Sorbie et al. Int J Sports Exerc Med 2016, 2:035
Volume 2 | Issue 1
ISSN: 2469-5718

International Journal of
Sports and Exercise Medicine

Original Research Article: Open Access

The Effect of Dynamic and Static Stretching on Golf Driving Performance

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Abstract

The aim of this study was to investigate the effect of dynamic and static stretching warm-up routines on golf driving performance. Three different components were tested; namely carry distance, accuracy and ball contact. Twelve male competitive golfers took part in the experiment. Two supervised warm-up treatments were tested on nonconsecutive days. Each subject was randomized to either a dynamic stretching (DS) or static stretching (SS) routine. The DS and SS protocols consisted of nine stretches targeting the entire body. Descriptive statistics and paired t-tests were applied ($P < 0.05$) between the dynamic and static stretching protocols. The results revealed significant differences between protocols in terms of driving distance and accuracy. Performing a dynamic warm-up before commencing golf driving produced a significant difference with regards to total carry distance ($P = 0.012$). In terms of shot accuracy, there were significant differences between participants after DS and SS ($P = 0.049$). The present data indicate that DS significantly increases driving distance and accuracy in comparison to SS in low handicap male golfers. No between subject differences were observed with respect to ball contact following DS and SS ($P = 0.064$). All participants produced a low shot accuracy distance index (≤ 0.04) after both stretching protocols. The present data further indicate a high level of symmetry with respect to distance and shot accuracy performance indicators in competitive male golfers.

Keywords

Golf Performance Indicators, Shot Accuracy, Driving Distance, Ball contact

Introduction

In recent years, there has been a major rise in golf participation worldwide [1-3]. With this increase in popularity, there is an increased demand for systematic research into the sport. Similar to many other sports, research has focused on: improving flexibility, endurance, strength and power or improving the technique of the individual.

Biomechanics has been further employed in an attempt to find the model golf swing, with emphasis on improving performance and reducing the rate of injury [4]. Theriault and Lachance (1998) state that the physical demands of golf are vast, particularly the swing. The golf swing is a highly coordinated, sub-sectional and rotational movement which requires a great level of joint flexibility and balance [5,6]. These attributes are more commonly found in lower handicap and elite golfers [6]. According to Adlington (1996), swing mechanics are described by many golf professionals as the defining factor for optimal golf driving performance [7]. During the backswing, the stretching of the hip and trunk allows greater muscle force and torque to be produced. The greater the range of motion (ROM) at this stage of the swing, the greater the club head velocity when initiating the downswing [8].

The biomechanical movement patterns that form the golf swing require great flexibility and ROM at specific joints and soft tissues [6]. This can be promoted through a warm-up protocol prior to competition or practice [9]. Flexibility is defined as the available ROM around a joint or the capacity of a joint to move through its full ROM in a fluent manner [10]. A high level of flexibility is essential in the shoulders, torso and hips to achieve biomechanical efficiency of the golf swing [2]. This in turn, will likely generate increased club head speed [2,11]. Fradkin et al. (2004) suggest that greater ROM in the upper body will create greater carry distance of the golf ball and greater swing speed velocity [12]. Gergley (2009) endorses this statement and comments that a muscle that has not been stimulated prior to competition, and has poor flexibility, will result in a shorter golf swing [9]. Similarly, this could limit the arc of the golf swing, which could reduce the velocity of the golf club; therefore the carry distance of the golf ball will ultimately be reduced [12]. The arc of the golf swing is described as the maximum radius of the swing [13].

Prior to competition, it is common for an athlete to partake in a warm-up routine, of which there are many variations [9,14,15]. As part of a warm-up routine, it is well accepted the athlete should perform submaximal aerobic exercises (i.e. running, cycling) before stretching exercises are conducted [16,17]. The rationale behind this light exercise is to stimulate a warm-up effect [18]. This will increase the core temperature, muscle temperature, blood flow and disrupt transient connective tissue bonds [19]. With increasing muscle temperature the warm-up effect will allow muscle contraction to become quicker and promote the relaxation of both agonist and antagonist muscles [18,19]. There are a number of different stretching

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Citation: Sorbie GG, Baker JS, Gu Y, Ugbolue UC (2016) The Effect of Dynamic and Static Stretching on Golf Driving Performance. Int J Sports Exerc Med 2:035

Received: October 12, 2015: **Accepted:** January 07, 2016: **Published:** January 11, 2016

techniques that can be used in warm-up protocols with static and dynamic stretching being the most common [20,21].

For decades, static stretching (SS) was considered an essential component of a warm-up [15]. SS is generally a form of active stretching and is described as holding a maximal stretch for a period of time, usually ranging from 20-30 seconds [22,17]. The method of stretching is popular within many sports because of its simple protocol, and safety [23]. SS includes both relaxation and concurrent elongation of the stretched muscle [24].

Dynamic stretching (DS) is described as moving a joint through an active ROM in a controlled movement [25]. Fletcher and Monte-Colombo (2010) reported DS is currently replacing SS as the most popular method of stretching to be incorporated into athletic warm-up routines [25]. Jordan et al. (2012) has proposed that DS is the most beneficial method of stretching prior to competition, due to its ergogenic potential that is likely achieved as a consequence of DS mimicking the functional ROM performed in a sport specific movement [24]. Alikhajeh et al. (2012) reported that this stretching method should be performed for approximately 30 seconds on each limb with the rate of stretch being 1 stretch for every 2-second cycle [22]. DS often mimics sports specific movements and involves continuous, rhythmic movements [26]. Therefore, it is often used in athletic warm-ups and sports specific flexibility programmes. This form of stretching uses one muscle group to stretch another and comprises of slow, controlled and repetitive movements [16].

Draovitch and Simpson (2007) propose that due to the dynamics of the golf swing, dynamic or static stretching could improve performance of the golfer due to the movement patterns that are repeated in the arc during the swing phase [27]. We hypothesize that the dynamic stretch protocol will be more efficient in terms of driving distance and ball contact outcome measures. Therefore, the purpose of this study was twofold: (a) to investigate the effect of dynamic and static stretching warm-up routines on golf driving performance, and (b) to establish a relationship between the shot accuracy and distance in the form of a performance index.

Methods

Subjects

A total of 12 subjects (age: 22.5 ± 3.0 years; mass: 80.3 ± 6.4 kg; height: 1.84 ± 0.1 m), volunteered to take part in the experimental study. All subjects held a Council of National Golf Unions (CONGU) handicap of 5 or less (1.4 ± 1.9). Each subject regularly undertook fitness training programmes specific to golf, this made the individuals competent in performing the warm-up protocols to a high standard. Before testing took place, subjects were provided with a participation information form to read before the initial screening assessment. Each subject was individually screened before participation with the use of a physical activity readiness questionnaire (PAR-Q). Informed written consent form was also obtained from each subject. Prior to commencing testing, approval for the study was obtained from the ethical committee of the School of Science and Sport, Institute for Clinical Exercise & Health Science, University of the West of Scotland, UK, Ethics Committee.

Experimental protocol

Each subject was required to attend two separate sessions on non-consecutive days. The testing lasted an average of two hours over a three / five day period. All testing was performed at the same time of day to minimise the effects of diurnal variation. Testing days varied slightly due to unpredictable weather conditions. The testing between the DS and SS warm-up protocols were conducted in similar weather conditions. Wind, rain and temperature were taken into consideration; as these were the main factors that affected ball deviation. Testing was cancelled when the wind speed was ± 2 mph different from previous testing sessions. A Kestrel 4500 anemometer (Champlain, NY, USA) was used to calculate weather conditions. Prior to performance measurements being recorded on four different aspects of golf driving, each subject was randomized to either a DS or SS routine on their first day of testing. The opposite routine was then performed on the final testing session. Each testing session began with a 5 minute run at 40% of their perceived maximum running speed around the practise area. This was based on a study by Yamaguchi et al. (2007) who suggested the application of light aerobic exercises prior to warm-up [16]. The stretching protocols targeted the following parts of the body: the neck, shoulders, back, chest, hips, glutes, hamstring and thighs (Table 1). The DS and SS were performed in the order displayed in Table 1. Dynamic stretches were performed 15 times on both sides of the body or 15 times in 1 full body stretch over 3 repetitions, lasting for approximately 30 seconds due to the rate of stretch being 1 stretch every 2-second cycle. The protocol used followed guidelines documented by [22]. In the absence of any golf-specific, dynamic stretching protocols, and due to the rotational similarities between football and golf, we selected the dynamic stretching protocol of Alikhajeh et al., 2012 to be suitable in the present cohort of golfers [22]. Instruction was given to move the body through as large a ROM as possible. One air golf swing was

Table 1: Description of stretches employed

Static Stretch (Described right side only)	Dynamic Stretch
Quadriceps: Stand with feet close together. Flex the right knee towards the right glute and hold the right ankle with the right hand. If possible, push the hips forward for a greater stretch.	**Quadriceps:** Step forward with the left foot, bring the right leg forward, flex right knee towards the glutes and grab the right ankle with right hand. At the same time raise the left arm. Repeat alternately.
Bicep Femoris: Lie down on the back with legs flat, lift the right leg and place the left hand to the outside knee. Push the right knee towards the left shoulder.	**Hamstring:** Step forward onto the left foot, kick right leg out towards the out stretched arm that are parallel to the shoulders. When right leg comes back towards the ground kick out behind.
Lunge: Step forward onto the right foot, lowering the hips into a lunge position. Keep the right knee above the right foot and the left knee just off the ground. The trunk and head should remain in an upright posture.	**Lunge into Glute Stretch:** Stand upright, step forward onto the right foot and lower the hips into a lunge position. Keep the right knee above the right foot and the left knee just off the ground. Lunge forward then lunge back, out stretch your left leg and sit forward to stretch the glute.
Glute Stretch: Lying on the floor lift right knee towards the chest. Hold the ankle and pull towards the chest.	**Supported Squats with Club:** Hold supporting golf club. Squat down from the knee position, keeping a straight back. Go just below parallel, so that the glutes drop below the knees.
Trunk Rotation: Start 6 to 8 inches from the wall; begin turning the right of the body until you can feel tension in the pelvis. Reach, right and left hand towards the wall.	**Side Lunge / Trunk Rotation:** Stand with feet hip width apart. Step with the side with the right knee and lunge, when in the lunge position rotate the trunk to the right side with the arms at head height.
Obliques: Stand with feet hip width apart. Tilt to the right side with the left arm coming over the head, keeping your torso straight. Keep the back in a neutral position.	**Obliques:** Identical to the static stretch but this is performed with a side to side motion.
Shoulder and Trapezius: Hold driver, put it over the head and drop it down the back. Hold the grip in the left hand, maintaining a 90 degree angle at the elbow. Stretch the right arm out behind the body holding the club head.	**Trapezius and Subscapularis:** Stand tall with the shoulder blades back. Bend elbows at 90 degrees, rotate thumbs outwards and bring forms back.
Anterior Shoulder: Stand with feet hip width apart. Hold golf club parallel to the ground, lift the club above the head with a slight bend in the elbow.	**Shoulder Baseball Movement:** Hold golf club at shoulder height and repeat swings from right to left, pausing for a second in the middle.
Chest: Stand with feet hip width apart and stand upright. Clasp arms behind the back, pressing the chest out.	**Chest:** Slowly swing your arms back and forth across the front of the chest, focusing on stretching the chest area.

performed prior to testing. Each static stretch lasted for the duration of 30 seconds on each leg or arm before changing immediately to the contralateral side. Each stretch was completed 3 times. Participants were encouraged to stretch until they approached the end of the ROM but within the pain threshold. A 20 second rest between each body part stretched was facilitated.

Golf performance tests

Prior to testing, a large practice area with driving bays at Hamilton golf club (Hamilton, Lanarkshire, Scotland, UK) was set up with the appropriate equipment. The practise area was situated on a slight slope with closely cut grass. Before testing began one particular driving bay was identified for the full testing process, this enabled a consistency of the golfers positioning throughout the testing period. Four target poles were placed in the hitting area, to enable subjects have a pre-determined target. On both days of testing, subjects were required to bring their personal golf equipment with them. All golf shots were hit with relatively new Titleist PTs solo golf balls (Fairhaven, MA, USA). No limitations were set for the driver the subjects used, however the make and model of the driver had to be identical on both testing days.

After the stretching exercises were completed each subject rested for 2 minutes before the hitting ten drives, with the distance, accuracy and ball contact being recorded from each shot. Subjects were encouraged to perform their personally devised pre-shot routine before every ball was struck. This allowed the subjects to mimic their tournament pre shot routine. Moran et al. (2009) suggests this approach has the potential to make the results more consistent [20]. Subjects were also instructed to strike the ball as hard as possible but with the aim of keeping control of the distance and accuracy of each golf shot. Ten drives were hit with a 1 minute rest between each shot; this was specified so that the participants could regenerate the metabolic energy that had been used in the previous shot.

A collection of data was taken from each subject with the use of a Silverline metric measuring wheel (Somerset, England, UK). This was sourced to calculate distance and accuracy with respect to the flags placed on the midline of the fairway. The markings on the fairway ranged from 150-300 yards (Figure 1). Accuracy was measured by the absolute distance each shot deviated, left or right, from the predetermined target line. Measurement recordings were taken from the teeing area to the final resting position of the ball. To collect the contact data for each drive the subjects were asked "How well did you hit that one?" and they responded either with "yes" for good contact or "no" for poor contact. This simple approach was used by Gergley and colleagues and is considered an appropriate mode of assessment when working with golfers with a high skill level [9]. Each individual subject was required to hit ten golf shots with a driver. This enabled calculation of the mean and standard deviation of each component of the ten drives. Driving performance indicators were also derived from the distance and shot accuracy measurements with respect to the dynamic and static stretch protocols. Distance index was expressed as a ratio of the driving distance after dynamic stretch to the driving distance after static stretch. Shot accuracy index was expressed as a ratio of the shot accuracy following dynamic stretch to the shot accuracy following static stretch protocols. Both the distance and shot indices were evaluated based on the outcome measure "symmetry" i.e. the closer the indices to 1 the more symmetric the performance. The shot accuracy distance index was defined as the ratio of the shot accuracy to the driving distance. The lower the shot accuracy distance index value the stronger the performance. This index was also applied after dynamic and static stretches.

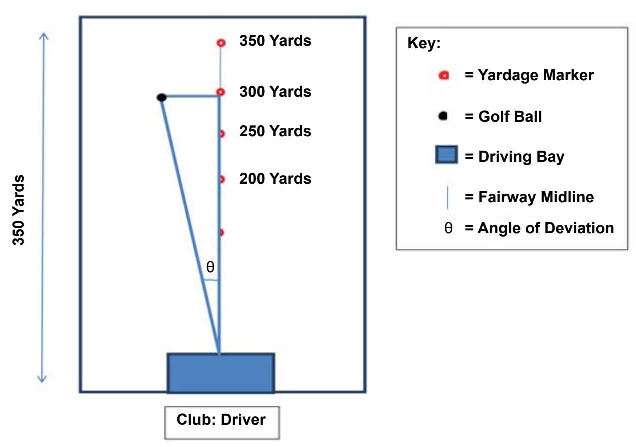

Figure 1: Illustration of the experimental setup at the golf driving range

Statistical Analysis

Descriptive statistics were performed to establish if there were any notable differences between the dynamic and static warm-up protocols. A relationship between shot accuracy and distance was established in the form of a performance index. Paired t-tests were applied and a null hypothesis was assumed between the two stretching protocols. Paired t-tests were performed to reject or accept each of the driving performance variables. Statistical significance was set to P = 0.05.

Table 2: Summary of Driving Performance Results

Participants	Handicap	Distance after Dynamic Stretch (Yards) Mean (SD)	Distance after Static Stretch (Yards) Mean (SD)	Shot Accuracy after Dynamic Stretch (Yards) Mean (SD)	Shot Accuracy after Static Stretch (Yards) Mean (SD)	Angle of Deviation after Dynamic Stretch (°) Mean (SD)	Angle of Deviation after Static Stretch (°) Mean (SD)	Percentage Clubface Contact after Dynamic Stretch (%)	Percentage Clubface Contact after Static Stretch (%)
A	+1	255.30 (16.08)	250.00 (17.62)	7.30 (2.83)	6.30 (3.47)	1.64 (0.64)	1.44 (0.82)	80	70
B	2	250.50 (16.47)	242.30 (17.18)	8.40 (2.67)	8.20 (5.05)	1.97 (1.28)	1.91 (0.57)	70	70
C	4	220.50 (13.02)	220.40 (11.35)	9.50 (4.25)	9.50 (3.37)	2.52 (1.26)	2.47 (0.89)	60	60
D	0	249.30 (8.72)	249.20 (10.68)	4.50 (2.01)	7.00 (4.24)	1.61 (0.98)	1.04 (0.48)	90	70
E	1	256.90 (7.33)	247.30 (11.70)	5.40 (2.59)	7.30 (3.06)	1.21 (0.58)	1.69 (0.70)	70	70
F	+2	253.40 (9.49)	249.70 (14.11)	4.90 (3.37)	5.20 (3.61)	1.22 (0.89)	1.11 (0.86)	80	70
G	4	238.90 (15.17)	234.20 (16.38)	5.70 (3.06)	7.90 (3.84)	1.40 (0.82)	1.98 (1.08)	80	70
H	3	253.60 (12.10)	248.90 (8.78)	5.70 (3.34)	8.20 (5.25)	1.92 (1.30)	1.31 (0.80)	70	80
I	0	227.90 (8.49)	224.70 (7.30)	4.40 (2.07)	4.60 (2.67)	1.10 (0.51)	1.17 (0.68)	90	80
J	3	247.00 (4.64)	243.70 (6.22)	5.90 (3.18)	5.70 (3.37)	1.35 (0.83)	1.38 (0.76)	90	70
K	2	253.80 (6.49)	248.00 (12.48)	6.90 (2.85)	8.10 (5.15)	1.87 (1.21)	1.56 (0.65)	100	60
L	1	229.00 (7.09)	229.10 (11.35)	5.10 (3.00)	5.80 (3.37)	1.28 (0.75)	1.46 (0.77)	60	70

Results

Within participants there was a significant difference between driving distance after performing the dynamic stretch and static stretch (P = 0.012). With regards to driving accuracy there was a significant difference between participants after the dynamic and static warm up (P = 0.049). Within participants the driving distance coefficient of variation after the dynamic and static stretch protocols were – range: 2.55% - 7.09% and range: 1.88% - 7.37% respectively. Also within each participant, there was a greater variability in the shot accuracy after the dynamic stretch protocol (Mean (SD): 55.77 (9.29) %) compared with the static stretch protocol (Mean (SD): 49.83 (12.18) %). The results showed no significant differences between the angle of deviation after the administration of both stretching protocols (P = 0.660).

In general, all the participants declared a high level of good clubface contact with the golf ball after stretching. The difference between the clubface contact with the golf ball after stretching was insignificant (P = 0.064). The data indicate that the participants have a 78.3% chance of generating solid contact with the clubface and ball after performing the dynamic stretch. The data also suggests that the same group of participants have a 70% chance of generating solid contact with the clubface and ball after performing the static stretch. All participants produced a low shot accuracy distance index (≤ 0.04) after both stretching protocols. The results showed a high level of symmetry with respect to the distance and shot accuracy performance indicators (Table 2, Table 3).

Discussion

The results of the present study demonstrate that DS could significantly increase driving distance and accuracy in comparison to SS. However, no significant difference was displayed in club contact with the ball between the dynamic and static stretching protocols. Although no control participants (i.e. performing task without the incorporation of either a DS or SS technique) were involved with the study, the above enhancements have the potential to improve total golf performance. The results of the present study support the findings of previous research comparing dynamic and static stretching. A considerable amount of studies report, dynamic stretching increases ROM in specific muscle groups and / or enhances sporting performance [16,20,21,27]. Fletcher and Jones (2004) report that a dynamic warm-up protocol significantly increased 20m sprint performance within trained rugby union players over static stretching [28]. Yamaguchi et al. (2007) also report an improvement in peak power output on a leg extension exercise after dynamic but not static stretching [16].

The results of the SS are in agreement with many previous studies. Research studies on SS often resulted in force production loss prior to competition, thereby having a negative effect on performance [28-30]. Young et al. (2001) reported that static stretching had an adverse effect on maximal strength exercise [31]. Wallmann et al. (2012) also reported that sprint performance showed greatest improvement without stretching. Joke et al. (2007) conflicts with these researchers, as they demonstrated static stretching in isolation improves jump height performance.

It has also been suggested that SS can have a further negative effect when the stretching duration is prolonged and when the speed of the muscle contraction performance task is relatively low [31,32]. In this study loading was limited to the body segments during the swing and the inertia of the club. Therefore this potentially could have caused the speed of the muscle contraction to be relatively high even though the static stretches were held for a short duration of 30 seconds with a 20 second rest period between stretches. Although the golf swing requires a significant amount of power output [5]. It is difficult to compare the findings in this study to previous research studies. The studies mentioned previously have generally looked at high intensity activities or maximum force production rather than light resistance load (golf club) and distinct performance constraints (accuracy and distance control) as previously mentioned [31].

No previous research has compared the effect of dynamic versus static stretching (as part of a general warm-up) on driving performance. Therefore this study is the first to report that a dynamic general warm-up will enhance driving performance over a static general warm-up. It is worth noting, however, that the study by Moran et al. (2009) looked at the effects of dynamic stretching versus static stretching and no stretching on golf performance using 5 iron [20]. The variables may have been similar; however the measurement procedures were different. Moran et al. (2009) calculated club head speed and ball speed [20]. A more scientific approach was adopted where the distance of each shot, clubface angle and swing path were calculated to measure accuracy. Both measurement approaches are relevant for calculating distance and accuracy; however, no study to date has recommended one approach over the other. According to the PGA tour and the United States Golf Association, the swing speed created with the driver is much greater than that of the 5 iron, 112mph and 94mph, respectively. Lindsay et al. (2002) also report that participants produced significantly different trunk motion characteristics with a driver than a 7 iron. The driver produced an average rotation of 88.2° to the right and 194.8° to the left whereas the average was significantly lower with the 7 iron (right rotation = 83.5°, left rotation = 180.3°). These researches also reported a 10% difference in the club angle at address between the driver and 7 iron.

The lack of significant difference in ball contact between dynamic and static stretching is not in agreement with previous literature [20]. These researchers reported that dynamic stretching produced significantly more central impact points than static stretching (P = 0.001). This value is vastly lower than the P value of the current study on ball contact (P = 0.064). These dissimilar results may be a result of contrasting methods on analyses. Moran et al. (2009) calculated ball contact with a video analysis system [20]. Williams and Sih also showed that three dimensional video analyses is a more accurate means of measurement when testing club orientation, a similar variable to ball contact [33]. While these researchers provide insightful research

Table 3: Summary of Driving Performance Indicators

Participants	Distance Index with respect to Dynamic and Static Stretch	Shot Accuracy Index with respect to Dynamic and Static Stretch	Shot Accuracy Distance Index after Dynamics Stretch	Shot Accuracy Distance Index after Static Stretch	Dominant Side with respect to Deviation from Fairway Midline after Dynamics Stretch Left / Right (%)	Dominant Side with respect to Deviation from Fairway Midline after Static Stretch Left / Right (%)
A	1.02	1.16	0.03	0.03	Left (80)	Left (80)
B	0.97	0.98	0.03	0.03	Right (80)	Right (70)
C	1.00	1.00	0.04	0.04	Left (70)	Left (80)
D	1.00	1.56	0.03	0.02	Right (80)	Right (70)
E	1.04	0.74	0.02	0.03	Left (90)	Left (70)
F	0.99	1.06	0.02	0.02	Right (60)	Right (70)
G	1.02	0.72	0.02	0.03	Right (80)	Left (70)
H	0.98	1.44	0.03	0.02	Right (60)	Left (80)
I	1.01	0.96	0.02	0.02	Right (80)	Right (60)
J	0.99	0.97	0.02	0.02	Right (70)	Right (80)
K	0.98	1.17	0.03	0.03	Right (80)	Left (50)
L	1.00	0.88	0.02	0.03	Right (80)	Right (70)

outcomes pertaining to using video analysis systems, a simple research design eliminating video analysis technology was incorporated in this study. Furthermore, during the study design, the authors were keen to investigate the efficacy of a video free environment by adopting a cost effective approach without the aid of video capture technology. In general, all the participants (which were all males) showed a high level of good clubface contact with the golf ball after stretching. Furthermore, our study provides a useful insight into the effect of dynamic and static stretches with respect to golf driving performance. The authors acknowledge the slight difference in target muscle groups between the dynamic and static stretching protocols. Indeed, there are plans for incorporating a control group for a future stretching study. It is worth noting the ethics committee will need a lot of convincing to approve a study without stretching. Hence, in the planned study the control group will only be required to perform a warm up jogging session before embarking on the task in question.

Although there were significant differences between both stretching protocols, the results of this study suggest competitive golfers with poor mechanics and lack of flexibility should perform a dynamic warm-up prior to practice or competition. Furthermore, they should also be encouraged to evaluate their levels of performance by using the driving performance indicators.

Practical application

We anticipate that the outcome of this research study will provide useful data to amateur and professional golfers that could help improve their performance following correct warm-up and stretching procedures.

Acknowledgments

The authors would like to thank the School of Science and Sport, and the Institute for Clinical Exercise and Health Science at the University of the West of Scotland for their continued support throughout the project. Recognitions also go to Hamilton golf club and their members for their participation in the study.

References

1. Cabri J, Sousa JP, Kots M, Barreiros J (2009) Golf-related injuries: A systematic review. European Journal of Sport Science 9: 353-366.
2. Doan BK, Newton RU, Kwon YH, Kraemer WJ (2006) Effects of physical conditioning on intercollegiate golfer performance. J Strength Cond Res 20: 62-72.
3. Sell TC, Tsai YS, Smoliga JM, Myers JB, Lephart SM (2007) Strength, flexibility, and balance characteristics of highly proficient golfers. J Strength Cond Res 21: 1166-1171.
4. Hume PA, Keogh J, Reid D (2005) The role of biomechanics in maximising distance and accuracy of golf shots. Sports Med 35: 429-449.
5. Thériault G, Lachance P (1998) Golf injuries. An overview. Sports Med 26: 43-57.
6. Tilley NR, Macfarlane A (2012) Effects of different warm-up programs on golf performance in elite male golfers. Int J Sports Phys Ther 7: 388-395.
7. Adlington GS (1996) Proper swing technique and biomechanics of golf. Clin Sports Med 15: 9-26.
8. Keogh JW, Hume PA (2012) Evidence for biomechanics and motor learning research improving golf performance. Sports Biomech 11: 288-309.
9. Gergley JC (2009) Acute effects of passive static stretching during warm-up on driver clubhead speed, distance, accuracy, and consistent ball contact in young male competitive golfers. J Strength Cond Res 23: 863-867.
10. Behm DG, Bambury A, Cahill F, Power K (2004) Effect of acute static stretching on force, balance, reaction time, and movement time. Med Sci Sports Exerc 36: 1397-1402.
11. Hume PA, Keogh J, Reid D (2005) The role of biomechanics in maximising distance and accuracy of golf shots. Sports Med 35: 429-449.
12. Fradkin AJ, Sherman CA, Finch CF (2004) Improving golf performance with a warm up conditioning programme. Br J Sports Med 38: 762-765.
13. Maddalozzo GJ (1987) An anatomical and biomechanical analysis of the full golf swing. National Strength and Conditioning Association Journal 9: 6-9.
14. Thacker SB, Gilchrist J, Stroup DF, Kimsey CD Jr (2004) The impact of stretching on sports injury risk: a systematic review of the literature. Med Sci Sports Exerc 36: 371-378.
15. Young WB, Behm DG (2002) Should static stretching be used during a warm-up for strength and power activities? Strength & Conditioning Journal 24: 33-37.
16. Yamaguchi T, Ishii K, Yamanaka M, Yasuda K (2007) Acute effects of dynamic stretching exercise on power output during concentric dynamic constant external resistance leg extension. J Strength Cond Res 21: 1238-1244.
17. Young WB, Behm DG (2003) Effects of running, static stretching and practice jumps on explosive force production and jumping performance. J Sports Med Phys Fitness 43: 21-27.
18. Behm DG, Chaouachi A (2011) A review of the acute effects of static and dynamic stretching on performance. Eur J Appl Physiol 111: 2633-2651.
19. Enoka RM (2008) Neuromechanics of human movement: Human Kinetics 10%.
20. Moran KA, McGrath T, Marshall BM, Wallace ES (2009) Dynamic stretching and golf swing performance. Int J Sports Med 30: 113-118.
21. Pagaduan JC, Pojskić H, Užičanin E, Babajić F (2012) Effect of various warm-up protocols on jump performance in college football players. J Hum Kinet 35: 127-132.
22. Alikhajeh Y, Rahimi NM, Fazeli H, Rahimi RM (2012) Differential stretching protocols during warm up on select performance measures for elite male soccer players. Procedia-Social and Behavioral Sciences 46: 1639-1643.
23. Hedrick A (2000) Dynamic flexibility training. Strength and Conditioning Journal 22: 33-38.
24. Jordan JB, Korgaokar AD, Farley RS, Caputo JL (2012) Acute effects of static and proprioceptive neuromuscular facilitation stretching on agility performance in elite youth soccer players. International Journal of Exercise Science 5: 2.
25. Fletcher IM, Monte-Colombo MM (2010) An investigation into the possible physiological mechanisms associated with changes in performance related to acute responses to different preactivity stretch modalities. Appl Physiol Nutr Metab 35: 27-34.
26. Manoel ME, Harris-Love MO, Danoff JV, Miller TA (2008) Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. J Strength Cond Res 22: 1528-1534.
27. Draovitch P, Simpson R (2007) Complete conditioning for golf: Human Kinetics.
28. Fletcher IM, Jones B (2004) The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. J Strength Cond Res 18: 885-888.
29. Behm DG, Button DC, Butt JC (2001) Factors affecting force loss with prolonged stretching. Can J Appl Physiol 26: 261-272.
30. McNeal JR, Sands WA (2006) Stretching for performance enhancement. Curr Sports Med Rep 5: 141-146.
31. Knudson D, Noffal G (2005) Time course of stretch-induced isometric strength deficits. Eur J Appl Physiol 94: 348-351.
32. Nelson AG, Kokkonen J (2007) Stretching anatomy: Human Kinetics 1.
33. Williams K, Sih B (2002) Changes in golf clubface orientation following impact with the ball. Sports Engineering 5: 65-80.