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DETERMINANTS OF CLUB HEAD SPEED IN PGA PROFESSIONAL GOLFERS

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ABSTRACT

Club head speed (CHS) has been significantly correlated to golf performance, but only in amateurs. The purpose of this study therefore, was to investigate the relationship between field-based measures of strength and power with CHS in PGA professional golfers, and further, determine differences between age groups. A correlation design was used to test relationships between squat jump (SJ), seated medicine ball throw (SMBT), rotational medicine ball throw (RMBT) and CHS. Twenty participants volunteered to take part in the study (age: 31.95 ± 8.7 years, height: 182.75 ± 6.88cm, mass: 90.47 ± 15.6kg). Intraclass correlation coefficients reported high reliability for performance variables (r = 0.85-0.95). Significant correlations ($p < 0.01$) were found between CHS and SJ (r = 0.817) and SMBT (r = 0.706), but not RMBT (r = 0.572). A stepwise linear regression analysis identified that SJ and SMBT explained 74% of the variance in CHS. When dividing the sample based on age, professionals < 30 (n = 10; 25.6 ± 2.9 years) displayed significantly ($p < 0.05$) higher CHS and SJ height compared to professionals of > 30 (n = 10; 39.7 ± 5.5 years). Correlations to CHS for < 30 were significant for SJ (r = 0.801) and SMBT (r = 0.643), but non-significant for RMBT. Those > 30 also had significant correlations to CHS in SMBT (r = 0.881) and SJ (r = 0.729), but also in RMBT (r = 0.642). The results of this study suggest that SJ and SMBT have the largest contribution to CHS in PGA professional golfers. When comparing age groups, it appears that younger golfers (< 30 years) utilise more leg strength while older golfers (> 30 years) utilise more upper body strength. Results suggest that strength based leg exercises and power based chest exercises may improve CHS in professional golfers.

Keywords: golf; handicap; driving; swing

INTRODUCTION

The golf swing is a complex movement of the whole body that transfers power to the golf ball to propel it long distances, commonly in excess of 300 yards, with accuracy (11). The speed at which the body can get the club head to travel through contact with the ball has been shown to be of paramount importance for the distance the ball travels (2). Club head speed (CHS) has been significantly correlated (r = 0.95; p < 0.01) to golfing handicap (5) and, due to this relationship, it is a measurement that is commonly used in golf literature to distinguish performance levels (3,4,6).

Research has found that increases in strength, power and flexibility have all led to improvements in CHS (1,3). For example, Fletcher *et al.,* (4) who used amateurs with an average handicap of 5.5, showed that following an 8-week training programme consisting of weight training and plyometrics, CHS significantly improved above that of a control group; with improvements being attributed to increased force and acceleration of the down swing. Wells *et al*., (18) used elite national level golfers and looked at the relationship between lower body power, strength endurance and CHS, and found that vertical jump (r = 0.50), number of pull ups in a minute (r = 0.55) and number of push ups in a minute (r = 0.48) all had significant (p < 0.05) correlations. This reinforces an investigation by Hellstrom, (7) which found that leg power (squat jump peak power r = 0.61), leg strength (back squat r = 0.54*),* and pushing strength (bar dips r = 0.35), significantly (p < 0.05) correlated to CHS in elite amateur male golfers. Read *et al*., (13) also found that chest power (via a seated medicine ball throw) had significant correlations (r = 0.67; p < 0.01) to CHS in male amateurs with an average handicap of 5.8; they referred to the work by Jobe *et al*., (9) who stated that the pectoralis major is highly active during the down swing toward contact with the ball. Furthermore, Read *et al.,* (14) reported that CHS could be acutely potentiated following 3 tuck jumps in amateur males with an average handicap of 5.8, suggesting notable involvement of leg strength and power to enhance driving distance. Finally, the importance of rotational strength for developing CHS has also been examined (10, 17). Keogh *et al.,* (10) using a golf specific cable wood chop, reported significant correlations (r = 0.70) to CHS. The investigators also found that lower handicap players had significantly greater rotational strength (28%; p <0.001) than high handicap players. Rotational power, tested via the use of a rotational hip toss (6), was found to correlate significantly (r = 0.54; p < 0.05) with CHS, as was rotational power measured using a golf specific rotational medicine ball throw (r = 0.63; p < 0.01) (13).

The current research associating strength and power characteristics to CHS has all been conducted on amateur golfers. To the authors' knowledge this is yet to be done with Professional Golfers Association (PGA) golfers. This is an important consideration as many different swing techniques are utilised to achieve similar impact positions to produce a consistent ball flight, but distance varies and thus CHS is the differential factor. Also, comparisons between different aged professional golfers are yet to be undertaken. This bares importance, as currently age is not considered a deciding factor in performance within elite golf, even though golfers < 30 years of age dominate the current world rankings (15). Logically this holds true until age starts to negatively impact CHS and thus driving distance. Therefore the aims of this study were to assess the correlations between field – based power measures and CHS and identify whether these correlations are age-group dependant. Also, we aimed to assess differences in power measures between PGA golfers under and above 30 years of age. It was hypothesised that all independent variables would be associated with CHS, with measures of lower body power showing stronger associations than upper body measures, and finally, that younger golfers would attain higher scores for CHS.

METHODS

Experimental Approach to the Problem

A correlation study design was used to investigate if significant relationships were present between field-based measures of physical performance, CHS and age within the professional golfers. CHS was the dependent variable, and performance measures of squat jump (SJ), seated medicine ball throw (SMBT) and rotational medicine ball throw (RMBT) were the independent variables. All participants performed familiarization attempts. Data was collected from a PGA event, with golfers performing the testing battery 30 minutes after completion of their round to aid recovery. Testing was performed after competition so as to not negatively impact their competition score and boost participation numbers. The study had full ethical approval from the Middlesex University London Sport Institute ethics committee, and all participants signed informed consent forms.

Participants

Twenty male participants volunteered to take part in the study (age: 31.95 ± 8.7 years, height: 182.75 ± 6.88 cm, mass: 90.47 ± 15.6 kg); this was from a field of 90 golfers. Participants were required to be a member of the PGA and still playing competitive golf. All participants were required to be injury free and in good health. The age group delineation was based on the average age of the top 100 hundred players on the Professional Golfers Association (PGA) tour (15). When separated by age, participant characteristics are as follows: the < 30 years of age group were 25.6 ± 2.9 years of age, 183.45 ± 7.34 cm tall and had a body mass of 83.56 ± 7.63 kg. The > 30 years of age group were 39.7 ± 5.5 years of age, 181.89 ± 7.1 cm tall, and had a body mass of 98.91 ±19.7 kg.

Anthropometry

Height (cm) was recorded using a Seca measurement platform (Seca, Milan, Italy). Body mass (kg) was recorded using calibrated Seca scales (Seca, Milan, Italy).

Procedures

Squat Jump (SJ). The participants were provided with one warm-up jump followed by three maximal attempts, with one minute separating all trials. All trials were used for reliability analysis, with the maximal jump height used in the subsequent analysis. Participants were instructed to jump as high as possible, avoid bending knees whilst airborne, and to keep hands in contact with hips throughout the test. The SJ involved lowering the hips until the knee joint was at approximately 90 degrees followed by a four second isometric pause, then an explosive concentric only jump. Trials were repeated if a visible countermovement was used. The SJ was measured using a contact mat (Kinetic Measurement System, Optimal Kinetics, Moorestown, NJ, USA).

Seated Medicine Ball Throw (SMBT). Participants used a chair as a platform from which they performed the throw which is described as a forward toss with hands starting in front of chest. A 4 kg medicine ball was used and participants were provided one warm-up throw followed by three maximal attempts, with one minute separating all trials. All trials were used for reliability analysis, with the maximal distance used in the subsequent analysis. For each trial, a ready position was assumed with the participant placing the ball against their chest. After a four second static hold, the participant was asked to throw maximally in a concentric only motion. Participants were required to maintain back contact with the chair to help reduce the use of trunk flexion during the test, also ensuring their feet remained on the floor for the trial to register. The landing zone was covered in sand to aid accuracy and the measurement was taken from the middle of the depression.

Rotational Medicine Ball Throw (RMBT). RMBT was performed in a golf posture with a 4 kg medicine ball. The Participants were asked to rotate away in a backswing type action followed by an immediate rotation toward the target as in a golf swing, aiming for maximal distance. Feet were required to remain in contact with the floor, although the rear heel is allowed to rise in the follow through in to full extension of the ankle, knee and hip, which would be present in the golf swing. The participants performed a warm up throw followed by three maximal efforts, with one minute separating all trials. The landing zone was covered in sand to aid accuracy and the measurement was taken from the middle of the depression. All trials were used for reliability analysis, with the maximal distance used in the subsequent analysis.

Club Head Speed (CHS). The GC2 foresight golf launch monitor (Stereoscopic high-speed digital camera system) was used to record CHS. Participants were asked to perform three "maximal" tee shots, accurate enough to hit a fairway but with distance being the priority. Their own drivers where used to provide both comfort and familiarity. The results were blind to the participants for reliability purposes. All trials were used for reliability analysis, with the maximal speed used in the subsequent analysis.

These performance measures were chosen due to their reliability and repeatability in field-based tests as showed by Read et al. (13). In addition, due to the location of the testing procedures, these tests fitted the requirements of the study.

Statistical Analysis

Descriptive statistics (mean ± SD) were calculated for anthropometric data, CHS, and all performance tests. Data was checked for normal distribution using Shapiro-Wilk calculation and within-test reliability was calculated using Intraclass Correlation Coefficients. Pearson's correlation coefficient was used to determine the relationships between variables. The data was split into two age groups (< 30 and > 30 years) and an Independent samples T-Test was performed to check for differences between groups across the tested variables. Relationships were also analysed with the sample split in this way. Finally, a stepwise liner regression was undertaken in an attempt to better explain the variance in CHS, but given the sample size and number of variables, the group was not split. All data analysis was performed using IBM SPSS statistics 21, with the level of significance set at $p < 0.05$.

RESULTS

All data was found to be normally distributed and reliable (see Table 1). Correlations between CHS and field based tests for all 20 golfers indicated that the SJ was the strongest correlate to CHS, followed by the SMBT (Table 1). When splitting the age groups, the SJ most strongly correlated to CHS in the < 30 age group, followed by the SMBT. In the > 30's, the SMBT was most strongly correlated with CHS followed by the SJ and RMBT. Comparisons between age groups revealed that < 30's demonstrated significantly faster

CHS and greater SJ heights than the > 30's. Using linear regression analysis, SJ and SMBT were found to account for 74% of total variance in CHS (Table 2).

Table one and two about here

DISCUSSION

The results of this study demonstrate that power is significantly correlated to CHS in PGA professional golfers, confirming previously established relationships observed in amateur golfers (1,3,18). The determinants of CHS, a variable strongly correlated to scoring average (5), had not been previously determined in this group. For the group as a whole, SJ (*r* = 0.817) and SMBT (*r* = 0.706) were the only correlates. This study also highlights that SJ and SMBT can explain the highest variance (R^2= 74%) in CHS. This is in keeping with recent studies, where Read *et al*., (13) suggests that concentric muscle actions have the biggest influence in CHS. The SMBT (*r* = 0.729), SJ (*r* = 0.881) and RMBT (*r* = 0.642) tests were significantly correlated with CHS in > 30's (Table 1), and is in line with results previously reported by Read *et al*., (13). Finally, the < 30 group produced significantly faster CHS than the > 30's (107.36 *vs.* 101.56 mph), justifying the group split, and also jumped significantly higher in the SJ (35.95 *vs.* 30.22 cm). These differences may help to explain the dominance younger golfers have within the top 100 hundred players on the Professional Golfers Association (PGA) tour (15).

From an understanding of the mechanics that govern the golf swing, it is reasonable to assume that the tests carried out in this study are assessing power in muscle groups that directly influence CHS (16). In addition, these results indicate that to varying degrees, the two different age groups rely on different areas of the body to contribute to the force production required to execute the golf swing. It may also be hypothesised that the significantly higher CHS in < 30's comes from their ability to utilise their leg power in their swing above that of the > 30's. This could be due to changes in technique that have come about in the past decade with leg drive and hip extension now being key parts in developing powerful consistent swings (16). Alternatively, it may be that the reliance of upper body power in the > 30's group is simply a compensation for reduced lower body power that could be avoided with strength training. Sell *et al*., (14) suggest that the golf swing follows a kinetic sequencing chain, starting from the ground upwards which allows force to be generated from the whole body and transferred down through the club to the ball. Nesbit and Serrano, (12) noted that lower handicap players worked at slower rates initially in the downswing in comparison to higher handicap golfers. Relating this to CHS, it can be said that the slower speed at the start of the downswing can facilitate increased force production, enabling leg power to play a greater part.

When viewing the group as a whole, rotational strength (RMBT) was not correlated with CHS, however, when the participants were split, the RMBT was found to correlate to the CHS in the > 30's only. Keogh *et al*., (10) had previously reported that rotational power was able to differentiate golfers between skill levels. The cause for this could be linked to the torso and its inherent rotational strength being a bridge between lower body strength and upper body strength (17). If there is enough strength to allow the transfer from the lower body to the top, then it has served its purpose in the kinetic chain; that is, further increases in strength would not result in further increases in performance. Higher skilled golfers have better rotational mechanics and also tend to perform many more rotational movements due to increased practice (17). This means that they are likely better able to transfer the power generated through the swing. As highly skilled golfers would be expected to have sufficient rotational strength and technical ability, it is perhaps reasonable to suggest that it would not be a deciding factor in distinguishing between CHS within an elite participant group, as was the case in the current study.

The potential limitations to this study were that participants performed the testing battery after a competitive round of golf and therefore despite the rest provided, fatigue could have affected results; results may actually better represent performances during the latter stages of a round. Also, there were a limited number of field-based measures and only 10 participants in each age group. Considerations for future studies should focus on testing the associations noted in this study. Would additional increases in the independent variables increase CHS and would improved leg power change the relationships noted in older golfers.

PRACTICAL APPLICATIONS

The results from this study reinforce the high correlations of SJ, SMBT and RMBT in field-based testing of golfers, and demonstrate their importance within PGA professionals. This study highlights that the SJ demonstrated the greatest association with CHS and the largest difference between age groups. This may imply that if PGA professional golfers can increase or maintain their leg strength, along with chest strength, then CHS may increase, or at least not decrease with age. Moreover, this highlights the use of concentric strength in the golf swing; strength and conditioning coaches should consider this when assessing and prescribing training programmes for golfers of all ages.

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Table 1. Descriptive Statistics and correlations between CHS and Performance Variables

		Mean (± SD) scores			Correlation with CHS		
Field-test	ICC	All	< 30	> 30	All	< 30	> 30
CHS (mph)	0.94	104.8 ± 6.48	107.36 ± 6.07*	101.56			
SJ (cm)	0.95	33.4 ± 6.48	35.95 ± 5.95*	30.22	0.817**	0.801**	0.729*
SMBT (cm)	0.85	580.5 ± 49.36	584.55 ± 47.92	580.16 ± 49.33	0.706***	0.643***	0.881**
RMBT (cm)	0.89	762 ± 107.06	771.36 ± 80.22	762.56 ± 107.06	0.57	0.59	0.642***

* Difference significant at the level of $p < 0.01$

** Correlation to CHS significant at the level of $p < 0.01$

*** Correlation to CHS significant at the level of $p < 0.05$

Table 2. Stepwise linear model to predict CHS in PGA Professional Golfers

	B	SE B	ß	P
Step 1				
Constant	77.47	4.61		p=0.000
SJ	0.82	0.14	0.82	p=0.000
Step 2				
Constant	58.42	9.62		p=0.000
SJ	0.62	0.15	0.62	p=0.001
SMBT	0.04	0.02	0.34	p=0.042

Note. R^2=0.69 for Step 1; ΔR^2=0.05 for Step 2.