STRENGTH, BALANCE, AND FLEXIBILITY CHARACTERISTICS OF GOLFERS OF A VARIETY OF HANDICAPS

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This research aimed to examine golf drive performance measures and physical performance variables of balance, strength and flexibility, for a wide range of golfing handicap levels. A total of 26 healthy right-handed golfers volunteered to participate in this study (M=17, F=9, 18-50 years, 0-36 handicap). Testing included an assessment of strength (hand grip strength test), balance (3 point star balance test), flexibility (sit and reach and shoulder reach flexibility), and indoor drive shot ball launch characteristics (high speed ball launch monitor). Golfers in the low handicap group had significantly ($p<0.05$) greater balance, strength, left shoulder flexibility, and better shot performnce than high handicap golfers. This research presents a rationale for the inclusion of strength, balance and flexibility conditioning in golf training programs.

KEY WORDS: golf, ball-launch characteristics, conditioning, driving, training.

INTRODUCTION: Golf not only provides a means of sports and recreation, it also can be a method of improving cardiovascular fitness and balance (Tsang & Hui-Chan, 2004; Parkkari *et al.,* 2000). Optimal physical conditioning has been a central principle of maximal performance in most sports but has been overlooked in golf. Golf instructors have long appreciated the importance of proper swing mechanics and are just beginning to recognise how physical attributes relate to the swing. Those who play and teach golf are beginning to realise the need for adequate strength, flexibility, and balance training to optimise swing mechanics to enhance golf performance and potentially to prevent injuries (Farrally *et al.,* 2003; Sato *et al.*, 2013). The information available from current literature indicates that the new elite golfer is fitter, stronger and leaner than ever before, with more musculature, and more flexibility than players from previous generations (Wells *et al.,* 2009). Most studies in the past have reported the effects of physical training and conditioning at university level (Doan *et al.,* 2006) or on recreational level subjects (Lephart *et al.,* 2007). These studies have analysed the effect of strength-only training programs or combined routines (also including endurance, flexibility and balance training) on a variety of different swing performance variables (Doan et al., 2006; Fletcher and Hartwell, 2004; Lephart et al., 2007; Seiler et al., 2006; Thompson et al., 2007). Regardless of rather different methodological procedures in each of these studies, they seem to indicate a positive relationship between strength and power development on golf performance. Further, the training programs that have been investigated used strength only training regimes or a combination of strength, power, plyometric, and flexibility training. Relationships between components of conditioning (balance, flexibility, core strength, upper and lower body strength and power, and cardiovascular conditioning) and golf performance have as of yet not been reported. The aim of the current research was to examine strength, flexibility, balance and drive shot performance with respect to proficiency level in the game of golf.

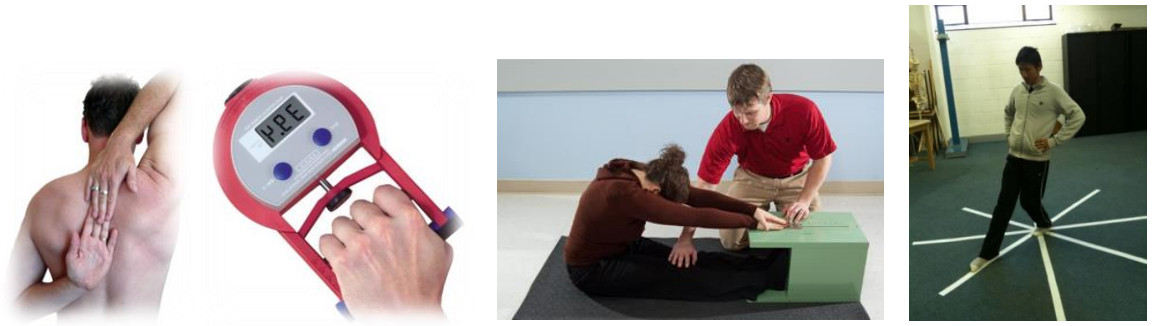
METHODS: A total of 26 healthy golfers volunteered to participate in this study (Male=17, Female=9) following institutional research board's ethical consideration. Subjects were separated into two groups according to proficiency based on their handicap index (HCP) group 1 (n=15 category 1 (Male=11, Female= 4), 0-5 HCP) and group 2 (n=11 category 3 (Male=6, Female=5), 4 & 5, 13-36 HCP). Table 1 shows the subject characteristics.

Table 1: Subject Characteristics across proficiency level

	Group 1 (HCP 0-5) (Category 1)		Group 2 (HCP 13-36) (Category 3,4,5)	
	Mean	±SD	Mean	±SD
Age (yrs)	34.9	11.3	34.9	18.6
Handicap	1.9	2.5	20.2	8.6

**HCP = Handicap index*

A Vector Launch System (Accusport, Inc., Winston-Salem, NC) was used to measure club head and ball launch conditions for the drive (Lephart et al., 2007; Kenny and Anderson, 2010). Each subject used his/her own driver. A warm-up consisted of approximately five minutes of general mobility, flexibility and practice shots, as each golfer would normally practice before playing a round of golf. Drive data were collected for five shots for each subject, with two minutes rest between shots. After the subject had completed their five golf shots, s/he was then asked to complete the following four physical tests: shoulder joint reach flexibility test (Figure 1a), hand grip dynamometer strength test (Figure 1b), sit and reach hamstring and lower back flexibility test (Figure 1c) and the modified Star Excursion Balance Test (SEBT) (Figure 1d).



a **b** **c** **d**

Figure 1: Physical performance tests a)Shoulder joint reach flexibility, b)Hand grip dynamometer test, c)Sit and reach, d) three direction modified Start Excursion Balance Test (SEBT)

For each of the above mentioned, test conditions included that of three maximal contractions. A rest period of one minute was also between each physical test. Statistical analyses were carried out using PASW v18 (SPSS Inc, Chicago, IL, USA). A one way analysis of variance (ANOVA) was performed on all data to determine whether strength, balance or flexibility as well as shot performance measures showed significant differences between the handicap groupings.

RESULTS & DISCUSSION: This study examined physical and ball launch performance characteristics of golfers of both high and low handicaps. Male and female golfers were combined, cognisant that the same golfer handicap system applies regardless of gender. The genders have been combined in other recent golf biomechanics studies (e.g. Horan et al., 2011) and have shown similar movement variability patterns although strength characteristics inherently differ. It was hypothesized that golfers with a handicap of ≤ 5 would possess significantly greater strength, balance, flexibility and ball launch characteristics than less proficient golfers, but as yet not validated in any literature. In the current study, it was found that golfers with a Low HCP ≤ 5 (group one) demonstrated significantly greater grip strength, shoulder flexibility (left) and balance than that of golfers with a high HCP of 13 to 36 (group two) (Table 2). Percent differences are relative values, stated to complement the absolute values in degrees, forces and distance. Interestingly, left lead shoulder flexibility demonstrated a 5.28 cm increase in joint range of motion compared to the right trail shoulder, for these right handed golfers.

Table 2: Strength (kg), flexibility (cm) and balance (cm) physical performance results for low and high handicap golfers

Physical test	Low HCP average ± SD	High HCP average ± SD	% difference
STRENGTH Hand grip left*	35.9 ± 11.2	29.0 ± 12.8	-19%
STRENGTH Hand grip right**	38.3 ± 10.5	30.2 ± 12.7	-21%
FLEXIBILITY Shoulder left hand***	-0.2 ± 8.8	-5.1 ± 6.6	2450%
FLEXIBILITY Shoulder right hand	1.1 ± 7.5	0.2 ± 4.8	-80%
FLEXIBILITY Sit and reach	19.3 ± 10.3	19.9 ± 11.3	4%
BALANCE left leg anterior[l]	78.2 ± 9.3	71.4 ± 25.9	-9%
BALANCE left leg posterolateral[s]	83.6 ± 15.3	72.0 ± 27.2	-14%
BALANCE left leg posteromedial[x]	89.5 ± 18.1	80.2 ± 30.2	-10%
BALANCE right leg anterior^	80.9 ± 13.6	73.3 ± 26.5	-9%
BALANCE right leg posterolateral[3]	91.7 ± 20.2	79.5 ± 30.0	-13%
BALANCE right leg posteromedial”	85.2 ± 18.4	72.7 ± 27.3	-15%

*$p < 0.05$, F = 4.457; **$p < 0.05$, F= 7.158; ***$p < 0.05$, F = 4.778; [l]$p < 0.05$, F = 10.454; [s]$p < 0.05$, F= 14.287; [x]$p < 0.05$, F= 9.465; ^$p < 0.05$, F= 9.937; [3]$p < 0.05$, F= 12.183; “$p < 0.05$, F= 14.269,

In addition, results for this cohort of low and high handicap golfers showed that ball launch characteristics of ball velocity, club head velocity, side spin and launch angle all differed significantly between groups (Table 3). Low handicap skilled golfers produced greater club head velocity (+8.8 m/s) and concomitant ball velocity (+13.4 m/s) at impact, closer to optimum drive shot ball launch angle, and less shot dispersion at impact (-0.63°). The shot performance measure of ball carry, as a result of improved launch conditions, also increased by an average 97.9 m for low handicap golfers. A study by Fradkin *et al.* (2004) revealed that a golfer's handicap is directly related to club head velocity, where lower handicap golfers produced greater the club head velocity than higher handicap golfers.

Table 3: Mean (±SD) drive shot performance characteristics of low and high HCP golfers

Variable	Low HCP average ± SD	High HCP average ± SD	% difference
Carry (m)*	216.3 ± 42.0	118.4 ± 51.8	-45
Ball velocity (m/s)**	64.6 ± 7.8	51.2 ± 12.7	-21
Club head velocity (m/s)***	44.3 ± 5.7	35.5 ± 8.7	-20
Launch angle (°)[l]	11.3 ± 2.5	7.5 ± 3.4	-33
Side angle (°)[s]	-1.0 ± 4.4	1.6 ± 4.7	-264
Back spin (rpm)	2769.8 ± 597.9	2777.9 ± 1225.8	0
Side spin (rpm)	-361.0 ± 752.8	-743.5 ± 1285.4	106

***$p < 0.05$, F = 124.003; **$p < 0.05$, F = 57.229; ***$p < 0.05$, F= 46.833; [l]$p < 0.05$, F = 36.28; [s]$p < 0.05$, F= 7.397.

Optimal launch conditions for acquiring distance by elite golfers are widely accepted to be a lunch angle between 10 and 14 degrees (Wallace *et al.,* 2007), which is what is achieved above on average by the low handicap golfers in the current study. It is also interesting to note that the effect between both launch angle and ball speed was statistically significant between groups, thus demonstrating that each group of golfers (high and low handicap) have a relatively consistent set of ball launch variables.

Cheetham *et al.* (2001), among others, studied the variation between hip and shoulder angle differential at the top of the backswing, and the apparent greater differential exhibited early in the downswing. The highly skilled golfers showed a 19% increase in the X-Factor due to the eccentric stretch at the beginning of the downswing and the less skilled golfers only a 13% increase. For most golfers, immediately prior to the transition from the backswing to the downswing, the pelvis decelerates and changes direction to rotate forward whilst the trunk continues to rotate backwards. This early release of the hips towards the direction of the target was shown to increase the X-Factor significantly. It was noted that the X-Factor stretch

facilitates force production and greater clubhead velocity at impact, thus relates directly to golfer flexibility.

CONCLUSION: The results from the current study have direct application to instruction of the golf swing. Instructors of the game who wish to increase ball velocity, driving distance and accuracy should focus on improving both the physical and ball launch characteristics of golfers given the relationship established in this study. This study supports anecdotal evidence that there are significant differences in physical characteristics of balance, strength, and flexibility between high and low handicap golfers. Future research may be directed at determining the strength of specific relationships between physical characteristics and launch characteristics. This research supports recent work by Sato, Kenny & Dale (2013), and presents a rationale for the inclusion of strength, balance and flexibility conditioning in golf training programs in order to improve overall performance.

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