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ORIGINAL RESEARCH

Strength and Balance in Recreational Golfers and Non-Golfers Aged 65–79 Years in Community Settings

David A. Wilson,[1,2,3] **Simon Brown,**[1,2] **Paul E. Muckelt,**[1,2] **Martin B. Warner,**[1,2]
Sandra Agyapong-Badu,[1,4] **Danny Glover,**[5,6] **Andrew D. Murray,**[6,7] **Roger A. Hawkes,**[8,9]
and Maria Stokes[1,2,10]

[1]School of Health Sciences, University of Southampton, Southampton, United Kingdom; [2]Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, University of Southampton, Southampton, United Kingdom; [3]Faculty of Health and Wellbeing, University of Winchester, Winchester, United Kingdom; [4]School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Birmingham, United Kingdom; [5]Health Education Yorkshire and the Humber, Leeds, United Kingdom; [6]Physical Activity for Health Research Centre, University of Edinburgh, Edinburgh, United Kingdom; [7]Center for Sports and Exercise, University of Edinburgh, Edinburgh, United Kingdom; [8]Medical and Scientific Department, R&A, St Andrews, United Kingdom; [9]World Golf Foundation, St Augustine, FL, USA; [10]Southampton NIHR Biomedical Research Centre, Southampton, United Kingdom

Inactive older adults tend to have decreased strength and balance compared with their more active peers. Playing golf has the potential to improve strength and balance in older adults. The aim of the study was to compare the strength and balance of recreational golfers with non-golfers, aged 65–79 years. Grip strength, single leg balance, and *Y* Balance Test (YBT) were assessed. Golfers ($n = 57$) had significantly (right, $p = .042$; left, $p = .047$) higher maximal grip strength, than non-golfers ($n = 17$). Single leg stance times were significantly longer in golfers (right, $p = .021$; left, $p = .001$). Normalized YBT reach distances were significantly greater for golfers than non-golfers for composite, posteromedial, and posterolateral directions on both right and left legs. Playing golf appears to be associated with better grip and both static and dynamic balance in 65–79 year olds, indicating that a study of the effects of playing golf is warranted through a larger, fully powered, longitudinal study.

Keywords*:* aging, *Y* Balance Test, handgrip

Regular physical activity can decrease premature mortality by 30%, playing a key role in the prevention of noncommunicable diseases (Lee et al., 2012), and helping prevent and treat over 20 chronic diseases (Chief Medical Officers, 2011). Adults aged over 65 are the least active and have the highest risk of death or serious injury arising from a fall (World Health Organization, 2018). The World Health Organization (WHO) recommends that those over 65 years undertake periods of moderate- or vigorous-intensity activity per week, as well as activities to enhance strength and balance (World Health Organization, 2020). Evidence of the beneficial effects of various activities needs to be established. For example, playing golf is a popular activity among older people and is played by 60 million persons worldwide (The R&A, 2018). A scoping review of golf and health (Murray et al., 2017) reported evidence of the physical (cardiovascular and respiratory) and psychosocial (mental health and well-being) benefits, and greater life expectancy (Farahmand et al., 2009), associated with playing golf but found limited evidence in relation to strength and balance. Although there is some evidence that playing golf fulfills WHO recommendations for moderate-intensity aerobic activity (Luscombe et al., 2017), there is little evidence for benefiting strength and balance (Murray et al., 2017). The present study addressed this knowledge gap by examining the association between strength and balance and playing a minimum of 18 holes of recreational golf per week in older people.

The importance of maintaining strength and balance in older adults was highlighted by Rubenstein (2006) where deficits in balance, gait instability, and muscle weakness represented the most important intrinsic risk factors for falls. Strength and balance, including dynamic balance, have been reported to decrease with age (Curcio et al., 2019; Howe et al., 2011; Stel et al., 2003; Sugiura et al., 2013; Takeshima et al., 2014) and increase the risk of falling for many older adults (World Health Organization, 2018). Possible causes of reduced strength and balance with aging are complex; however, reduction in physical activity is thought to be an important factor (Campbell et al., 1989; Cwikel & Fried, 1992). Also, evidence from a meta-analysis suggests that disuse may be responsible for muscle atrophy and weakness, more than aging (Peterson et al., 2010). Due to the combination of walking and controlled, rapid force movements while maintaining a steady base of support while performing shots (Sheehan et al., 2019), golf has the potential to improve strength and balance (Tsang & Hui-Chan, 2010). However, the effect on strength and balance of playing golf for older adults remains unknown.

Grip strength is well-established as a reliable measure of overall body strength and is commonly used in the assessment of health in older adults (Bobos et al., 2020; Mehmet et al., 2020). Additionally, the European Working Group on Sarcopenia in Older People recommended the use of handgrip strength as the most practical measure of generalized muscle strength (Cruz-Jentoft et al., 2010). A decline in handgrip strength has been associated with an increased risk of morbidity, disability, and mortality (Rantanen et al., 2000). In relation to handgrip strength in older golfers, female golfers (aged 65–79 years), Buckley et al. (2017) reported a moderate correlation ($r = .44$) with quadriceps peak

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Brown https://orcid.org/0000-0001-9646-3285
Muckelt https://orcid.org/0000-0001-5995-881X
Warner https://orcid.org/0000-0002-1483-0561
Agyapong-Badu https://orcid.org/0000-0002-5105-8443
Hawkes https://orcid.org/0000-0002-7828-7975
Stokes https://orcid.org/0000-0002-4204-0890
Wilson (David.wilson@winchester.ac.uk) is corresponding author, https://orcid.org/0000-0002-3647-799X

torque. However, there was no comparison of grip strength to non-golfers (Buckley et al., 2017). A study of female golfers aged over 80 years reported greater grip strength normalized to body weight (0.33 ± 0.06 kgF/kg) than non-golfers (0.29 ± 0.06 kgF/kg). However, the difference was not statistically significant ($p = .051$; Stockdale et al., 2017). Further research is warranted to compare grip strength in older golfers and non-golfers in both sexes.

Previous research on balance in older golfers has typically been limited to assessing static balance, for example, the single-leg stance test. For example, Tsang & Hui-Chan (2010) reported that older male golfers demonstrated significantly longer single-leg stance times compared with non-golfers (28.1 ± 3.6 s vs. 17.1 ± 11.9 s; $p = .020$; Tsang & Hui-Chan, 2010). Older males and females significantly increased, $F(2,17) = 5.32$, $p = .03$, their single-leg stance time following 2 weeks of playing 10 holes of golf on an Xbox Kinect each day compared with a control group (Chow & Mann, 2015). In relation to dynamic balance, Gao et al. (2011) reported older male golfers had significantly longer functional reach distance normalized to their height (28.1 ± 3.6% vs. 17.1 ± 11.9%; $p = .012$) than non-golfers (Gao et al., 2011). The research above suggests playing golf may be associated with better balance in older participants. However, there is a need for research on balance in older female golfers and more comprehensive assessment of dynamic balance.

A dynamic balance test that is sensitive to change and more challenging in active older adults than the single-leg stance or functional reach tests is the *Y* Balance Test (YBT), which evolved from the Star Excursion Balance Test (SEBT) (Plisky et al., 2009). The SEBT was developed to standardize the performance of balance testing and improve measurement repeatability (Plisky et al., 2009). The YBT is a shorter version of the Star Excursion Balance Test and has been reported to be valid and reliable in older participants (Sipe et al., 2019). The YBT has also been shown to be sensitive to detect change following training in older men (65 ± 14 years; Hosseini, 2011). The YBT has been used to quantify decline in balance with aging, with Lee et al. (2015) reporting significantly longer normalized composite reach distances for middle aged versus older females (105.2% [5.5%] vs. 85.0% [6.9%]; $p_{\text{adj}} < .007$). Similarly, Freund et al. (2019) reported healthy women in 70–79 years group had significantly ($p < .001$) lower composite reach scores than those in the 50–59 years group. The sensitivity to change for the YBT was demonstrated by significant improvement in scores from older males and females following an 8-week step training intervention (Morat et al., 2019).

The research outlined above suggests older adults have decreased strength and balance, which is associated with lower physical activity, and greater risk of falls (World Health Organization, 2018). Regarding strength, there is some evidence that playing golf is associated with greater handgrip strength, a widely used measure of overall strength, in females aged over 80 years (Stockdale et al., 2017). However, further research is warranted on the effect playing golf may have on handgrip strength in older adults aged 65–80 years, in both sexes. In relation to balance, single-leg balance appears to be better in older male golfers than non-golfers (Tsang & Hui-Chan, 2010), but dynamic balance requires investigation in both sexes.

Aim

To compare the grip strength and static and dynamic balance of recreational golfers who play a minimum of 18 holes per week with inactive non-golfers aged 65–79 years in community settings.

Methods

The study design was a cross-sectional, two-group comparison of golfers and non-golfers to examine the association between playing golf and specific aspects of physical function, that is, strength and static and dynamic balance, to provide statistical data to inform a power calculation for a larger intervention study.

Participants

Sixty-two recreational golfers (31 females) and 17 non-golfers (nine females) aged 65–79 years were recruited from the local community in Hampshire, United Kingdom. Samples of convenience were used. Based on the findings of Gao et al. (2011) who reported older golfers had significantly better balance than healthy controls, a high effect size (1.25) was calculated. Therefore, it was assumed there would be a moderate to high effect size for the difference in balance between golfers and non-golfers. Based on Cohen's (1998) rule of thumb, it was deemed that a participant group size of 30 would be sufficient. Local golf clubs were contacted, and permission was obtained to display recruitment posters at the club with researcher contact details. Patient and Participant Involvement (PPI) representatives were recruited at some clubs to assist with communication about the study and recruitment. Contact was also made with the Senior Captains of the golf clubs, where possible, to seek assistance with recruitment. Non-golfers were recruited through the local community using posters, presentations, adverts in newspapers, and on local radio. Written informed consent was gained from every participant prior to data collection. Ethics approval was obtained from the Faculty of Environmental and Life Sciences' Ethics Committee, University of Southampton (Ethics number: 31619).

Golfers who played a minimum of 18 holes per week and walked around the course, rather than using a golf cart, were included. Participants could take part in other activities as excluding them would not have been representative of this group, but their main activity had to be golf. Age-matched non-golfers were permitted to do no more than 1 hr of physical activity per week.

Measures

Physical activity of all participants was assessed using the General Practice Physical Activity Questionnaire (GPPAQ) (Department of Health 2009). The GPPAQ is a short self-report questionnaire on physical activity and occupation and is scored according to four categories: active, moderately active, moderately inactive, or inactive. The GPPAQ was used as it is rapid and easy to use (designed to take less than 1 min to complete), with participants scoring questions on occupation, cycling, sport, and walking (Department of Health, 2009). The GPPAQ has been reported to be the most frequently used tool to assess physical activity in primary care with high reliability (Ahmad et al., 2015; Smith et al., 2017). However, due to the low reliability, walking data are not used to calculate physical activity (Department of Health, 2009).

All participants were screened using the following exclusion criteria: musculoskeletal injury or surgery in the last 5 years which led to immobility for more than 1 week; uncontrolled diabetes or blood pressure; known neurological disorder; arthritis which restricted everyday activities; undergoing treatment for cancer; taking medication which affects muscle function; and total hip replacement surgery (due to the potential risk of dislocation with the movements required for testing dynamic balance).

Body mass and height were measured using weighing scales (Salter portable scales) and a tape measure, and body mass index

(BMI; kg/m^2) was calculated. The data collection procedure were standardized and conducted in the following order: grip strength, single-leg balance, and YBT. All equipment was portable and suitable for use in community settings.

Grip strength was measured using a MIE digital grip analyzer (MIE, Medical Research). The device is accurate (Innes, 1999) and lighter than devices such as the Jamar, therefore is suitable to use with participants who may have limited grip strength. The participant was tested in a standardized position, seated in a straight-backed chair, with feet flat on the floor, shoulder in neutral, forearm rested on arm of chair with elbow flexed at 90°, and the forearm and wrist in neutral (Roberts et al., 2011). Up to three practice trials of 50% force were used to familiarize the participant with the equipment. A minimum of three successive grip strength measurements were performed or until the participant's maximum force was reached and the maximal value was used in the analysis. Participants were verbally encouraged to squeeze as hard as possible. Bilateral measurements were made with the right side measured first.

A protocol similar to Springer et al. (2007) was used for the measurement of static balance. Participants stood barefoot and were instructed to have their arms folded across their chest and place the non–weight-bearing foot close to, but not touching, the ankle of their stance limb. The investigator used a stopwatch to measure the time the participant was able to stand on one leg. Time commenced when the participant raised the non–weight-bearing foot off the floor. Time ended when either the maximum of 60 s was reached, or the participant did one of the following actions to maintain their balance: (a) uncrossed their arms, (b) used the raised foot (moved it toward or away from the standing limb or touched the floor), and (c) moved the weight-bearing foot (e.g., rotated foot on the ground). The duration of 60 s was chosen as this had been used for over 60-year-olds (McLay et al., 2020). Springer et al. (2007) reported normative mean (*SD*) best of three trials nominal values for 32.1 (16.2) s and 21.5 (17.3) s for groups of 60–69 and 70–79 years, respectively; therefore, 60 s was chosen to reduce the chance of a ceiling effect in the lower age group. The procedure was repeated twice on both the right and left legs, with the longest time used for each leg for data analysis.

A YBT kit was used to carry out the testing (Move2 perform; Evansville, IN, USA). The participant stood on the central plastic footplate. Following pilot testing and feedback from participants, two blocks of rubber matting (https://www.diy.com/departments/safety-mat/2006341_BQ.prd) were placed on either side of the footplate to increase the surface area for standing on prior to starting and on completing the test (Figure 1).

All data collection and practicing were performed with bare feet to eliminate any additional stability from shoes aiding balance (Lee et al., 2015). The participants maintained a single-leg stance with hands on the pelvis while pushing a rectangular reach-indicator block with the contralateral leg as far as possible along one of three directions (anterior, posteromedial, and posterolateral; Figure 1). The reach distance was recorded to the nearest centimeter from the central footplate to the near side of the reach-indicator block. The standardized order was: right anterior (Figure 1a), left anterior, right posteromedial (Figure 1b), left posteromedial, right posterolateral, and left posterolateral similar to the protocol used by several authors (Lee et al., 2015; Plisky et al., 2009; Sipe et al., 2019). A trial was classified as invalid if the participant did any of the following: did not return to the starting position; kicked the plate with the reaching foot to gain more distance; failed to maintain a unilateral stance on the platform; was deemed to have used the reach indicator for support (transferred weight); or removed their hands from their hips. If an invalid trial occurred, the data were discarded, and the participant repeated the trial.

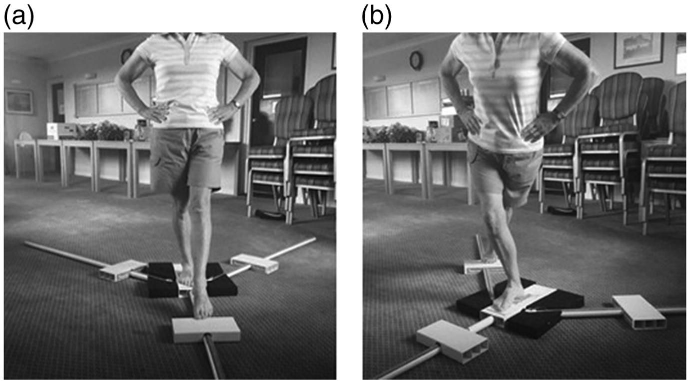

Figure 1 — Participant performing (a) right anterior reach test (standing on right leg, moving left); and (b) right posteromedial reach on the *Y* balance system (note the blocks of black rubber matting either side of the central foot plate, to increase surface area for standing before and after the test).

Each participant was allowed a maximum of three practice trials in each direction and on each leg prior to formal testing, for familiarization. They then performed three recorded trials in each direction, starting with the left foot reaching, while standing on the right. Further trials were permitted if the distance reached was further than the previous trial. The maximum reach distance trial was used for data analysis like that used by Sipe et al. (2019). The participant rested for a minimum of 30 s between right and left trials and directions of reach.

To normalize the reach distance, the participants' right and left lower limb length was measured in centimeters in supine (anterosuperior iliac spine to the center of the ipsilateral medial malleolus; Lee et al., 2015). For data analysis, the mean of the right and left lower limb length was used. A normalized composite maximized distance (%MAXD) on the right and left sides, for all three reach directions, was calculated by the formula (three excursion distance/lower limb length × 3) × 100 = (%MAXD). For comparison for all three reach directions, the mean of the right and left maximum reach distance in each direction was normalized to the lower limb length.

Data Analysis

Due to the difference in number of participants between the groups of golfers and non-golfers, a nonparametric statistical analysis was used. Median and interquartile ranges were used for descriptive statistics. The Mann–Whitney *U* test was used to compare the two groups. Data were analyzed using SPSS (version 26). Effect size was calculated using the formula $r^2 = \frac{Z^2}{n}$, where $Z = Z$ score, $n =$ total number of observations on which the Z score is based (Tomczak & Tomczak, 2014). According to Cohen (1992) r^2, .2 should be considered a "small" effect size, .5 represents a "medium" effect size, and .8 a "large" effect size.

Results

All measurements were reported by the participants to be tolerated well. There were no significant differences in any of the participant demographics (sex, age, or body characteristics) between groups of golfers and non-golfers (Table 1). Golfers reported that they took part

Table 1 Participant Characteristics of the Two Study Groups

	Golfers ($n = 62$)	Non-golfers ($n = 17$)
Male	31	8
Female	31	9
Age (years)	71.0 (5.0)	71.0 (8.0)
Weight (kg)	74.0 (25.0)	73.8 (21.4)
Height (m)	165.0 (16.0)	167.0 (15.0)
BMI (kg/m^2)	26.4 (6.3)	26.4 (4.2)

Note. No significant differences ($p > .05$) for all participant characteristics between golfers and non-golfers. The values are presented as median (IQR). BMI = body mass index; IQR = interquartile range.

Table 2 GPPAQ Scores for All Participants Presented for Each Subgroup

	Inactive	Active
Golfers ($n = 62$)	31% (50%)	31% (50%)
Non-golfers ($n = 17$)	11% (65%)	6% (35%)

Note. GPPAQ = General Practice Physical Activity Questionnaire.

Table 3 Grip Strength Normalized to Body Weight in Golfers and Non-golfers Aged 65–79 Years

	Golfers ($n = 57$[a])	Non-golfers ($n = 17$)	p
Normalized grip strength (N/kg)			
Right	4.33 (1.19)	3.32 (1.93)	.042*
Left	4.05 (1.33)	3.04 (1.88)	.047*

Note. IQR = interquartile range.

[a] Due to a fault with the handgrip dynamometer, data from five of the 62 golfers were not recorded.

*Significant difference ($p < .05$) between golfers and non-golfers.

Table 4 Single-Leg Stance Times in Golfers Compared With Non-golfers

	Golfers ($n = 62$)	Non-golfers ($n = 17$)	p
Right	32.0 (42.3)	11.0 (33.5)	.021*
Left	37.0 (38.3)	21.0 (24.5)	.001*

Note. The values are presented as median (IQR). IQR = interquartile range. *Significant difference ($p < .05$) between golfers and non-golfers.

in other activities, which included walking, cycling, tennis, and exercise classes.

The data suggest there were no substantial (proportionate) differences between the physical activity levels for the golfers and non-golfers calculated using the GPPAQ, when categorized as inactive or active (Table 2). The numbers were too small (particularly for non-golfers) to classify according to all four physical activity levels (i.e., including moderately active and moderately inactive). However, such further classification of golfers did not alter the relative proportions of inactive ($n = 21$; 34%) and active ($n = 24$; 39%), with the moderately inactive ($n = 10$; 16%) and moderately active ($n = 7$; 11%) also having similar proportions.

Golfers had significantly higher maximal grip strength normalized to body weight on both the right ($z = -2.04$, $p = .042$, $r^2 = .06$) and left ($z = -1.97$, $p = .047$, $r^2 = .05$) sides (Table 3). The r^2 scores were below .2, indicating a small effect size.

Maximum times for single-leg stance were significantly longer for golfers than non-golfers on both the right ($z = -2.30$, $p = .021$, $r^2 = .07$) and left ($z = -3.19$, $p = .001$, $r^2 = .13$) sides (Table 4). The r^2 scores were below .2, indicating a small effect size.

A higher percentage of golfers achieved the maximum 60 s for the single-leg stance on both the right (32.3% vs. 17.6%) and left sides (35.5% vs. 0.0%), compared with non-golfers.

The composite normalized reach distances for the YBT for the golfers were significantly higher than those for non-golfers on both the right ($z = -2.80$, $p = .005$, $r^2 = .10$) and left ($z = -3.14$ $p = .002$, $r^2 = .13$) sides (Figure 2 and Table 5). Additionally, posteromedial and posterolateral normalized reach distances from the YBT were all significantly higher for golfers than non-golfers, on both right and left legs (Table 5). In analyzing each reach direction individually, only anterior reach had no significant difference between golfers and non-golfers on both the right ($p = .331$) and left ($p = .414$) sides (Table 5).

Discussion

The present study is one of the first to indicate that playing recreational golf is associated with better grip strength, and both static and dynamic balance in 65–79-year-olds, compared with non-golfers. However, the small, unequal sample size does not provide conclusive evidence of better results in golfers, therefore, the findings need to be treated with caution. This study also demonstrated the feasibility of using simple and portable equipment to detect differences in grip strength and balance in a community setting.

There are a limited number of studies on golfers' grip strength to compare with the present study. The significantly higher grip strength in golfers than non-golfers (right, $p = .042$; left, $p = .047$) was similar to the findings of Stockdale et al. (2017) for female golfers aged over 80 years compared with non-golfers. However, direct comparison of data between the two studies is not possible, as Stockdale et al. (2017) used a different dynamometer (Jamar), which produces different units of strength (kgF/kg) and they only measured the dominant hand in females. Irrespective of these methodological differences, the results of the present study and Stockdale et al. (2017) suggest playing golf may be associated with higher grip strength.

Although grip strength is considered a measure of overall strength, golf involves specific training of handgrip, so strength of the lower limbs should also be studied to determine whether handgrip is reflective of overall strength. Testing quadriceps strength, for example, has limited utility outside the laboratory environment for large muscles (e.g., quadriceps) of stronger participants, so was not considered an appropriate outcome measure in the present study, which used portable tests for use in community settings. Both the balance and grip strength were significantly greater in the golfers compared with non-golfers, indicating they may be related. The association between strength and balance is supported by Lee et al. (2015) who, along with significant differences in YBT scores, also reported significantly greater strength in muscles surrounding the hip, knee, and ankle for middle-aged compared with older females.

The present study reported significantly longer single-leg balance duration for golfers compared with non-golfers (Table 3), which was similar to the older golfers studied by Tsang & Hui-Chan (2010) (28.1 ± 3.6 s golfers vs. 17.1 ± 11.9 s non-golfers; $p = .020$). However, Tsang & Hui-Chan (2010) only studied the dominant leg

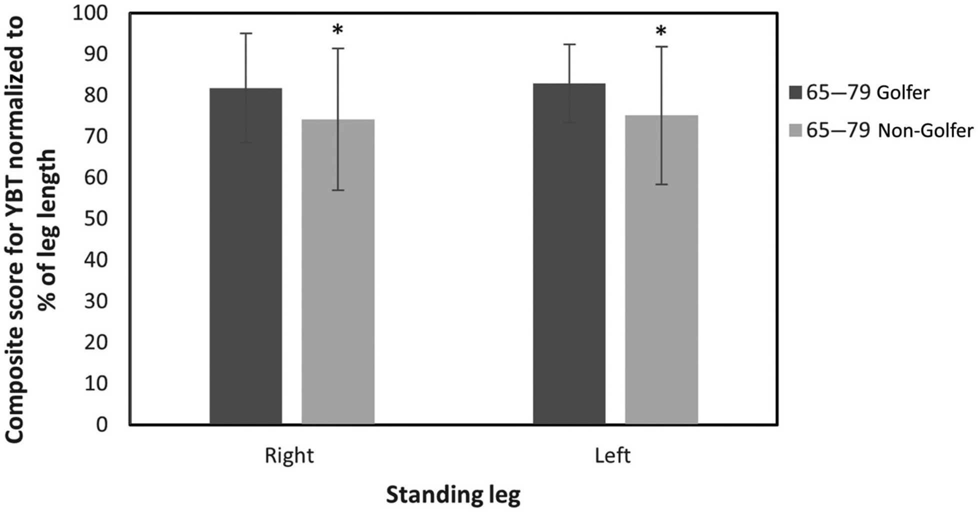

Figure 2 — Composite scores for the *Y* Balance Test (YBT): Distance as a percentage of leg length for golfers compared with non-golfers (median, IQR). *Significant difference ($p < .05$).

Table 5 *Y* Balance Test Distance as a Percentage of Leg Length for All Directions in Golfers Compared With Non-golfers

	Golfers (*n* = 62)	Non-golfers (*n* = 16[a])	*p*
Composite			
Right	81.7 (13.3)	74.4 (14.9)	.005*
Left	82.9 (9.6)	75.4 (14.3)	.002*
Anterior			
Right	59.3 (10.8)	58.6 (13.0)	.532
Left	61.3 (8.6)	61.4 (10.5)	.643
Posteromedial			
Right	89.1 (16.9)	74.6 (17.3)	< .0001*
Left	89.4 (14.2)	77.3 (13.5)	< .0001*
Posterolateral			
Right	96.7 (14.1)	87.5 (9.4)	< .01*
Left	98.9 (14.0)	86.9 (19.1)	< .0001*

Note. Left, right, denotes the standing leg. The values are presented as median (IQR). IQR = interquartile range. * significant difference ($p < 0.05$) between golfers and non-golfers.

[a] One female non-golfer unable to carry out *Y* Balance Test so removed from analysis.

*Significant difference ($p < .05$) between golfers and non-golfers.

in males. Additionally, Tsang & Hui-Chan (2010) appeared to limit the maximum time to 30 s and took a mean of three trials, whereas the present study had a maximum of 60 s and took the best time from the three trials to reduce the chance of a ceiling effect, based on normative values in 60–69 year olds reported by Springer et al. (2007). The present study suggests that golf is associated with better single-leg balance for both the dominant and nondominant legs.

In comparing the single-leg balance times from the present study to reported normative values, it appears golfers may have better balance (Springer et al., 2007). The study by Springer et al. (2007) reported normative mean (*SD*) best of three trials of 32.1 (16.2) s and 21.5 (17.3) s for groups of 60–69 and 70–79 years, respectively. Although direct comparison of the results from Springer et al. (2007) is limited as the present study involved a 65–79 age range, the golfers had greater single-leg stance times (median, right, 32.0 s, left, 37.0 s). This comparison to normative values suggests that golfers may have better single-leg balance than sedentary healthy older adults of similar age in the general population. Furthermore, the importance of balance on golf performance was highlighted by Speariett and Armstrong (2020), who reported single-leg balance negatively correlated ($r = -.722$, $p = .01$) with golf handicap in players aged 18–70 years.

The YBT assesses dynamic postural control, which was suggested by Howe et al. (2011) to be essential to evaluate in relation to falls prevention and potentially more important than static balance. The present finding that the YBT is an appropriate and safe method to assess balance in older participants is supported by several authors (Freund et al., 2019; Lee et al., 2015; Morat et al., 2019; Sipe et al., 2019). The addition of the rubber matting around the base of the YBT kit was reported by participants to increase their confidence and not limit their performance of the test itself, which was designed for use in young sports people. Therefore, the use of the rubber matting is recommended for future studies for older participants using the YBT.

The YBT provided a dynamic measure to assess balance in the present study and, similar to the static measure (single-leg stance) showed golfers had significantly better balance than non-golfers. These similarities in the results in the present study support the findings of Sipe et al. (2019) who reported significant correlation between the YBT and single-leg stance times ($p = .03$ and $p = .05$ for the right and left sides, respectively) in males and females with a mean age of 66.8 ± 6.5 years. In addition to being a safe method to assess balance in older participants, as discussed above, the results of the present study and Sipe et al. (2019) suggest the YBT will be a valid tool to assess balance in an older adult population.

The sensitivity of the components of the YBT for detecting differences between golfers and non-golfers is worth considering. Despite the composite score showing a significant difference between groups, the anterior reach did not show a significant difference (right, $p = .331$; left, $p = .414$; Table 5). Although the present study was not fully powered, the ability of the posterolateral (PL) and posteromedial (PM) to be more sensitive to detect differences compared with the anterior reach may be real, as this finding was also reported by Krysak et al. (2019) in school age and young professional golfers. Similarly, McCann et al. (2017) reported decreased posteromedial and posterolateral reach in high school footballers compared with college footballers, but no difference in anterior reach. Furthermore, Hertel et al. (2006) reported the PM reach direction was also able to identify individuals with chronic ankle stability compared with healthy controls. Although the results of Krysak et al. (2019) and McCann et al. (2017) were carried out on young adults and school pupils, combined with the results of the present study, they suggest the posterior reach tests from the YBT may be more sensitive than the anterior reach to detect differences in balance.

In considering why the PM and PL reach from the YBT may be more sensitive to detect changes compared to the anterior reach, Robinson and Gribble (2008) suggested a possible factor to be the greater hip muscular strength required to reach in the PM and PL directions compared with anterior. This greater strength requirement could be due to the greater trunk and hip flexion necessary for the PM and PL compared with the anterior reach (Robinson & Gribble, 2008). The present participants also reported reaching posteriorly, in particular medially, to be difficult due to being unable to see the nonstanding foot to locate the reach-indicator block. Therefore, the posterior reaching tests could place more demand on proprioception which may be reduced in those with poorer balance.

Lee et al. (2015) reported significant differences between middle-aged females (53.9 ± 5.0 years) and older females (77.5 ± 2.7 years) for all three YBT reach directions and composite scores. However, due to Lee et al. (2015) reporting a mean of the three trials, it is not possible to compare the results with the present study directly, which used maximum reach distance.

The better strength and balance indicated in the present golfers compared with the non-golfers does not appear to be explained by a difference in physical actively levels, other than playing golf or not, as assessed using the GPPAQ, which does not assess walking. There were no substantial (proportionate) differences between the golfers and non-golfers' physical activity levels (Table 2). The self-reported International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003) includes an assessment of time walking. It is possible that due to playing golf, the golfers did more walking than the non-golfers and therefore could be considered more physically active. However, in the present study, it is not possible to determine whether there was a difference in the amount of walking between the golfers and non-golfers.

Several potential participants were excluded from the present study due to having had a total hip replacement, as the rotational movements required for the posterior reaching for the YBT were considered a risk. Further work could be undertaken to examine the risk of total hip replacement participants doing the YBT, as examining the effect of golf on balance in those with total hip replacement would be worthwhile. Further research could be undertaken on the effect of golf in people with chronic conditions where balance may be compromised such as dementia and Parkinson's disease. According to Bliss and Church (2021) in their literature review, the strength, balance, and coordination demands of playing golf have the potential to reduce falls in older adults with Parkinson's disease, but further study is needed.

In consideration of participation in balance activities in older adults in Scotland, golf was the most popular activity to improve balance in older men (Strain et al., 2016). In contrast, for older women golf was less popular than a range of activities including aerobics, hill walking, and bowls (Strain et al., 2016). Similarly, for strength, other activities such as swimming and hill walking were more popular than golf (Strain et al., 2016). The findings of Strain et al. (2016) highlight that to improve or maintain strength and balance in older adults, a range of activities should be considered, and golf may not be the most popular or appropriate for all.

Limitations

The limitations of the present study include lower numbers in the non-golfer group compared to golfers, which required the use of nonparametric statistics and may have affected the results. Golfers were recruited initially to enable recruitment of age-matched non-golfers. However, recruitment of non-golfers proved difficult and then COVID-19 restrictions occurred which prevented further recruitment. The present study was underpowered, so the findings cannot be considered to have shown definitive differences between the groups. Also, it is not possible to state for certain that the better strength and balance in the golfers were only due to playing golf, as the golfers also took part in other activities such as cycling and tennis.

Golfers in the present study played at least 18 holes per week, but the number of times per week was not recorded. Future studies should record how much golf the participants played.

The standardized order of testing that was followed for the YBT (Plisky et al., 2009) was not randomized, so did not minimize fatigue effects; that is, left posterolateral testing could always have been in the fatigued state.

Future research on strength and balance in male and female golfers over 80 years old is also warranted, as the need for maintaining physical activity to combat sarcopenia increases with age (Narici & Maffulli, 2010). For example, Abe et al. (2016) reported male golfers over 80 had significantly lower handgrip strength per body mass ($p < .001$) than golfers aged 70–74 years and loss of strength appears particularly prevalent in individuals over 80 years (Cruz-Jentoft et al., 2010). The present cross-sectional study only examined the association of physical function with playing golf, so prospective longitudinal intervention studies in older people who are new to golf are needed to determine the true training effects of playing golf. The present findings indicating differences between golfers and non-golfers suggest that the outcome measures used would be suitable for such intervention studies of the effects of playing golf on strength and balance.

Conclusions

Playing recreational golf appears to be associated with better grip strength, and both static and dynamic balance in 65–79-year-old golfers ($n = 62$), compared with non-golfers ($n = 17$), although this cross-sectional, comparative study cannot determine a cause, and effect relationship. As dynamic balance is more functional that static balance, the YBT appears a feasible and sensitive test to detect differences in balance in older people. A prospective longitudinal study is warranted to investigate a causal relationship between playing golf and the effects on strength and balance.

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