# Comparison on Selected Fitness Indicator and Golf Performances among Elite and Non-elite University Golfers

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## ABSTRACT

*The purpose of the study was to investigate the differences of physical fitness between elite and non-elite golfers in the National Golf Academy, UUM. The two groups were compared based on their physical fitness (leg power, muscular endurance, muscular strength, cardiovascular endurance, balance and abdominal muscle performances) and golf performances (handicap, 5-iron ball speed, 5-iron clubhead speed, 5-iron carry distance, average score, greens in regulations, and putts per round). Significant differences were found on handicap and predicted Vo2max variables ($p < 0.05$). Significant differences were also found on non-dominant leg vertical jump ($20.6 \pm 4.5$ vs. $14.7 \pm 5$, $p < 0.05$) and push up performances ($27.9 \pm 10.1$ vs. $16.4 \pm 11.2$, $p < 0.05$) between the elite and non-elite groups. Elite golfers have better performances in static balance (both dominant and non-dominant leg) and abdominal muscle performance where the significant level was found to be less than 0.05. While for golf performances, the difference between those two groups were found on the 5-iron clubhead speed, 5-iron ball speed, 5-iron carrying distance and average score ($p < 0.05$). These results can be used for developing training programmemes, as well as for the development of talent identification programmemes.*

**Keywords:** *golf, fitness, performance, comparison, elite, university*

## INTRODUCTION

Nowadays, most golfers have incorporated physical conditioning regimes to become the best players. This is why we can see that the new generations of golfers nowadays are leaner, muscular, and more flexible than the previous generations (Wells, Elmi & Thomas, 2009). Despite enhancing their performance, golfers also do physical preparation in helping them to prevent and also to recover from common injuries, such as low back pain and elbow injuries (Grimshaw, Giles, Tong & Grimmer, 2002). This will enable golfers to play at high level of performance with consistency without injury (McHardy, Pollard & Luo, 2006).

Golfers that integrate physical conditioning in their training (flexibility, strength and power) have significant increase in their club head speed and driving distance (Hume, Keogh & Reid, 2005). This was also supported by Fletcher and Hartwell (2004), Hetu, Christie and Faigenbaum (1998) and Lephart, Smoliga, Meyers, Sell and Tsai (2007) who found that plyometric training programmemes did have a significant impact on the club head speed and carrying distance. However, according to Wells *et al.* (2009) there are several studies that have been reported on the effects of training on golf performance of university level and recreational golfers, but none of the studies focused on elite golfers at university level. Furthermore, they added that most of the studies look at the effects of physical conditioning and not much on the relationships between the elements of conditioning and golf performance. Most of the studies investigated the combination of strength, power, flexibility and plyometric (Wells *et al.*, 2009).

According to Torres-Ronda, Sanchez-Medina and Gonzalez-Badillo (2011), past studies that investigated the relationship of fitness and golf performance have some issues on the differences in methodological approaches and the heterogeneous issues among participants. The authors also suggested that future research should focus on elite golfers. There are a number of studies which focused on elite golfers (Lindsay & Horton, 2002; Vine, Moore & Wilson, 2011, Evans & Refshauge, 2005) but most studies concentrated more on psychosocial factors (example: imagery, stress, self-confident, self-efficacy). However, limited studies have reported on the differences on the physical fitness between elite and non-elite golfers. To date, based on the literature review, there is only one study on comparing

the elite and non-elite golfers. Kim, Chung, Park and Shin (2009) compared the anxiety level of elite and non-elite Korean Junior Golfers but not on their physical fitness level. Dong, Sojung, Moon, and Young (2016) suggested that future studies need to focus not only on elite golfers, but also on amateur or non-elite golfers.

There are eight fitness components that were selected in the current study (power, muscular endurance, muscular strength, cardiovascular endurance, balance and abdominal muscle performances). The sport of golf is a game which requires mentally and physically complex skills as thousands of articles and journals have analysed the performance of this sport (Jacobson, Stemm, Redus, Goldstien & Kolb, 2005). Although golf can be considered as a leisure activity for both men and women (Kobriger, Smith, Hollman & Smith, 2006), it is a very demanding physical activity game which requires players to create an explosive power through a wide range of motion, despite the accuracy and the complexity of the golf swing (Wells *et al.* 2009). For example, a player could create up to 900 kg of force that is being applied to a golf ball in a millisecond during the impact (Cochran & Stobbs, 1999). Furthermore, the authors added that a golf club head speed could reach up to 160 km. hour-1 during a single golf swing, which takes only 0.2 seconds to reach this speed. Besides the strength and power needed in a golf swing, the cardiovascular demands are also very important. A normal healthy individuals requires approximately $8.2 \pm 0.2$ metabolic equivalents (METs) per 18 holes and approximately $46 \pm 2.6$ per cent of golfer functional lung capacity on a flat course and up to 50 per cent to 85 per cent of functional lung capacity on a hilly course (Dobrosielski, Brubaker, Berry, Ayabe & Miller, 2002). Due to this, the current study was carried out to investigate the differences between elite and non-elite golfers on their fitness and golf performances, as there is limited study on comparing these two groups.

# METHODOLOGY

## Subjects

A purposive sampling was used in the current study where the elite golfers were selected from the National Golf Academy located in Universiti Utara Malaysia, Sintok, Kedah. A total number of 17 golfers participated in the current study. The golfers were divided into two groups, elite and non-elite. The elite group is defined as golfers who have the handicap index below 5 (Bull & Bridge, 2012) while the non-elite group comprised golfers who have the handicap index of above 5. This is supported by Kim *et al.* (2009) where the authors examined the anxiety level of elite (Handicap: 2.67±0.82) and non-elite groups (Handicap: 7.83±1.17). In the current study, there were eight elite golfers (Handicap: 3.8±3; 20.4±2.3 years old) and nine non-elite golfers (Handicap: 7.8±2.5; 22.3±1.7 years old). The participants have declared that they are free from any diseases or injuries at the point of the testing. All participants had been involved in competitive golfing for at least five years before the beginning of the study and are actively involved in golf training and performance at the time of the study (Wells *et al.*, 2009). The participants were among the golfers in a university in Malaysia, and some of them are actively competing in local amateur tournaments during the year, besides representing Malaysia in the Asean University Games, World University Golf Championship and Universiade during current and past years.

## Procedures

Descriptive data of all subjects were collected (i.e. age, gender, date of birth, height, body mass index (BMI), history of competitive golf statistics, including their current handicap). The experimental golf data were collected: a) during a physical testing session at an outdoor stadium; b) during a separate testing session at an indoor golf facilities and c) data entered by the golfers to track their golf performance in an online database (www.shotzoom.com). Before testing, the golfers need to go through a brief warm-up led by a qualified trainer/coach that consists of light running and stretching for about ten minutes. The physical test was conducted in

a standard order to minimize fatigue, and players were given at least five minutes recovery period between each test. The physical test was conducted in the morning session and the golf performance test was conducted in the afternoon with at least two hours rest after the completion of the physical test (Wells *et al.*, 2009). Physical fitness/characteristics that were measured included: a) anthropometric; b) muscle performance; and c) cardiovascular performance. The golf performance data for 5-iron that was collected included; a) ball speed and b) carry distance. All procedures for physical testing were adapted and adopted from Wells *et al* (2009).

(a) Anthropometric Protocol

In anthropometric variables, standing height, weight, and Body Mass Index (BMI) were measured. All length measurements were measured to the nearest 0.2 m by using a roll-up measurement tape SECA 206, while the mass measurement was measured to the nearest 0.5 kg by using a digital weighing scale SECA 803. BMI was calculated by using the formula height (in metre) divided by weight (in $kg^2$).

(b) Muscle Performance Protocol

For muscular power, subjects were required to do a vertical jump test with both legs, followed by dominant and non-dominant leg. The test measurement were measured by recording the differences between reach and jump heights (cm). Three trials were executed on each subjects and result was taken as the average of the best two jumps. Digital handgrip dynamometer (Takei 5401) was used to measure muscular strength which was measured in kilograms for both the dominant and non-dominant hand. It was measured in a standing position while maintaining a straight arm. Upper body muscular endurance was tested by doing push-ups for one (1) minute duration. Maximum number of repetitions was recorded in 60 seconds.

(c) Cardiovascular Performance Protocol

Cardiovascular endurance test was assessed by using Leger multi-stage shuttle run test. This test requires the subjects to run at gradually increasing speed between lines that are separated by 20 meters. The test was described by Leger in 1988 and was validated by himself in 1989 (Leger & Gadoury,

1989; Leger, Mercier, Gadoury & Lambert, 1988). An equation developed by Stickland *et al.* (2003) was used to predict the maximal aerobic capacity (V02max) where, Y = 2.75X + 28.8 for men and Y = 2.85X + 25.1 for women, where X was equal to the last half-stage of the test that had been completed.

(d) Balance Protocol

The golfers were asked to stand on one foot and placed the other foot against the lower part of the support leg below the knee. They were required to place their hands on their hips and the test began when they raised their heel of the support foot from the floor and have to maintain the position as long as possible. The test ended when the gofers replaced their heel to the floor or removed their hands from their hips (Wells *et al*., 2009). The tests were performed for both the right and left leg and the results were recorded in seconds and the best time of two attempts were taken as the results.

(e) Abdominal Muscle Performances

The golfers began the test by lying in prone position and placed their hands and elbows on the ground. The test started when they raised their body off the ground using their hands and toes as the pivot points. They were required to maintain the body in a neutral and straight line. The maximum duration of time that they could maintain the position was taken as the final results. The results were measured in seconds. The test ended when a golfer: a) returned his/her body to the original position; b) moved the core in any way, and c) allowed the hip or head to touch the ground. The test was performed in three (3) different positions which are: front, dominant and non-dominant side.

(f) Golf Performance Assessment

A short stretching protocol and approximately 20 to 30 shots at a driving range next to the test facility were done. The test was performed using calibrated assessment equipment, Foresight Sports GameChanger2 (GC2) Camera System. The GC2 has a stereoscopic camera system that allows it to capture and analyse ball characteristics which enables it to record the ball speed, horizontal and vertical launch angles, balls spin, spin

axis of the ball and distance traveled. The test was performed by using a fairway iron (5-iron) because it represents the major types of clubs used in golf. Ten trials were given for the 5-iron. The golf performance statistics were recorded by subjects onto an online database (www.shotzoom.com). These measurements include mean score, green in regulations and number of putts taken per round.

### Data Analysis

Data analysis was performed by using Statistical Package for Social Science (SPSS) version 21. All variables descriptive statistics calculated were expressed as mean and standard deviation (mean±SD). Differences between the elite and non-elite golfers were performed by using the independent t-test. All statistical significance was set at $p \leq 0.05$.

## RESULTS AND DISCUSSION

To the best of our knowledge, this is the first study to compare the physical fitness components between elite and non-elite golfers. Based on Table 1, we can see that there were only two variables that have significant differences between the elite and non-elite golfers. The average handicap for elite golfers was 3.8 ± 3 compared to non-elite golfers 7.8 ± 2.5. While for the Predicted Vo2max, the value for elite and non-elite golfers were 49.3 ± 2.9 vs. 42.5 ± 7.3, respectively. All the significant differences were found to be less than 0.05. By looking at Table 1, the average handicap and predicted VO2max were the only significant variables found in the anthropometric data between elite and non-elite golfers. The results showed that the average handicap for elite golfers were 3.8 ± 3 compared to non-elite golfers 7.8 ± 2.5. This was due to the different level of skills practiced by those two groups. One study that compared elite and non-elite golfers (Kim *et al.*, 2009) found a significant difference on the handicap possessed by the two groups (Handicap: 2.67±0.82; vs. 7.83±1.17). For the predicted VO2max, elite golfers were found to be significantly different from the non-elite golfers. This was supported by Lorenz, Reiman, Lehecka and Naylor (2013) who concluded that elite athletes in anaerobic sports are more powerful and

explosive than their counterparts. In addition, golf is a sport that requires more anaerobic performance rather than aerobic performance. The results indicated that the elite golfers are fitter than the non-elite golfers. This is very interesting because as other studies had found that golf incorporated more anaerobic power compared to aerobic capacity. However, a study by Burgomaster, Hughes, Heigenhauser, Bradwell and GIbala (2005) found that anaerobic training can have significant improvement in aerobic capacity. It was also supported by Elliott, Wagner and Chiu (2007), who suggested that golfers should do aerobic training while at the same time maintaining the power and strength training. Besides, having better results in aerobic (VO2max) performance can increase the chances of lowering the average total number of scores per round (Wells *et al.*, 2009). The findings by Wells *et al.* (2009) is in line with the current study findings, where the elite golfers have better VO2 max performance (49.3 ± 2.9 vs. 42.5 ± 7.3) compared to non-elite golfers and they also have better average score per round 76.4 ± 2.4 shots for elite golfers compared to non-elite golfers, 80.7 ± 3.6.

**Table 1: Descriptive statistics of anthropometric data for elite (*n*=8) and non-elite (*n*=9)**

| Variable | Combined (mean±SD) | Elite (mean±SD) | Non-Elite (mean±SD) | Elite Vs. Non-Elite |
|---|---|---|---|---|
| Age (years) | 21.4 ± 2.2 | 20.4 ± 2.3 | 22.3 ± 1.7 | 0.062 |
| Handicap | 5.8 ± 3.4 | 3.8 ± 3 | 7.8 ± 2.5 | 0.010* |
| Weight (kg) | 83.3 ± 24.4 | 74.3 ± 12.8 | 91.3 ± 29.9 | 0.160 |
| Height (m) | 1.74 ± .04 | 1.74 ± .02 | 1.75 ± .05 | 0.680 |
| Body Mass Index (BMI) | 27.3 ± 7.4 | 24.6 ± 4.5 | 29.7 ± 8.8 | 0.157 |
| Predicted Vo2max (ml. kg/min) | 45.7 ± 6.6 | 49.3 ± 2.9 | 42.5 ± 7.3 | 0.026* |

*significance level at $p < 0.05$

Non-dominant leg vertical jump performance was found to have significant differences between elite and non-elite golfers (20.6 ± 4.5 vs. 14.7 ± 5, $p < 0.05$). The other variable that was found to be significant was push-up (27.9 ± 10.1 vs. 16.4 ± 11.2, $p < 0.05$). It shows that for non-dominant vertical jumps there is a significant difference between elite and non-elite golfers (20.6 ± 4.5 vs. 14.7 ± 5, respectively). With regards to the non-dominant leg, the reason for the significant differences between those

two groups is because the elite groups have much more leg strength (power) which results in the faster swing speed (Table 4) and better performances in balance (Table 3). It can be said that the elite groups have a better control of both legs (dominant and non-dominant) during the entire golf swing. Explosive power comes from the development of speed strength and pure strength. Power represents the amount of work a muscle or muscle group can produce per unit of time (Adams, O'shea, O'Shea and Climstein, 1992). To the best of our knowledge, studies done on comparing physical fitness between elite and non-elite golfers are very limited. Due to that, the current study has referred to previous studies on different sports. Some of the previous studies were on similar physical fitness requirement as golf (power, strength, muscular endurance, cardiovascular endurance and etc.) In a study by Conlee, McGrown, Fisher, Dalsky and Robinson (1982) they suggested that sports such as volleyball, basketball and golf rely more on the anaerobic energy system to supply the energy demands during the match. It can also be said that elite golfers utilised both the dominant and non-dominant leg during the golf swing which create a balance swing and weight transfer throughout the entire golf swing. In relation to the upper body endurance, push-up ($27.9 \pm 10.1$ vs. $16.4 \pm 11.2$) had a significant difference between elite and non-elite golfers. This was supported by Marinho, Andreato, Follmer and Franchini (2016) who found significant differences in one-minute push up performance between elite and non-elite Brazilian jiu-jitsu athletes. Another study by McIntyre (2005) also found significant differences in upper body endurance performances between an elite group of Gaelic footballers, hurdlers and soccer players. The author stated that the greater upper and abdominal endurance of soccer players in comparison to Gaelic footballers and hurdlers indicates the importance of strength endurance in soccer as players are required to repeatedly resist physical challenges during competition which are also similar to golf. Thus, we suggest that the differences found between elite and non-elite golfers on muscular endurance performance indicated that it is very important to golfers as it requires them to swing repeatedly during the entire five to six hours round of golf.

**Table 2: Summary for vertical jump, handgrip strength and push-up data for elite (*n*=8) and non-elite (*n*=9)**

| Variable | Combined (mean±SD) | Elite (mean±SD) | Non-Elite (mean±SD) | Elite Vs. Non-Elite |
|---|---|---|---|---|
| Vertical jump (cm) | 35.6 ± 7.2 | 37.4 ± 7.6 | 33.9 ± 6.9 | 0.347 |
| Dominant leg vertical jump (cm) | 18.6 ± 5.6 | 20.5 ± 5.7 | 17 ± 5.3 | 0.219 |
| Non-dominant leg vertical jump (cm) | 17.5 ±5.6 | 20.6 ± 4.5 | 14.7 ± 5 | 0.023* |
| Push-up | 21.8 ± 11.9 | 27.9 ± 10.1 | 16.4 ± 11.2 | 0.044* |
| Dominant handgrip (N) | 43.5 ± 5.1 | 44.3 ± 5.5 | 42.7 ± 4.9 | 0.548 |
| Non-dominant handgrip (N) | 41.9 ± 6.2 | 43.7 ± 3.5 | 40.4 ± 7.8 | 0.292 |
| *significance level at | $p < 0.05$ | | | |

Results from Table 3 show that static balance dominant side (63.5 ± 22.5 vs. 30.9 ± 10.3), static balance non-dominant side (64.8 ± 22.9 vs. 23.7 ± 7.9), and the performance of abdominal muscle endurance-front side (42.6 ± 15.1 vs. 31.9 ± 10.7) were found to be significantly different between the elite golfers and non-elite golfers ($p< 0.05$). Table 3 showed that elite golfers have significantly better performance in balance (both dominant and non-dominant side). The greater performance in both legs of elite golfers can be related to the performance of their leg strength (power). The golf swing requires constant weight shifting from the right foot to the left foot (backswing to downswing). Golf swing can be said to have a similar weight transfer movement just like *tai-chi*, but golf requires a faster movement. Tsang & Hui-Chan, (2005) stated that the execution of various arm and leg movements in a coordinated manner during single-leg stance demands a high degree of balance control. This was supported by Koslow (1994), who stated that only 27 per cent of beginner golfers could make the weight shift from the right foot to the left foot (right handed golfers) at impact, which indicated that the beginners have poor balance control. Besides, novice golfers have about half the lateral movement of elite golfers during the downswing (Sanders & Owens, 1992). Spence,

Caldwell, and Hudson (n.d.) added that a greater range of motion (ROM) can lead to a better weight transfer from beginner to intermediate golfers. Golfing requires coordinated trunk and arm movements and controlled weight shifting from two legs to predominantly one leg during precise golf swings, as well as prolonged walking comprising single- and double-leg support over uneven ground (Selicki & Segall, 1996). The results showed that the abdominal muscle performance (front side) for elite golfers is much better than the non-elite golfers. The core muscles have been known to control the movement of the body during the swing, to impact and adjust the cooperation of physical stabilisation (Omkar and Vishwas, 2007). Muscles around the lumbar region play a role in neuromuscular control to maintain stabilisation of physical function (Akuthota and Nadler, 2004). In golf, the mobilisation of core muscles is apparent when examining the results of electromyographic analysis performed during each segment of the swing (McHardy and Pollard, 2005). The current study suggest that, a better abdominal muscle performance would influence the enhancement of overall swing performance.

**Table 3: Summary for balance and abdominal muscle performance, data for elite (*n*=8) and non-elite (*n*=9)**

| Variable | Combined (mean±SD) | Elite (mean±SD) | Non-Elite (mean±SD) | Elite Vs. Non-Elite |
|---|---|---|---|---|
| Static balance dominant (s) | 116.5 ± 65.6 | 63.5 ± 22.5 | 30.9 ± 10.3 | 0.002* |
| Static balance non-dominant (s) | 110.7 ± 73.3 | 64.8 ± 22.9 | 23.7 ± 7.9 | 0.000** |
| Abdominal muscle-Front (s) | 100.6 ± 47.5 | 42.6 ± 15.1 | 31.9 ± 10.7 | 0.005* |
| Abdominal muscle-Dominant (s) | 52.6 ± 24.9 | 12.7 ± 4.5 | 29.9 ± 9.9 | 0.107 |
| Abdominal muscle-Non-dominant (s) | 56.4 ± 29.2 | 24.4 ± 8.6 | 29.1 ± 9.7 | 0.072 |
| *significance level at | $p < 0.05$ | | | |
| **significance level at | $p < 0.00$ | | | |

Table 4 shows the summary of golf performances for both the elite and non-elite golfers. Most of the variables in the table have p value of less than 0.05, which indicated that there were significant differences between elite and non-elite golfers. The variables included were 5-iron ball speed (195.5

± 6.5 km/h vs. 185.2 ± 10.3 km/h), 5-iron clubhead speed (133.9 ± 4.2 km/h vs. 127.1 ± 7.4 km/h), 5-iron carry distance (170.8 ± 7.6 m vs. 154.9 ± 13.2 m) and average score (76.4 ± 2.4 vs. 80.7 ± 3.6). Greens in regulations and putts per round both have p value of more than 0.05 which indicated that the variables have no significant differences. Significant differences were found on the 5-iron clubhead speed, ball speed, carry distance and average score between elite and non-elite golfers, where elite golfers out-performed non-elite golfers on those variables (Table 4). The reason for the differences between elite and non-elite golfers can be due to the type of training that has been done by both groups. According to Hellstrom (2009), the elite group have higher ground reaction forces (power) thus resulting in increased body segment angular velocities, which is in line with the current study. The results can also be related to the vertical jump performances of both groups. It can be said that the leg power have influence on golf performance, especially in increasing speed and carry distance. This was also supported by Bull and Bridge (2012), who found that golfers who participated in an 8 week plyometric exercise programme have improved the lead arm and hand speeds during the golf swing.

By increasing the speed and carry distance, the ball will travel much farther, which makes it closer to the hole, thus making it much easier for golfers to make less strokes. It can be suggested that leg power is critical in developing power during the golf swing. This was supported by Wells *et al.* (2009) and Doan, Newton, Kwon and Kraemer (2006) who stated that the muscles in the legs, arms and upper torso are positively correlated with the swing speed. This can be seen in the current study where the elite group has better leg power and scoring ability compared to the non-elite group. The results of the current study show the importance of power training and strength training for the improvement of driving distance. Previous study by Dong, Sojung, Moon, and Young (2016) showed that those who participated in non-dominant arm strength exercise would be more effective in improving driving distance in golfers. In relation to the lower average score of the elite groups compared to non-elite groups, the carrying distance plays an important role. By increasing the carrying distance of golf shots, golfers would have a shorter distance to the hole, thus increasing the chances to shoot a better score on every hole.

**Table 4: Summary for golf performances data for elite (*n*=8) and non-elite (*n*=9)**

| Variable | Combined (mean±SD) | Elite (mean±SD) | Non-Elite (mean±SD) | Elite vs. Non-Elite |
|---|---|---|---|---|
| 5-iron ball speed (km/h) | 190.1 ± 9.9 | 195.5 ± 6.5 | 185.2 ± 10.3 | 0.030* |
| 5-iron clubhead speed (km/h) | 130.4 ± 6.9 | 133.9 ± 4.2 | 127.1 ± 7.4 | 0.039* |
| 5-iron carry distance (m) | 162.4 ± 13.4 | 170.8 ± 7.6 | 154.9 ± 13.2 | 0.009* |
| Average score | 78.7 ± 3.8 | 76.4 ± 2.4 | 80.7 ± 3.6 | 0.012* |
| Greens in regulations (GIR) | 9.8 ± 2.3 | 10 ± 2.5 | 9.5 ± 2.3 | 0.713 |
| Putts per round | 30.8 ± 2.1 | 30.9 ± 2.1 | 30.8 ± 2.1 | 0.912 |
| *significance level at | $p < 0.05$ | | | |

## CONCLUSION

The current study presents a report on the differences in physical fitness performance between elite golfers and non-elite golfers and how these physical fitness variables affect their golf performance. Significant differences in some of the physical fitness and golf performance found in the current study can be used as a foundation to develop golf-specific training programmes besides using it in talent identification programmes. The current study also suggested that golfers should include power training, strength training and cardiovascular endurance training in their golf conditioning programmes in order to help them improve their golf performances. However, due to the small sample population and limited literature in the current study, future research is recommended, focusing on the differences between elite and non-elite golfers.

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