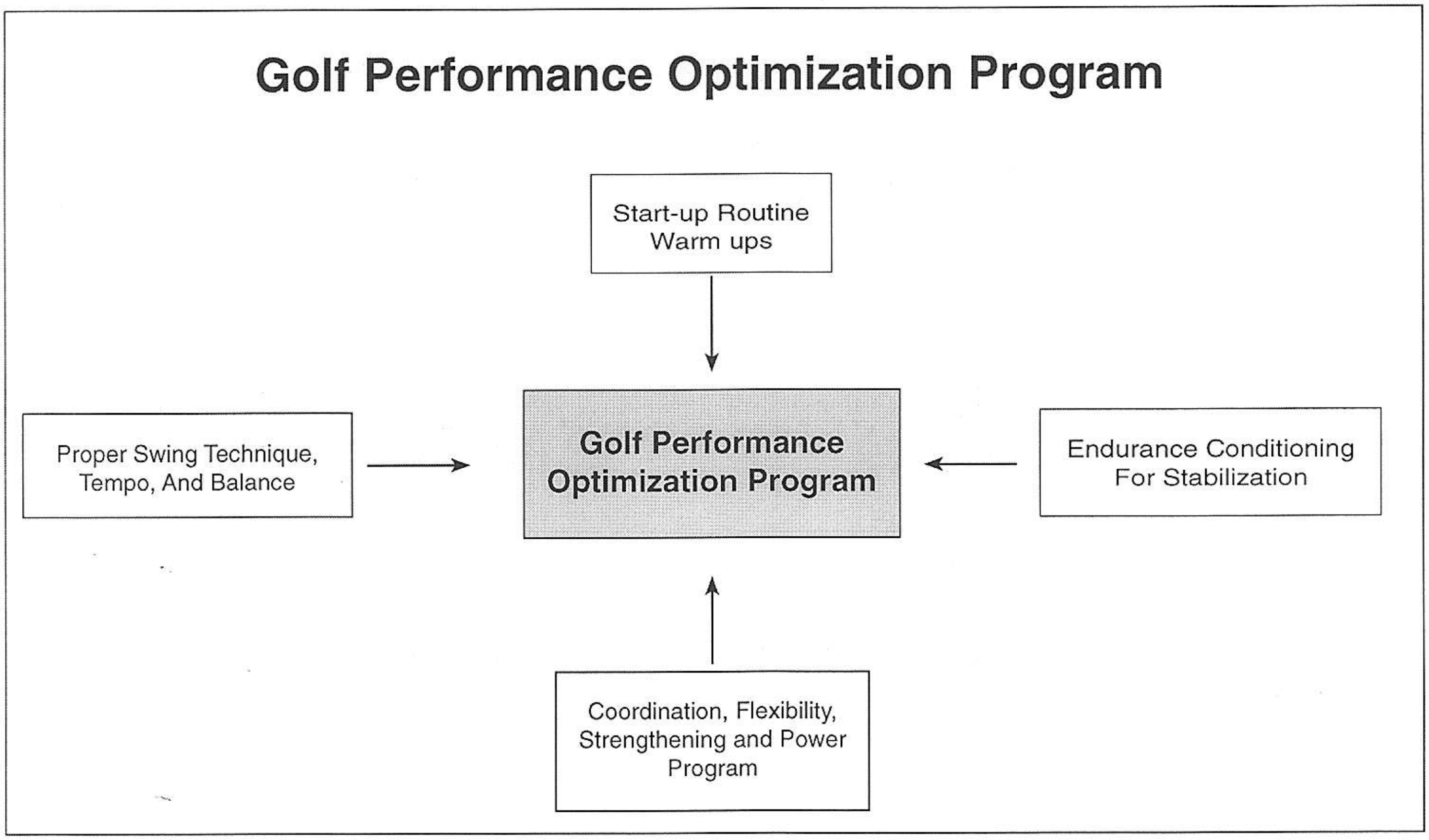


Figure 6. Adapted from: The 'foursome' for optimizing performance in golf. (Lindsay 2000)

Golf Swing Mechanics

To develop a training program that will improve the golf swing, an understanding of the biomechanical elements that compose the swing are necessary. Golf is a ground-up activity where movement proceeds in a whip-like fashion from the feet towards the hands and club, increasing club and club head speed to produce the greatest impact force on the ball. When the club head is aligned properly, distance is proportional to club head speed, and clubhead speed is highly related to handicap. (Hosea 2005, Fradkin 2004)

Initiation of the golf swing begins at the feet and progresses upward towards the hands and club. (Hume 2005, Nesbit 2005) Muscle activation begins with the foot and ankle stabilizing muscles, proceeds in a stepwise pattern to the knees, hips, trunk, shoulder, elbow, and finally the wrists. These activation patterns and the consequent joint positions result in anticipatory postural adjustments in the leg and trunk segments that allow proximal stability to occur in order for the distal segments (arms and wrists) to have maximum mobility. (Kibler 2004)

Not unlike other sports, golf utilizes the entire body to produce the swing. For example, in throwing, between 63% and 74% of the kinetic energy and force delivered to the hand is developed by the hip/trunk and shoulder segments. (Kibler 1004) In golf, between 78 % and 80% of the work comes from the hip/trunk and shoulder segments. (Nesbit 2004) As with muscle activation, the generation of work appears to be a bottom up phenomenon (upward and outward. i.e. feet-trunk-hands) where a type of segmental summation of work occurs as the swing progresses from the legs, through the hips, lower back, upper back, shoulders, arms, then wrists. The work generation in each joint generally peaks in the same order from bottom up and is accumulative (Nesbit 2005)

Developing a progressive conditioning program is out of the scope for this workshop. However, the following guidelines will help you to understand how an integrated conditioning program is put together. If you are interested in pursuing this aspect of golf working with a trainer who has a sound background in sport specific, functional training is imperative.

Components of an exercise program include: warming up; flexibility; improving muscular endurance and coordination; balance; strengthening for power; and cardiovascular conditioning. The first phase of a conditioning program begins with developing stability and endurance of the trunk, hips and scapulae. Particular attention should be given to proper movement

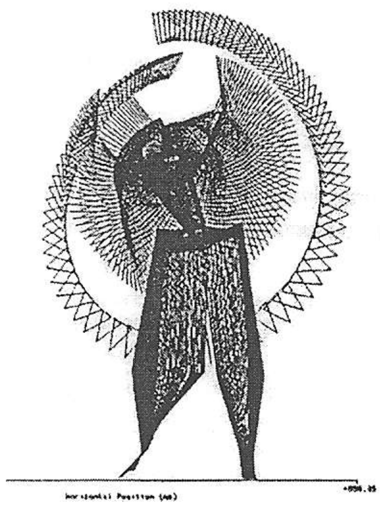


Figure 7 Motion analysis data.

The golf swing as seen in motion analysis. Each frame represents 0.01 seconds. (Nesbit 2005)

and motion. Concurrently, time should be spent improving balance. When adequate stability, control and balance have developed, strength training can begin. Isolated muscle training is good in the initial phase and to supplement functional training.

Training should evolve to replicating the golf swing in order of movement, intensity, and speed, incorporating multijoint systems through multi planar movements. For example, during the slow backswing, key muscles of the trunk and upper limb are being lengthened in a controlled manner, and thus primed to contract powerfully on the downswing. The timing of this cycle is critical to execute the maneuver effectively: the pause in the transition phase has to be kept very brief. Hence, exercises which mimic this pattern and strengthen in both concentric and eccentric mode are advisable. (Lindsay 2000)

The Warm Up Routine

It is generally believed that preparing the body before play benefits performance and decreases the risk of injury. Warm up is defined as a period of preparatory exercise undertaken to enhance subsequent competition or training performance. (Fradkin 2001) The purpose of a warm up is to prepare the body both physiologically and psychologically, while at the same time reducing the risk of injury. (Fradkin 2004) Warming up results in: warming of the body tissues, increases in heart rate and metabolic rate, the muscles become more flexible, circulation increases, movements become smother and more coordinated, and the body feels more invigorated. Some people use a wedge-to-driver warm up; however, this outline fails to prepare all the major muscle groups for golf. Also, it is a very time-consuming activity. (Pink 1996)

Studies have shown that warming up prior to play will improve performance compared with doing nothing at all. In fact, it has been shown that golfers that merely perform a 10 minute warm up before play increased club head speed by 3-6 m/s (12%) over baseline. This equates to a four shot drop in their handicap. After engaging in performing the same warm up routine five days a week for five weeks, they improved club head speed by 7-10 m/s (24%) over baseline. This equates to a 7 shot drop in their handicap. (Fradkin 2004) This improvement is similar to previously published data. (Gosheger 2003) Furthermore, golfers who did not warm up for more that 10 minutes had 2.5 times more injuries than those golfers that did warm up for more than ten minutes. (Gosheger 2003) Given these benefits to warming up it is very curious that only 3% of golfers perform an adequate warm up. (Fradkin 2001)

An appropriate warm up for golfers should include a period of aerobic exercise to increase body temperature, followed by stretching of the "golf muscles" beginning with static, progressing to dynamic stretching for the hands, wrists, forearms, shoulders, lower back, chest, trunk, hamstrings, and groin. A series of golf swings with a progressive increase in range of motion and

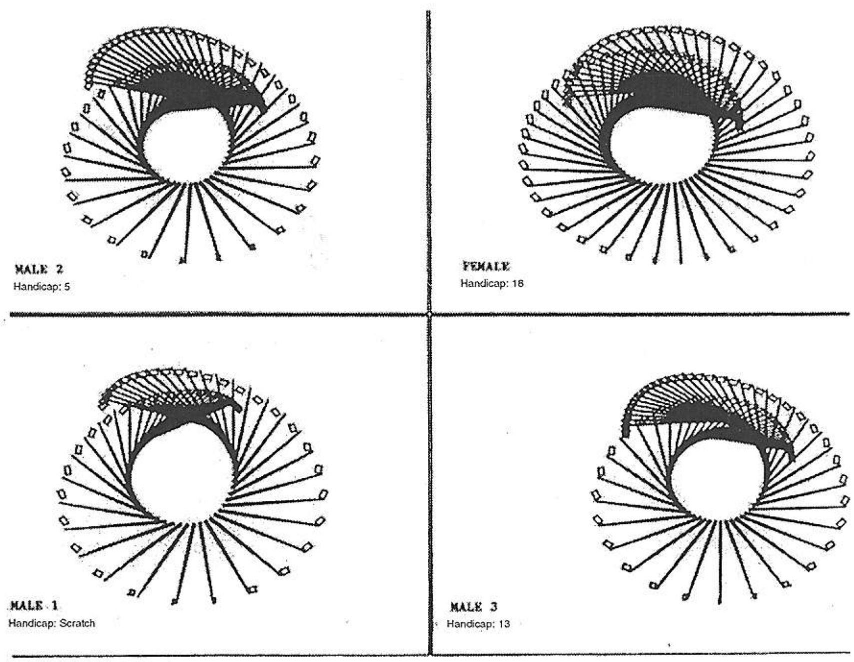


Figure 8 Front superimposed view of subject swings.

The golf swing as seen in motion analysis. Each frame represents 0.01 seconds. Individual swing characteristics are evident by differences in the amount of bakcswing, the path of the club head, the shape and size of the inner hub, the spacing between the frames, club deflection patterns and the action of the wrists. The figure clearly shows that the inner hub has a constantly changing radius which is necessary for delaying the outward motion of the club. (Nesbit 2005) vigor should then be performed. (Jobe 1991, Pink 1996, Theriault 1998, Fradkin 2001, Fradkin 2004) See Appendix 1

Endurance Conditioning for Stabilization

Stability of the trunk is the first requirement and of the utmost concern. Learning to develop trunk endurance and strength, while at the same time minimizing power requirements of the trunk are paramount to improving function and reducing risk of injury. This training should include maintaining neutral spine through all movements and maintaining proper cocontraction of the abdominal musculature to adequately brace the trunk. (McGill 2004) During the forward swing the hips sustain considerable loads. (Nesbit 2005) Therefore, the hips should be trained for endurance to improve stability and for strength and power to improve work capacity. The shoulder sustains higher velocities in addition to its work load. Improving endurance of the rotator cuff (supraspinatus, infraspinatus/teres minor and subscapularis) and scapular stabilizers (serratus anterior, trapezius, levator scapulae, and rhomboids), especially the serratus anterior, will protect the shoulder from injuries of instability. While developing strength and power in the primary muscles (pectoralis major, latissimus dorsi, and subscapularis) will affect swing speed and club head velocity. Developing strength and power in the muscles of wrist for pronation/supination will contribute to wrist uncoiling and stability.

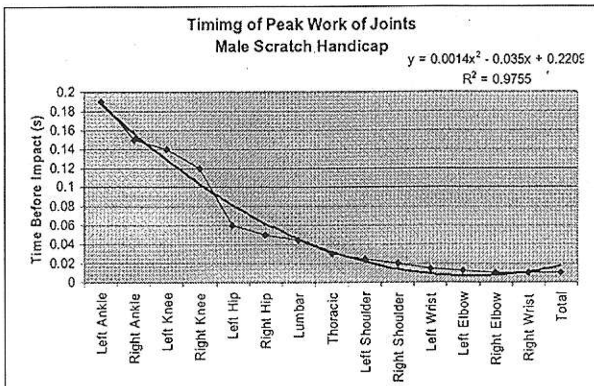


Figure 9. Timing of pead work of male scratch handicap. (Nesbit 2005)

Developing Coordination, Flexibility, Strength And Power

Optimum performance requires flexibility, coordination, endurance and power in most sports including golf. This is especially important for the senior, since natural aging can accentuate their loss. Fortunately, research has shown that physical aging can definitely be slowed, and its effect on physical skills and performance delayed with a progressively greater commitment to body maintenance through regular exercise and proper nutrition. Although great strength is not required in golf, working with light weights does improve and maintain muscle tone. (Stover 1996)

Activities to improve whole body balance should be included at all times throughout a training program beginning with activities on the floor and gradually proceeding to labile surfaces that eventually include concurrent body movement against resistance.

Stretching is a suggested part of a regular exercise program for athletes of all ages. In that people can play the game of golf throughout their lifetimes, and that aging tends to decrease flexibility, it is even more important to incorporate stretches into a workout regime. The majority of golf-related injuries are to the spine. When examining the mechanics of the swing, the risk for injury is understandable. (Pink 1996) Stretching for the shoulder should be performed judiciously and only when specific tightness is noted. This rule applies especially to

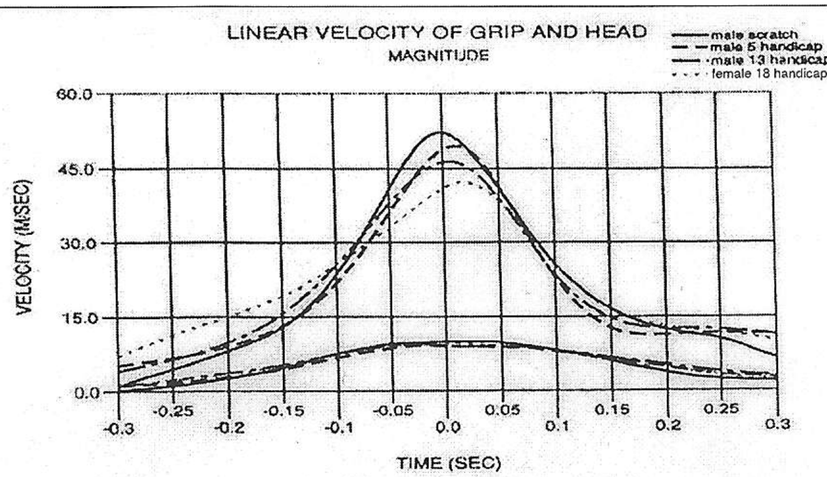


Figure 10. Linear velocity of grip and club head.

This figure illustrates the relationship between maximum club head velocity and skill level. Maximum club head velocity occurred at impact for the scratch golfer and on both sides of impact for the other subjects with the degree of spread related to the skill level of the four subjects. This finding is not unexpected noting the precise timing required to simultaneously coordinate the swing motion, wrist uncocking, wrist roll, swing plane stabilization, and shaft unflexing to cause the peak velocity to occur at impact. The large differences between grip and club head velocity highlights the importance of the wrists in generating club head velocity. The slope of the velocity curve during the downswing is an indication of both the delay and the magnitude of the wrist swing motion. It also shows when the wrist motion occurs and its relationship to skill level of the four subjects. (Nesbit 2005) the front of the shoulder. The leg muscles are obviously more important if one is walking rather than riding the course. (Jobe 1991) The stretches are to be done slowly and gently. Each stretch is held for 15 seconds. In addition to before a round of golf, stretches should be done on a daily basis for optimal results. (Fradkin 2004)

Of the total work generated during the golf swing 29% comes from the hips, 43% from the trunk, 8% from the shoulders and 16% from the elbow and wrists. (Nesbit 2004) However, it is not strength that sets off the expert golfer from the rest, it is the precise timing to simultaneously coordinate the swing motion, wrist uncocking, wrist roll, swing plane stabilization, and control of shaft unflexing that results in peak velocity at impact. Swinging harder does little to generate additional club head velocity. Swinging further (expanded range of motion) has the potential to generate additional club head velocity if you possess sufficient muscular power. Exercise programs thus should promote flexibility and strength training for power as opposed to just strength conditioning. (Nesbit 2005) The golf swing does not require maximum strength: coordination, timing, speed, power and stabilization are the keys to improving your golf swing. The key regions to train are the hips, trunk, shoulders and wrist/elbow.

Cardiorespiratory conditioning can be accomplished by 20-30 minutes of brisk walking three or more days a week. As mentioned above, walking 18 holes of golf provides adequate cardiorespiratory exercise.

Swing With Proper Technique, Tempo, And Balance

Optimal performance must not be achieved at the expense of safety or injury. Avoiding end range of motion keeps stresses on the ligaments, joint capsule and bony constraints to a safe level. A typical example would be in golfers who "slam" their spine into the passive tissues (ligaments and joint capsules) at the end range of the backswing and into lateral bending during ball contact. This causes troubles and symptoms for many a golfer. Position of the spine also determines muscle and ligament mechanics. When the lumbar spine is flexed, the muscles of the back loose their ability to buttress imposed shear forces on the spine. Furthermore, the spinal ligaments (interspinous ligaments) become tight and increase spinal shear forces. Finally, fatigue causes poor technique, and poor technique leads to

Figure 11 Full-body model of golf swing.

Nesbit

poor performance and elevated injury risk. Efficiency of movement and of training sessions reduces fatigue, and improves mechanics and technique of the swing. (McGill

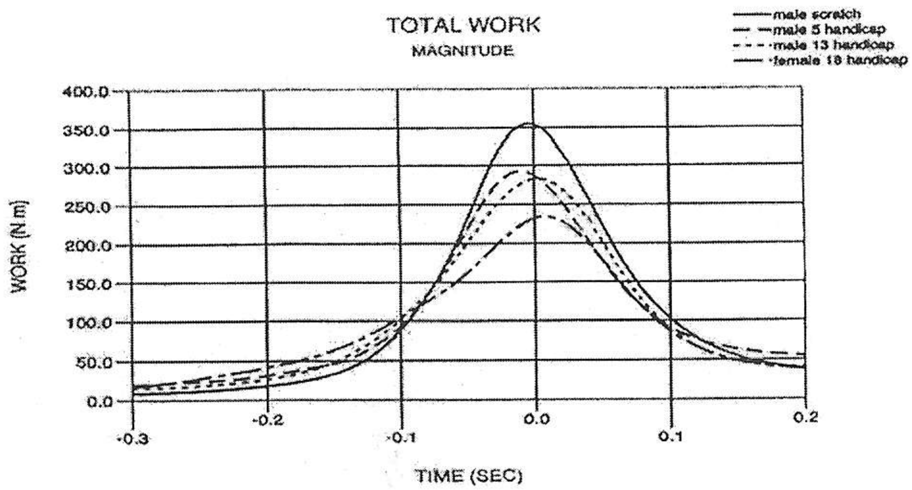


Figure 12 . Total work for all subjects.

Work and Power. The ability to apply forces and torques in the direction of motion during the downswing is indicated by the total work, and the ability to apply forces and torques as the swing increases in velocity is indicated by the total power. This figure illustrates total work curves and reveals differences among the four golfers in magnitude, shape, and timing. It is interesting that all subjects had the same total work at time -0.85 seconds which corresponds to the club position shown in the figure above (Figure 1). The better golfers initially do work at a slower rate, then do work more rapidly through impact. The better golfers also had higher club head velocities, higher total work done, and were able to peak total work closer to impact.

Total work is a combination of angular work and linear work. The linear force, work, and power are primarily transferred from the golfer to the club via pulling on the club by and through the arms. The angular torque, work, and power are transferred by and through the wrists. The ability to develop high peak forces and torques reflects the strength of the arms and wrists respectively. The better golfer use their arms more relative to their wrists to do work (by a 1.41:1 ration for the scratch golfer). (Nesbit 2005)

2004)

There cannot be enough said for working with a trained and certified professional golf instructor who has developed a critical eye and effective methods for correcting problems in the golf swing. (THERE NEEDS TO BE MORE ADDED TO THIS SECTION!)

A Final Word: On Injuries

Throughout this discussion we have inferred that injuries can occur from playing golf. Indeed, they can. Playing with pain is not a good idea. Studies have shown that when experiencing pain, stability of the painful region is compromised. (Hodges 1996, Ruwe 1994,) The muscles are slower to respond, and have reduced strength. (Hodges 2001) This can lead to early fatigue and increased chances of injury. Furthermore, pain avoidance postures and movements develop and, if sustained, become learned and do not self-correct after you are painfree and back to your normal activities. (Hides 1996, Ludewig 2000)

The concepts presented in this workshop are designed to prevent injuries. However, when you experience a golf related injury it is important for both your golf game and your health that you consult with a qualified professional experienced with addressing sports related injuries. A multidisciplinary approach to assessing the problem, addressing the biomechanical dysfunctions that contribute to the problem, and correcting golf swing mechanics has been shown to be most effective. (Parziale 2002) Early detection and correction of the dysfunctions that produced the tissue overload and caused your injury are paramount to your speedy recovery, avoidance of long term sequelae, and getting you back to what is really important in life: Golf.

Appendix 1
Warming Up To A Better Game Of Golf

Pre-Game Warm up

In addition to before beginning a round of golf, this warm-up routine should be done on a daily basis for optimal results. (Fradkin 2004)

Walk: 1-5 minutes

Legs - Place the back of one hand on your low back with finger spread. You should not feel any motion in you low back

- Hamstrings - (10) Kick forward with a straight leg. Easy at first, increasing intensity after five reps
- Hip Flexors - (10) Kick back with bent knee like kicking your self in the rear. Bring your knee back at the same time. Easy at first, increasing intensity after five reps.
- Knee raises - (10) Bend your knee as you raise it up towards your chest. Easy at first, increasing intensity after five reps.
- Toe hops - (20) Hop on your toes. Easy at first, increasing height after 10 reps.
- Toe hops to the side - (10) Hop on your toes side to side. Easy at first, increasing height after 5 reps.

Trunk Mobility And Motor Control – Move slowly, deliberately, and do not force end range.

- Club behind neck. To include neck rotation range of motion, spot on a point straight ahead and level, tuck chin back. Keep the front of you feet in peripheral vision (keeps posture straight). Optional: transfer weight to side of turn.
- Pelvis only turn (shoulders forward) – Hold 2s, repeat 5 times.
- Shoulder only turn (pelvis forward) – Hold 2s, repeat 5 times.
- Combined turn (both pelvis and shoulders) – Hold 2s, repeat 5 times.

Activation of Scapular Stabilizers – 5-10 reps each

- Shoulder presses (similar to lat pull-downs):
  - Push club up and away (towards the sky) from you on an angle of 45°
  - Pull club back, at the same time pull your shoulder blades down and back (in your back pocket). Keep your arms straight.

Air swings

Begin at half range and half intensity. Slowly increase range and intensity to full range and vigor in about one minute.

Warm Down

Static Stretches – The stretches are to be done slowly and gently. Each stretch is held for 15 seconds.

- Calf – Standing against a wall: Knee straight, knee bent.
- Quads – Knee on a bench behind you, pull ankle up.
- Hamstrings – Heel on a bench, back straight (hands on back-chest to knee): isolated at straight and 45° -> Low back stretch (nose to knee).
- Shoulder – posterior; reach past the opposite shoulder.
- Shoulder – Appley's overhead: grab a club behind your back, pull down.
- Shoulder – Appley's up back: grab a club behind your back, pull up.
- Forearm/wrist – pronate and flex.
- Forearm/wrist – supinate and extend.
- Lateral Trunk – club overhead, behind neck with elbows back, or hand over head and run other hand down leg.

Appendix 2
Strength And Power Conditioning Program For Better Golf

It is commonly believed that specific strength and conditioning programs may be able to improve performance in many sports, including golf. Although isolated strengthening of individual muscles play a role in increasing strength, conditioning that simulates the target activity, namely, order of movement and muscle activation, speed and intensity, results in greater improvements than general training. (REFERENCES) Factors that influence shot length are: range of motion, strength and muscle power, muscle balance, and muscular and aerobic endurance. (Hume 2005)

Understanding the biomechanics of the golf swing is a necessary prerequisite to developing an effective conditioning program. Biomechanics of the golf wing includes an analysis of the movement and muscle activation patterns as well as internal and external forces. (Hume 2005) The following is a brief review of current information about the golf swing particularly posture, sites of potential overload, and the activation and function of muscles during each phase of the swing. Information is given relative to a right-handed golfer. (For relative levels of muscle activations throughout the golf swing, see the Appendix 3)

Set-up

The set-up or starting position for executing a golf swing should align the golfer properly with the target, establish dynamic and static balance, be in a sound biomechanical position (i.e. golf posture) and provide an effective grip of the club. (Geisler 2001) An effective grip allows the golfer to control the club-face and allows the club o hinge and unhinge during the golf swing. During the set-up, 50-60% of the golfer's weight should be on the back foot. (Hume 2005) The knees should be flexed to 20-25°, the trunk flexed to approximately 45° at the hips (primary spinal angle), with a right lateral shoulder tilt of approximately 16° (secondary spinal angle) due to the right hand being placed lower on the club than the left hand. (Geisler 2001)

Backswing

The purpose of the backswing is to position and align the golfer's hub centre and club head so that the golfer can execute an accurate and powerful downswing, to provide a base link for the downswing's kinetic chain, and to stretch the muscles and joint structures that are responsible for generating power in the downswing. The average shoulder rotation (78-102°) and pelvis rotation (47-55°) at the top of the backswing vary depending on the level of the player. Shoulder and hip rotation can be affected by spine and knee angles. At the top of the back swing the wrists and hands are cocked. Golfers with limited range of sideward bending (radial deviation) of the wrists will use wrist extension to gain the square hand and club face position at the top of the back swing. The left arm is reaching across the chest which results in the rotator cuff and muscles across the back of the shoulder being stretched and the shoulder in a position that would cause impingement of the structures at the top of the shoulder (left rotator cuff). The golfer with limited hip rotation will compensate by tilting of the pelvis and straightening of the right knee. Throughout the backswing the left hand is firmly in control of the club while the right hand is passive. (Hume 2005)

Downswing

The purpose of the downswing is to return the club head to the ball in the correct plane with maximum velocity. The average duration of the downswing is 0.23 seconds for elite golfers performing a drive. (Cochran 1968) The forward swing is divided into two sub phases: the forward swing and the acceleration.

The trunk muscles initiate the downswing sequence. The left pelvic rotation starts before the arms have completed the backswing. This increases the stretch on the muscles of the hips, trunk and left shoulder. The right hip extensors (Glute max) and abductors (Glute med) and the left adductor magnus initiate left pelvic rotation. There may also be left foot supination and lateral rotation of the patella prior to this movement. In the downswing, the subscapularis and latissimus dorsi are very active with the pectoralis major becoming more active in the acceleration phase. The trunk muscles maintain body posture and the rotator cuff muscles and serratus anterior stabilize the shoulder and scapula, respectively. (Hume 2005) During the acceleration phase the right elbow extends and the wrists uncock to provide power and increase club head velocity. The variable that most closely corresponds to club head velocity was the delay of wrist uncocking. (Nesbit 2005)

The kinetic chain action involves the initiation of the movement with the legs and hips followed by movement of the trunk and shoulders, and finally the wrists and hands. Club head speed is maximum when the movement is in a sequential order from the ground up. (Springings 2000)

Forces sustained by the body are the highest in the downswing: Anterior shear of the right knee is up to 10% of the body weight compounded by increased rotational stresses similar to side-cutting maneuvers; The left knee sustains up to 80% of body weight during impact, with large side, rotational and compressive forces. (Gatt 1998)

In golf, loading the back foot during the backswing and transferring this weight onto the front foot during the downswing and acceleration phases can achieve a grater club head velocity at impact. To enhance this transfer of force, the body segments should be kept rigid (e.g. the trunk). During the golf swing vertical forces can approach 2 bodyweights. In accordance with the weight transfer principle, low-handicap player produce greater forces with the front foot during the downswing. In order to use these forces effectively, the timing and the magnitude of the transfer of bodyweight is more important than simply the magnitude of the force: the low-handicap players transfer more of their weight at a faster rate throughout the entire downswing. (Hume 2005)

Also during the downswing there is a rapid stretching of the muscles of the lower, mid-section and upper body prior to shortening (contraction). This is known as the stretch-shorten cycle (SSC). It is believed that the stretching then contracting (shortening) of a muscle/ muscle group within a short time should increase elastic energy to enhance work and efficiency in the contraction. However, the effect on performance is lost the greater the pause between the stretch and contraction. In golf, the SSC is created by the hips beginning to move forward before the completion of the backswing by the arms resulting in increased rotation between the pelvis and shoulders (the X-factor). This places a stretch on the left shoulder, hip and trunk.(Hume 2000) Because of the tissue stresses, it is here during the SSC that many injuries of the low back and shoulder take place.

Follow-Through

The purpose of the follow-through is to decelerate the body and club head by using controlled muscle elongation (eccentric contraction). The rotator cuff muscles and serratus anterior are active through this phase to stabilize the shoulder complex. Also, the end of follow-through can generate excessive trunk rotation and shoulder ranges of motion. After impact the spine should stay in a vertical position as the player turns their hips and shoulders through to a level position. At the completion of the follow-through, most of the weight has transferred to the left foot, the player is standing in an upright position facing the target, and hips and shoulders are parallel to the ground. Excessive lumbar twist will almost certainly lead to injury over time. (Adlington)

Warm Up and Motor Control

Walk/Run 10 minutes

Legs - Place the back of one hand on your low back with finger spread. You should not feel any motion in you low back

- Hamstrings - (10) Kick forward with a straight leg. Easy at first, increasing intensity after five reps
- Hip Flexors - (10) Kick back with bent knee like kicking your self in the rear. Bring your knee back at the same time. Easy at first, increasing intensity after five reps.
- Knee raises - (10) Bend your knee as you raise it up towards your chest. Easy at first, increasing intensity after five reps.
- Toe hops - (10) Hop on your toes. Easy at first, increasing height after 5 reps.
- Squat hops - (10) Hop using a brief short squat. Easy at first, increasing height after 5 reps.

Toe hops to the side - (10) Hop on your toes side to side. Easy at first, increasing height after 5 reps.

Squat hops to the side - (10) Hop side to side using a brief short squat. Easy at first, increasing height after 5 reps.

Trunk Mobility And Motor Control – Move slowly, deliberately, and do not force end range.

- Club behind neck. To include neck rotation range of motion, spot on a point straight ahead and level, tuck chin back. Keep the front of you feet in peripheral vision (keeps posture straight). Optional: transfer weight to side of turn.
- Pelvis only turn (shoulders forward) – Hold

2s, repeat 5 times.
Shoulder only turn (pelvis forward) – Hold 2s, repeat 5 times.
Combined turn (both pelvis and shoulders) – Hold 2s, repeat 5 times.

Activation of Scapular Stabilizers – 5-10 reps each

Shoulder presses (similar to lat pull-downs):
- Push club up and away (towards the sky) from you on an angle of 45°
- Pull club back, at the same time pull your shoulder blades down and back (in your back pocket). Keep your arms straight.

Strength and Power Conditioning

Isolated Strengthening

Hip
- Bridges: Double leg stance to single leg stance
- Wall Squats
- Reaches: 6:00
- Steps: Back
- Lunges: 12:00, add cable resistance at hip
- Clam on a half shell
- Wall squats with band at knees
- Reaches: 3:00 and 7:00
- Steps: Side
- Lunges: 3:00, add cable resistance at hip
- Steps: Forward

Core
- Birddog
- Extensions
- Side bridge
- Prone abdominal brace
- Dying bug

Shoulder Complex
- Internal rotation at waist, and at 90° abduction (Cable)
- External rotation at waist, and at 90° abduction (Cable)
- Pushup plus
- Straight arm dips
- Scaption with scapular set
- Prone: lateral raises, and overhead raises
- Lat pull-downs
- Shoulder presses
- Prone row into elbow extension

Upper Extremity
- Elbow flexion
- Supination
- Wrist flexion
- Elbow extension
- Pronation
- Wrist extension

Balance Training

Do all of the above on a ball while sitting, supine and prone. Feet apart moving together as balance allows, to single leg, alternating legs every 10 reps or loss of balance

Perform the Trunk Rotation exercises above standing on a rocker board, going from double to one leg stance as balance allows

Rocker board:
- Reaches at 3:00, 6:00, and 7:00 with knee raises. Board rocking forward, sideways, and diagonal.
- Body turns with arms is divers positions, with/without weights, upright or in golf posture, double leg and single leg, etc. Board rocking forward, sideways, and diagonal.
- Squats, double leg to single leg. Board rocking forward, sideways, and diagonal.

Bosu:
- Repeat Rocker board exercises on Bosu
- Catch and Throws.

Training of the Kinetic Chains

Emphasis on Shoulders:
- Flexion/extension
- Abduction/adduction
- Translation
- Pushes/pulls
- Diagonals

Emphasis on Core/hip:
- Cable: short pulls/pushes, add transfer of weight, add step out, add shoulder translations (pull/push)
- Diagonals

Emphasis on Lower Extremity
- Step forward/back with side cable opposite to stance foot.

Emphasis on Upper Extremity
- Elbow flexion/supination/wrist flexion
- Elbow extension/pronation/wrist extension
- Prone on ball: scapular depressions – arms at extn, horiz abd, flxn

Whole body

Ball: Prone walk outs, SA Pushups, transfer weight, lift leg, trunk rotation, single arm stand, etc
Lunges: pushes and pulls: Forward and sideways especially
Lunges - sideways with resistance
Steps: arm reaches forward and translation

Plyometrics For Power

Ball throws: Forward and sideways
Jumps: Floor, onto/ off steps or Bosu. Begin double leg advancing to single leg stability allows.
Push up plyometrics: wall, bench, knees on floor, feet on floor.
Weighted Golf club

Drills – Replication of the Golf Swing (Golf Pro)

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Appendix 3

Dynamic Electromyographic Analysis Of Musculature During The Golf Swing

Research done by Jobe, et. al.

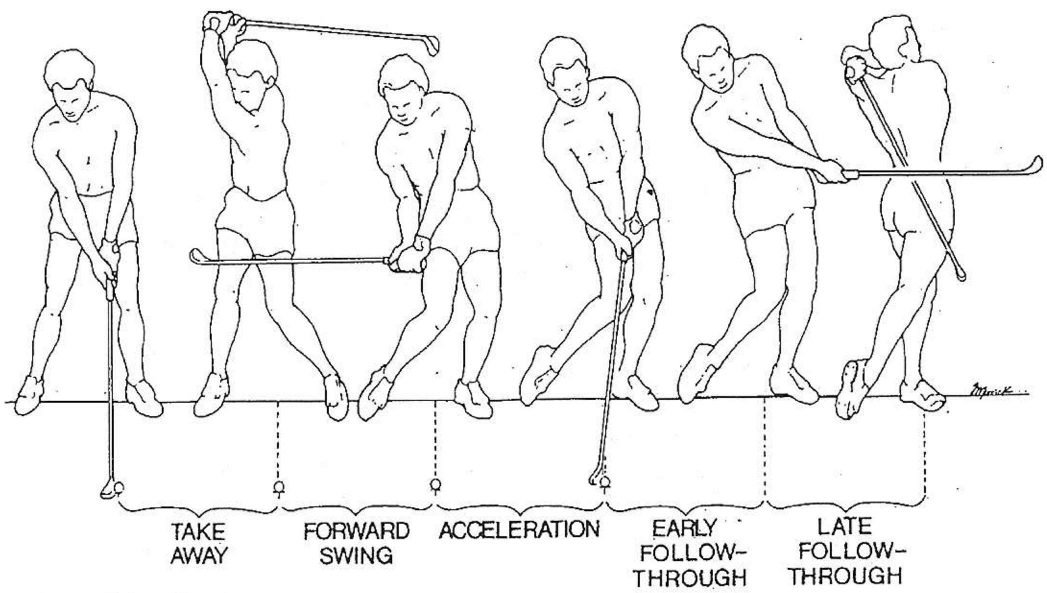


Figure 1. Phases of the golf swing.

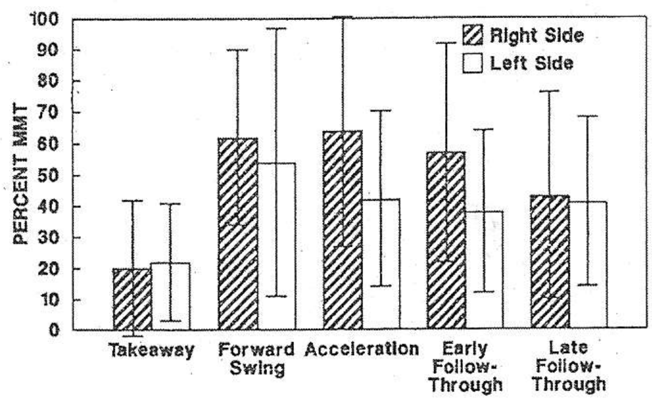


Figure 3. Muscle activity in the abdominal oblique muscles.

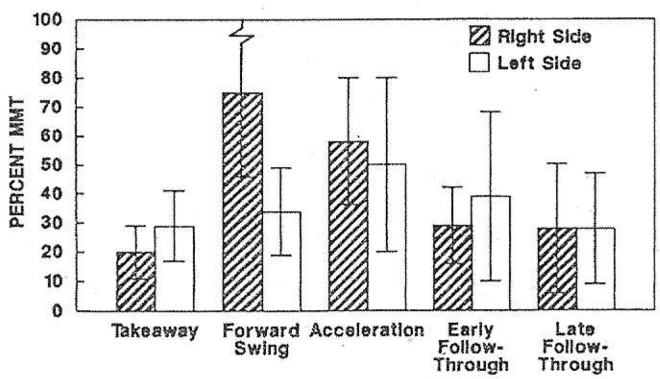


Figure 2. Muscle activity in the erector spinae muscles

Shoulder Muscle Activation During the Phases of Swing

LEFT

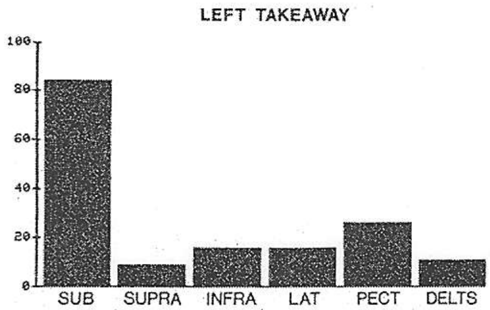


Figure 5. Bar graph showing activity of muscles, expressed as percentages of maximal manual muscle test values, during takeaway on the left side. Subscapularis activity is conspicuous.

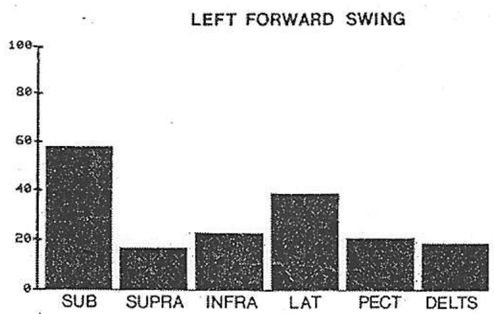


Figure 6. The forward swing phase is marked on the left side by moderate subscapularis and latissimus dorsi activity.

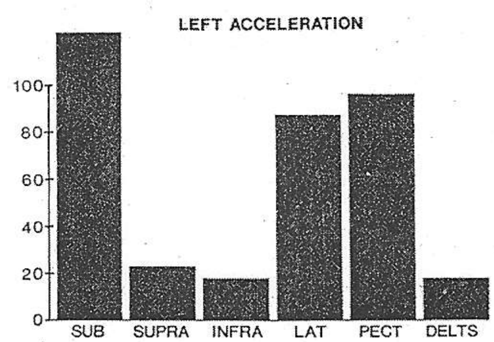


Figure 7. The pectoralis major, latissimus dorsi, and subscapularis on the left side fire at a high level during the acceleration phase prior to ball contact.

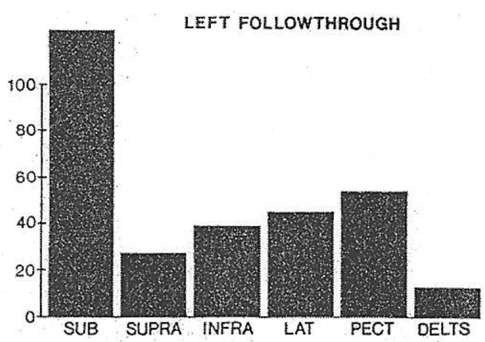


Figure 8. Marked subscapularis activity on the left side continues into the follow-through phase, while latissimus dorsi and pectoralis major activity subsides to the moderate level.

RIGHT

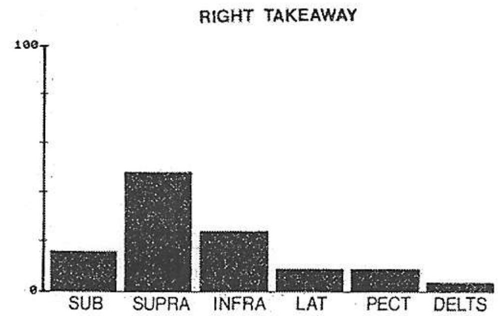


Figure 9. The supraspinatus is only active muscle on the right side during takeaway.

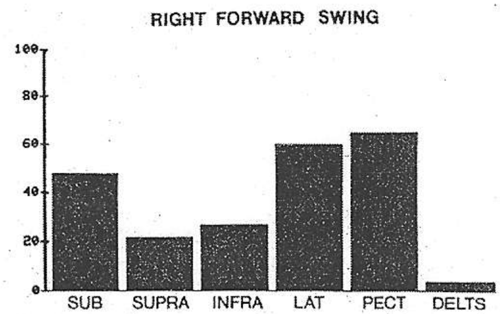


Figure 10. Activity of the pectoralis major on the right side is marked during forward swing; the latissimus dorsi and subscapularis exhibit moderate activity.

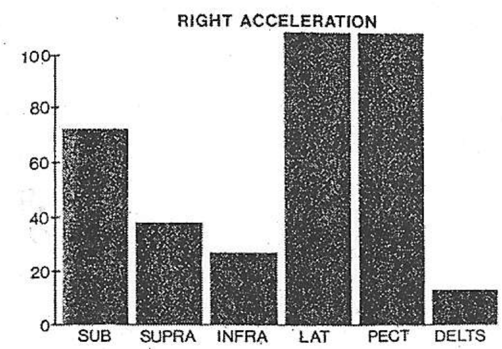


Figure 11. The latissimus dorsi and pectoralis major combine with the subscapularis during the acceleration phase to provide power.

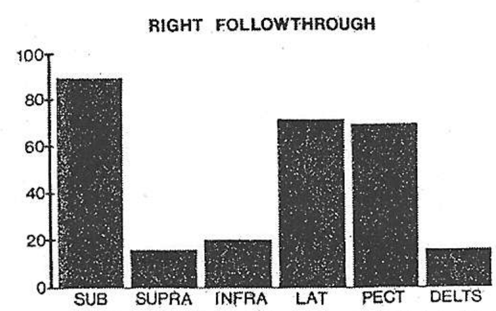


Figure 12. Marked activity of the subscapularis, latissimus dorsi, and pectoralis major on the right side is persistent during the follow-through phase.

INFRASPINATUS

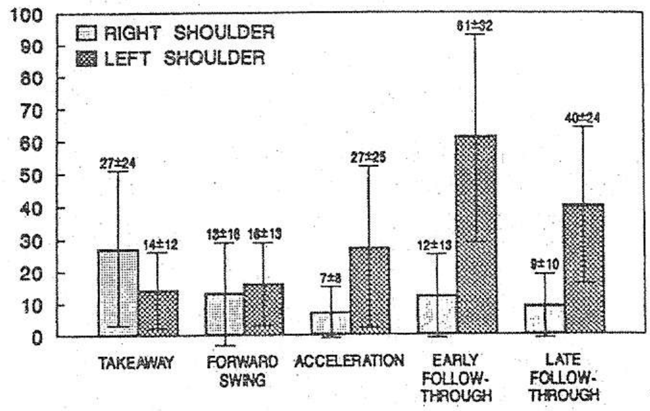
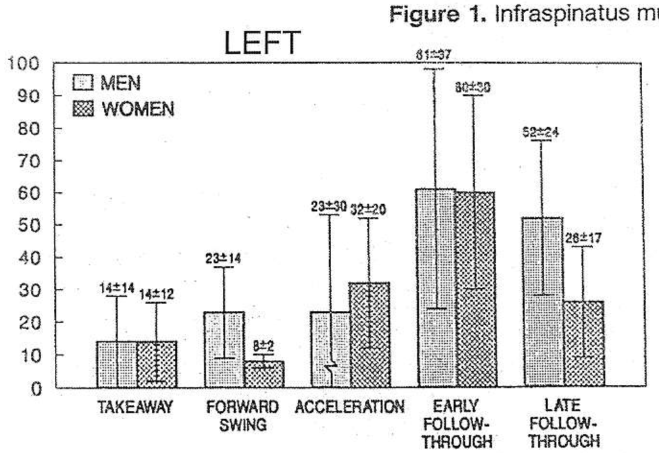
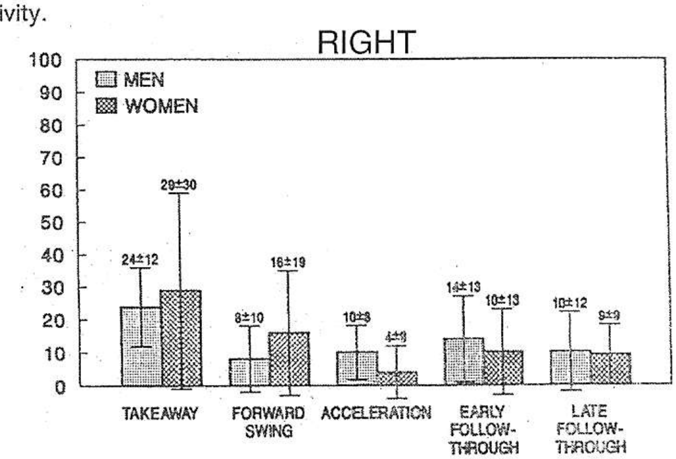


Figure 1. Infraspinatus muscle activity.





SUPRASPINATUS

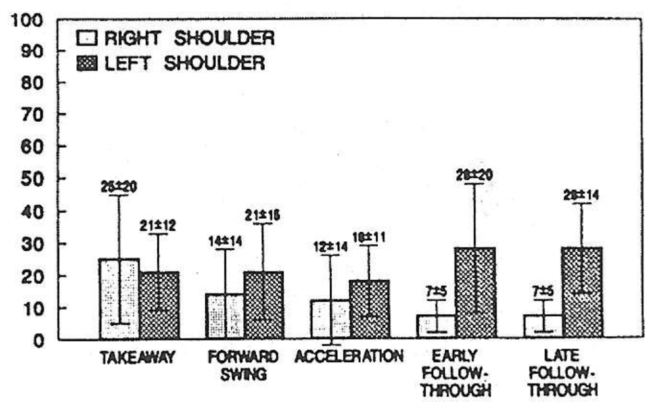
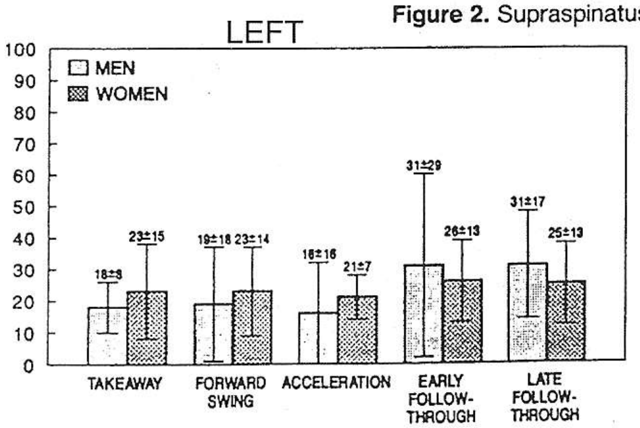
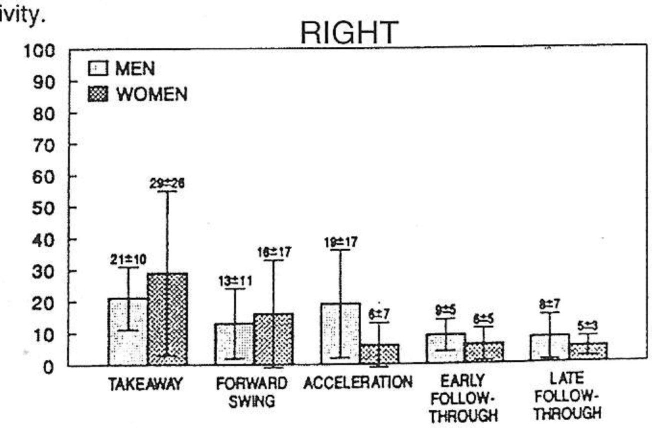


Figure 2. Supraspinatus muscle activity.





SUBSCAPULARIS

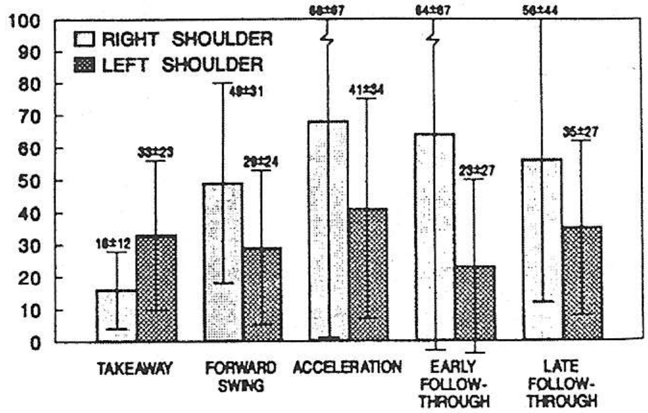
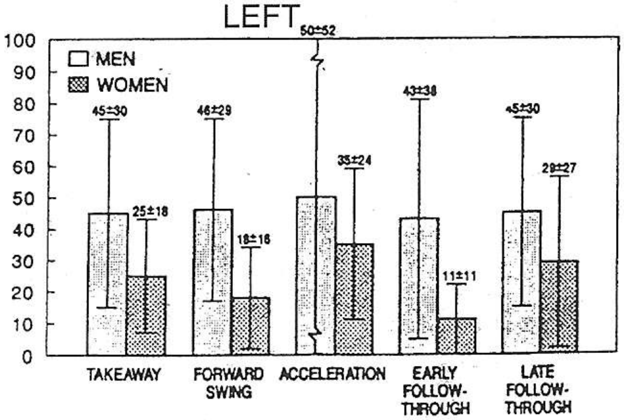
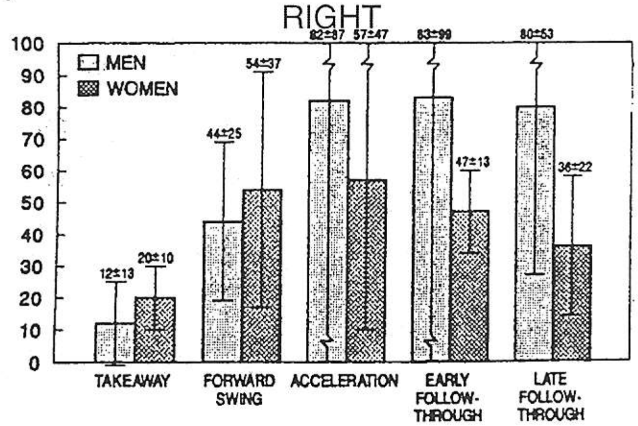


Figure 3. Subscapularis muscle activity.

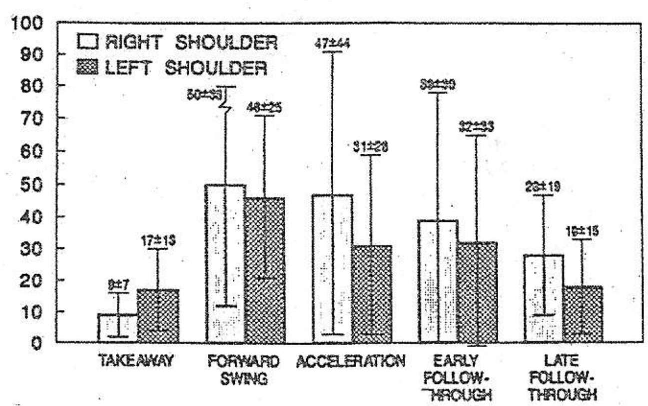
LEFT



RIGHT



LATISSIMUS DORSI



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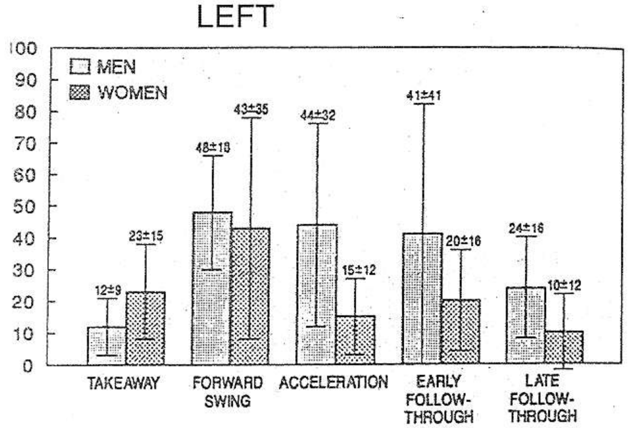

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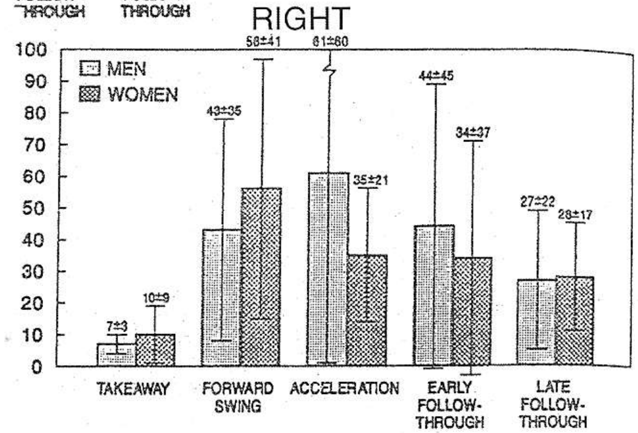
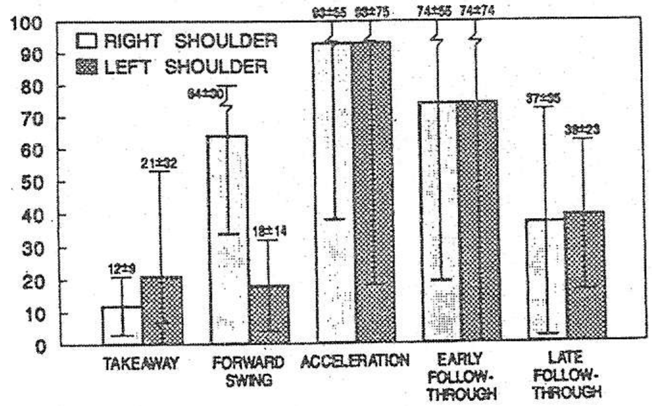
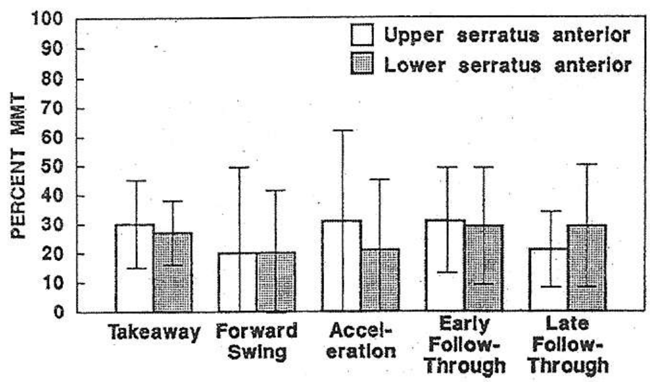


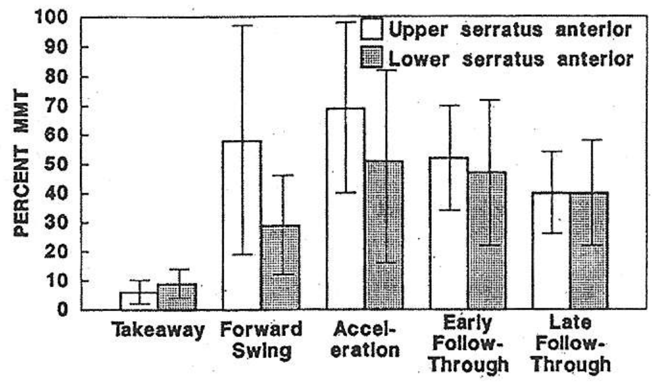
PECTORALIS MAJOR

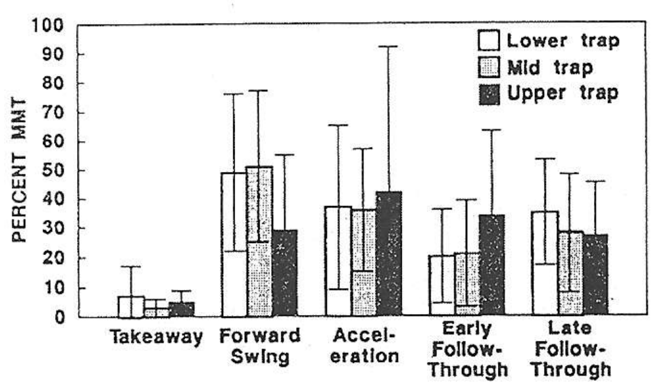


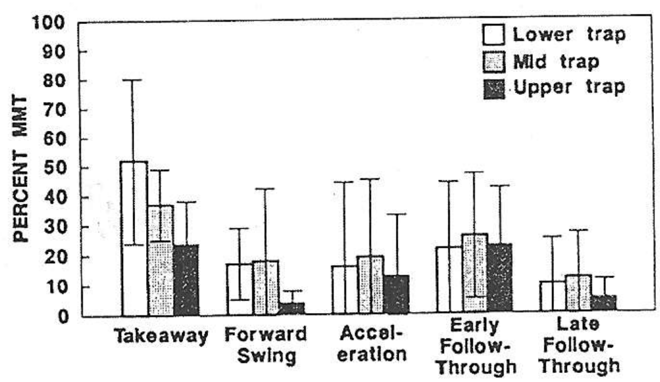
LEFT

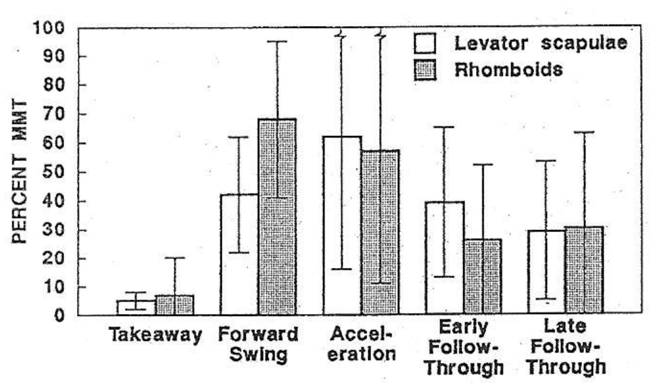
RIGHT

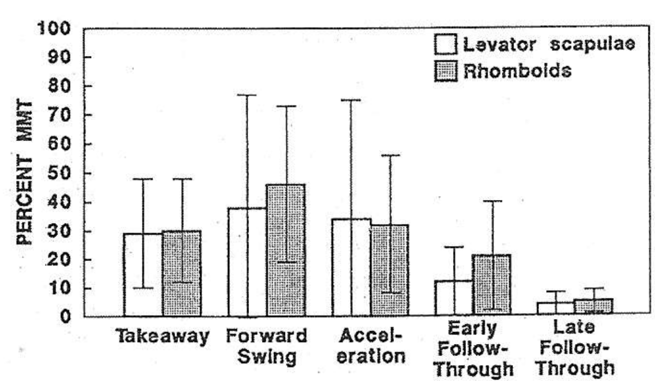












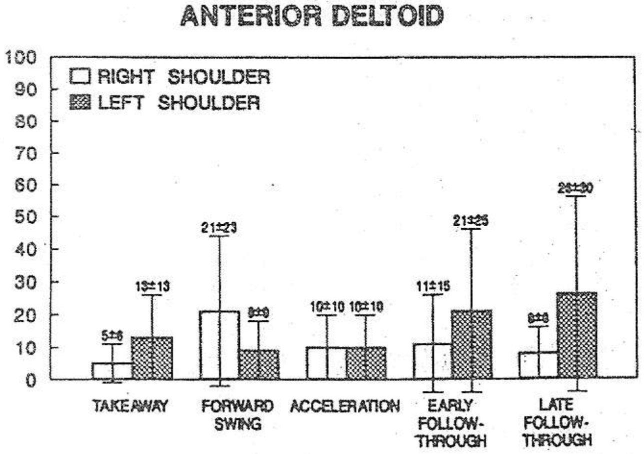


Figure 6. Anterior deltoid muscle activity.

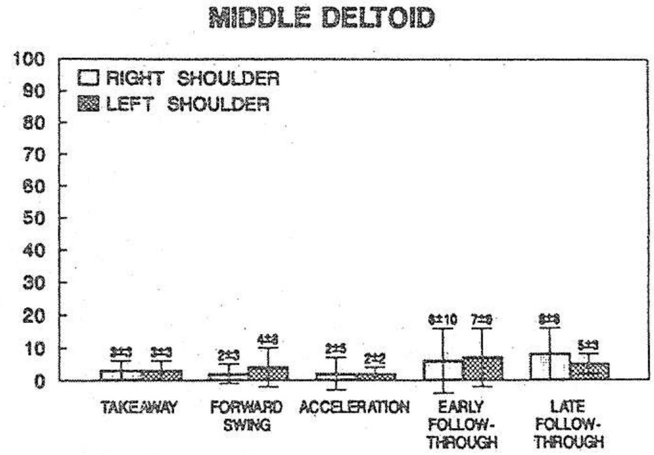


Figure 7. Middle deltoid muscle activity.

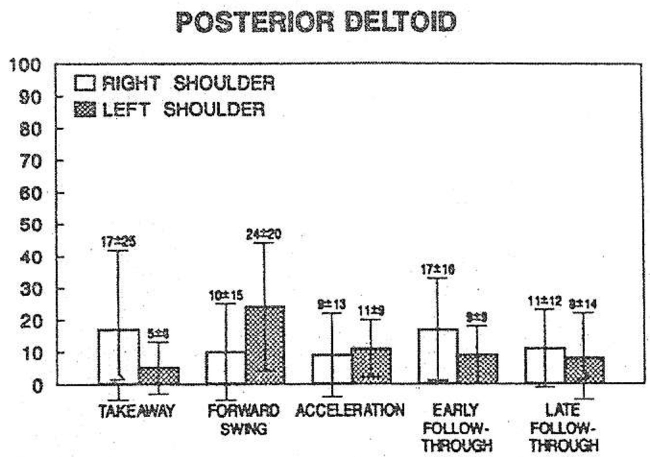


Figure 8. Posterior deltoid muscle activity.