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Driver Club Head Speed Correlates to Rotational Power in Competitive Amateur High School Golfers

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Jacob Winqvist & Christopher Grenzdörfer

Abstract

Background: As a sport Golf is known for its power and precision regarding the swing. The swing that produces the most power is the drive. The club head speed (CHS) of the drive is a commonly used measurement of swing performance. Studies have shown a strong correlation between CHS and rotational power of the trunk musculature. Up until this year the gold standard for measuring rotational power of the trunk has been the medicine ball side throw (MBST). In 2012 a study investigating the rotational power in the trunk measured by a seated cable torso rotation (SCTR) was published. For this thesis, the authors hypothesized that the SCTR would have a higher correlation to CHS than MBST. *Method*: A correlation study design was used to examine the relationship between CHS, SCTR and MBST. 20 healthy competitive amateur high school golfers (n=20 - 17 male, 3 female, age 17 ±1.2, weight 73 ±12 kg, height 180 ±9 cm, handicap 6,6 ±2,4) were recruited. *Results*: Significant correlations were found between; CHS and MBST (r=0,79 p=0,01); CHS and SCTR (r=0,80 p=0,01, r=0,80 p=0,01). MBST and SCTR also significantly correlated with ball speed. *Discussion*: Results did not confirm the authors' hypothesis, although both tests proved to be significantly correlated to CHS. This shows that both tests seem to be equally effective when testing rotational power in competitive high school golfers, although the MBST seems to be more efficient.

Sammanfattning

Bakgrund: Golf är känt för dess kraft och precision i golfsvingen. Den typ av sving som producerar mest kraft är den så kallade Driven. Klubbhuvudets fart vid en Drive används vanligen för att mäta svingprestation. Studier har visat på en stark korrelation mellan klubbhuvudets fart och rotationskraft i bålmuskulaturen. Fram till i år har guldstandarden för att mäta rotationskraft i bålmuskulaturen varit ett medicinbollskast från sidan. År 2012 presenterades en studie som undersökte rotationskraft i bålmuskulaturen uppmätt med en sittande kabelrotation. Inför denna uppsats hypotiserade författarna att en sittande kabelrotation skulle ha en högre korrelation till klubbhuvudets fart än ett medicinbollskast från sidan. *Metod:* En korrelationsstudie användes för att undersöka förhållandet mellan klubbhuvudets fart, sittande kabelrotation och medicinbollskast från sidan. 20 friska tävlande gymnasieamatörgolfare (N=20 – 17 män, 3 kvinnor, ålder 17±1.2, vikt 73 ±12 kg, längd 180 ±9cm, handikapp 6,6 ±2,4) rekryterades för studien. *Resultat:* En signifikant korrelation uppmättes mellan; klubbhuvudets fart och medicinbollskast från sidan (r=0,79 p=0,01); klubbhuvudets fart och sittande kabelrotation (r=0,80 p=0,01, r=0,80 p=0,01). Medicinbollskast från sidan och sittande kabelrotation visade sig också signifikant korrelera med bollhastighet. *Diskussion:* Resultaten bekräftade inte författarnas hypotes, även om båda testen visade sig korrelera med klubbhuvudets fart. Detta visar på att båda testen verkar vara likvärdigt effektiva vid mätning av rotationskraft hos tävlande gymnasieamatörgolfare även om medicinbollskast från sidan verkar vara mer användarvänligt.

List of Abbreviations

BS - Ball Speed

CHS - Club Head Speed

ICC - Intra-Class Correlation

LPT - Linear Position Transducer

MBST - Medicine Ball Side Throw

SCTR - Seated Cable Torso Rotation

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Background

Strength, power and neuromuscular control of the trunk musculature, often referred to as the core muscles, is considered an important aspect of any sports performance as well as injury prevention and rehabilitation (Akuthota & Nadler, 2004, Kibler et al., 2006, McGill, 2010). A widely accepted model of the core muscles is the one used by McGill (2010). It defines the core as the lumbar spine, the abdominal wall, back extensors and Quadratus Lumborum, which interacts with the Lattissimus Dorsi, Iliopsoas and gluteal muscles (McGill, 2010). The core acts as a bridge between the lower and upper extremities, allowing for the build-up and transfer of force between them through stiffening (Kibler et al., 2006, McGill, 2009, 2010). Rotational power is regarded as an important aspect of most sports involving throwing, swinging and striking, such as Hockey, Floorball, Baseball and Golf (Earp & Kraemer, 2010). Power is defined as mechanical work over time (P = W/t) or Power = force x velocity (P=Fv) and is expressed in watts. (Hall, 2011, Kawamori & Haff, 2004). Angular velocity in rotation (torque) is developed through the kinetic link principle or summation of speed, which states that the total velocity is greater than the velocity of each segment by itself (Hall, 2011, Hume et al., 2005, McGill, 2009, Keogh et al., 2009).

As a sport Golf is known for its power and precision regarding the swing. The different types of golf swings and clubs are used by the golfer to orientate the ball around the golf course with as few strokes as possible. The golf swing combines many forces of motion with the underlying goal of hitting the golf ball with the amount of force needed to propel the ball the desired distance (Hellström, 2009). A common way to evaluate the performance of a golf swing is by measuring club head speed (CHS) (Doan et al., 2006, Fletcher & Hartwell, 2004, Fradkin et al., 2004, Gordon et al., 2009, Read et al., 2013). The swing that produces the most power and acceleration of the club head is the drive. CHS has been shown to be a critical factor affecting the distance the ball travels when performing a golf swing (Fletcher & Hartwell, 2004, Fradkin et al., 2004, Gordon et al., 2009, Keogh et al., 2009). Studies have investigated the relationship between CHS and handicap in amateur golfers and found a strong positive correlation between a lower handicap and a higher CHS (Fradkin et al., 2004, Keogh et al., 2009, Hellström, 2009). In agreement with Hellström (2009), the ability to achieve a higher velocity of the club head generally increases with level of player skill. However, other studies have investigated the relationship between rotational power and CHS (Adler-Henerud, 2006, Doan et al., 2006, Fletcher & Hartwell, 2004, Gordon et al., 2009, Read et al., 2013). Fletcher & Hartwell (2004) investigated golf drive performance after eight weeks of strength and plyometric training. They found that 8 weeks of strength training resulted in a 1.5% increase in CHS which in turn increased drive distance by as much as 4.3% in amateur golfers with a mean handicap of 5.5 ±3.7 (Fletcher & Hartwell, 2004). Multiple studies have confirmed the positive effects of strength and plyometric training on golf swing performance (Doan et al., 2006, Hellström, 2000, Lephart et al., 2007). These findings show that while handicap strongly correlates to CHS, CHS is also dependent on power production (Doan et al., 2006, Fletcher & Hartwell, 2004, Gordon et al., 2009, Read et al. 2013).

The factors contributing to CHS and drive distance is summarized as 1) muscular force applied through the extremities, 2) the leverage arms over which the forces act and 3), the segmental sequence when performing the swing that contributes to the final velocity (Fletcher & Hartwell, 2004, Hume et al., 2005). The segmental sequence is defined as the order of which the muscles and joints interact when performing the golf swing and is closely connected to skill (Hellström, 2009, Hume et al., 2005). The leverage arm is defined as arm and club length and has been shown to correlate with CHS (Keogh et al., 2009, Well et al., 2009). As it is genetically predetermined, it ceases to be a changeable factor when a person reaches adulthood. To increase CHS, the two other factors contributing to drive distance must be manipulated. The golfer can either improve the segmental sequence or increase the muscular force applied. When increasing the muscular force studies have shown that a powerful rotation of the hip, upper body and torso are key components of a successful drive (Gordon et al., 2009, Keogh et al., 2009, Leary et al., 2012, Meister et al., 2011, Myers et al., 2008, Yoon, 1998). High muscular power has been shown to allow for more mechanical work to be applied to the club during the golf swing per unit of time, which then contributes to a higher CHS (Doan et al., 2006, Hellström, 2009, Yoon, 1998).

Up until this year, the gold standard for measuring rotational power in the hip and torso has been the medicine ball side throw (MBST) (Gordon et al., 2009, Ikeda et al., 2007, Ikeda et al., 2009, Read et al., 2013, Szymanski et al., 2007).
Gordon et al. (2009) and Read et al. (2013) used the MBST as a way of measuring how rotational power correlated to the golf swing. Gordon et al. (2009) found the relationship to be $r=0.54$ ($p=0,05$) with a high test-retest reliability of Intra-Class Correlation (ICC), ICC=0,89 for the MBST. Read et al. (2013) performed the same test and found the relationship to be $r=0,67$ with a ICC=0,90.

Other methods to examine the relationship between rotational power and the golf swing have been tested. Yoon (1998) and Adler-Henerud (2006) used a custom-built stationary torso-rotation machine to measure power output. Yoon (1998) found the relationship between isolated trunk power and CHS to be r2=0,63 ($p=0,01$). Although a small sample, Adler-Henerud (2006) found the correlation to be $r=0,87$ between isolated trunk power and CHS. Keogh et al. (2009) investigated the relationship between a standing cable wood-chop and CHS and found it to be $r=0,71$ ($p=0,01$). Although promising, the study lacked statistical power and reported no test-retest reliability score for the standing cable wood-chop exercise. In 2012, a study by Andre et al. (2012) used a cable pulley and Linear Position Transducer (LPT) to measure rotational power of the torso in a seated position. The purpose was to isolate the rotation of the torso from the leg and hips by using a seated position. They found the test-retest reliability of the pulley/LPT system to be between ICC=0,94-0,99, higher than the test-retest reliability for the MBST reported by Gordon et al. (2009) and Read et al. (2013). The method used by Andre et al. (2012) has not yet been validated as a test for measuring rotational power specifically for golf.

The MBST used by Gordon et al. (2009) and Read et al. (2013) has an advantage over other methods for testing power output in torso rotation. It requires few preparations to implement and is a cost- and time-efficient field-test compared to lab tests using more advanced equipment, such as the tests performed by Yoon (1998), Adler-Henerud (2006), Keogh et al. (2009) and Andre et al. (2012). Based on the results of earlier studies, the authors hypothesized that the seated cable torso rotation (SCTR) used by Andre et al. (2012) would have a stronger correlation to the golf swing than the MBST.

Purpose

The purpose of this study was to examine the relationship between the club head and ball speed of a golf drive, the peak power in a Seated Cable Torso Rotation and the throwing length of a standing Medicine Ball Side Throw.

- Is there a significant correlation between a seated cable torso rotation and club head speed?
- Is there a higher correlation between a seated cable torso rotation and club head speed than between a standing medicine ball side throw and club head speed?

Hypothesis

The authors believed the peak power in a Seated Cable Torso Rotation, expressed in watts, had a higher correlation to the club head speed and ball speed of a golf drive than the rotational power of a standing Medicine Ball Side Throw, expressed as maximum throwing length, in competitive amateur high school golfers.

Method

A correlational study design was used to examine the relationship between the club head speed and ball speed of a golf drive, the peak power in a SCTR and the throwing length of a standing MBST.

Testing was divided over two days and performed in the golf pre-season. Data for the golf drive and MBST was collected on the first day and data for the SCTR on the second day. Descriptive data (age, height, weight, swing side) was collected during the first session. Handicap was collected from www.golf.se, a player and competition database, and was based on the subjects last competitions.

Subjects

20 healthy high school students (n=20 - 17 male, 3 female, age 17 ±1.2, weight 73 ±12 kg, height 180 ±9 cm, handicap 6,6 ±2,4) were recruited for this study. All subjects were competitive amateur golfers with at least six months of strength training background. 18 of the test subjects were right handed and 2 subjects were left handed. Subjects were informed of the purpose of this study and gave consent to participate in ordinance with the ethical guidelines of CODEX (CODEX, 2013). Since the data collected was not of sensitive nature no ethics board was consulted. Subjects were in good health and reported no injuries that would limit their testing performance. Originally, 25 subjects were invited to participate in the study. Five subjects were excluded due to failure to complete all tests.

Descriptive data for anthropometrics is shown in table 1.

Table 1. Descriptive statistics

Table 1. Descriptive Statistics for age, height, weight and handicap

	N	Minimum	Maximum	Mean	SD
Age	20	16	19	17,50	1,19
Height (cm)	19	165	199	180,05	9,10
Weight (kg)	20	54	93,10	73,50	12,24
Handicap	20	1,10	9,70	6,60	2,42

Procedures

Seated Cable Torso Rotation (SCTR): Upper body rotational concentric power was measured using the Musclelab system, an external LPT, attached to a cable pulley. The LPT has been shown to be a reliable way of measuring power output in linear motion (Bosco et al., 1995, Hansen et al., 2011). Hansen et al. (2011) tested the reliability of a LPT (HX-VPA-200, Unimeasure, Oregon) in comparison to the gold standard force plate measurement (Accupower, AMTI, Watertown, MA, USA). In conclusion, although the LPT tended to overestimate peak force slightly, it was still deemed a reliable method of testing power output. (Hansen et al., 2011)

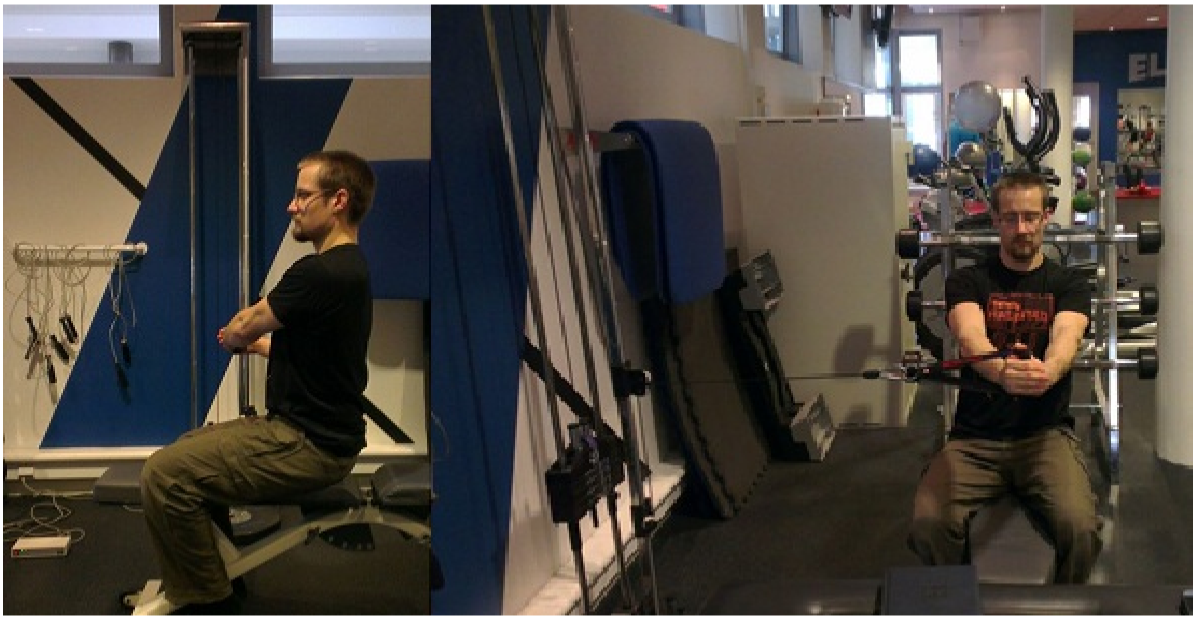

Figure 1. Seated cable torso rotation, Left – start, Right - midpoint.

Subjects were seated to eliminate excessive movement in the hip and legs with the cable pulley at chest height with arms straightened in front of the chest (Figure 1). Subjects performed three rotations on both their dominant and non-dominant side, with 1-3 minutes of rest between each side. The test used individualized resistance as a percentage of body weight. The percentage used in this study was 12 percent of subjects bodyweight for both genders. This resistance was chosen based on an earlier pilot study by the authors (Grenzdörfer & Winqvist, 2013). The authors found the other percentages used by Andre et al. (2012), 9 and 15 percent, to be too light respectively too heavy to achieve adequate technique. The procedure described above is in line with the testing procedure described by Andre et al. (2012). Subjects performed a warm-up consisting of five minutes of treadmill running at a desired pace as well as one practice rotation towards each side.

Medicine ball side throw (MBST): A three kg medicine ball was used for testing, with a measurement tape along the floor as a line of center as described by Read et al. (2013) and Gordon et al. (2009). The diameter of the medicine ball was 28 cm. The medicine ball was held in front of the body, with slightly bent arms. Subjects were asked to mimic the golf swing as much as possible and made three throws on each side, separated by the same resting period applied in the SCTR. For a throw to be valid, it had to land within two meters on each side of the center line. The rear foot was allowed to rise and rotate as in a golf swing but with neither foot losing contact with the ground. The procedure followed those described by Read et al. (2013) and Gordon et al. (2009). Subjects performed three practice throws as a warm-up.

Club head speed and Ball speed (CHS, BS): CHS and BS were measured using Flight Scope Doppler Radar System (Kudu Launch Monitor, Stellenbosch, South Africa). The radar system was placed three meters behind an artificial tee. Each subject used their own Driver with a Titlest Pro V1 golf ball and performed three swings. Subjects were encouraged to swing as fast as possible. Subjects performed a ten minute warm-up of practice swings and were blinded to the results during the test. Multiple studies have confirmed the validity of CHS as a golf performance measurement (Doan et al., 2006, Fletcher & Hartwell, 2004, Fradkin et al., 2004, Gordon et al., 2009, Read et al., 2013).

Statistics

Statistical analysis was done using SPSS 20.0. (SPSS for Windows version 20.0 SPSS Inc., Chicago, IL) Mean and standard deviation were calculated for height, weight, CHS, BS, MBST and SCTR. Pearson correlation coefficient was used to determine the relationship between CHS, BS, MBST and SCTR. Only the highest recorded repetition for each test was used for statistical analysis. Test results for left-handed subjects were inverted to examine dominant versus non-dominant side correlations.

Results

Descriptive data and correlations for CHS, BS, MBST and SCTR is shown in table 2.

Table 2. Descriptive statistics

Table 2. Descriptive Statistics, min, max, mean, SD, correlation to Clubhead speed (CHS) and Ball speed (BS)							
	N	Minimum	Maximum	Mean	SD	r (CHS)	r (BS)
Clubhead speed (mph)	20	82,40	124,10	108,44	12,35	1	0,98**
Ball speed (km/h)	20	180,80	271,20	240,07	25,77	0,98**	1
Medicine Ball Side Throw dominant side (m)	20	6,40	11,00	8,86	1,34	0,79**	0,80**
Medicine Ball Side Throw non-dominant side(m)	20	1,10	11,80	8,64	2,45	0,36	0,36
Seated Cable Torso Rotation dominant side (W)	20	111,50	280,90	190,69	47,37	0,80**	0,79**
Seated Cable Torso Rotation non-dominant side (W)	20	96,80	286,80	203,76	54,95	0,80**	0,80**

* Correlation is significant at P=0,05
** Correlation is significant at P=0,01

Mean CHS was 108,44 mph (±12,35) and mean BS was 240,07 km/h (±25,77). Average throwing length for the MBST was 8,86 meters (±1,34) on the dominant side respectively 8,64 meters (±2,45) on the non-dominant side. Average peak power in the SCTR for the dominant and non-dominant side was 190,69 watts (±47,37) and 203,76 watts (±54,95) respectively.

There were several significant correlations reported. The correlation between CHS and the MBST was r=0,79 (p=0,01) and is shown in figure 2.

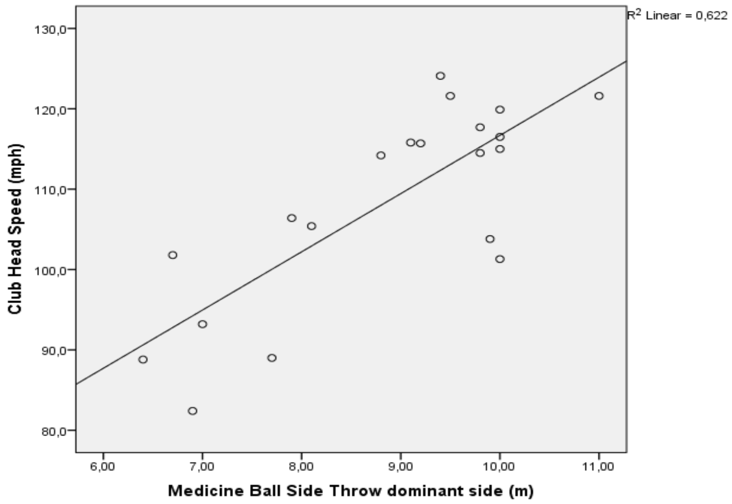

Figure 2. Scatterplot CHS & MBST

The correlation between CHS and SCTR dominant side was r=0,80 (p=0,01) and is shown in figure 3.

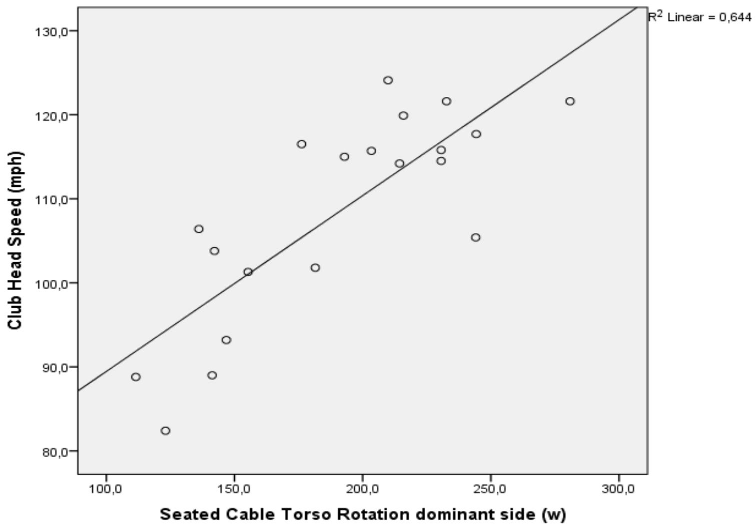

Figure 3. Scatterplot CHS & SCTR dominant side.

The correlation between CHS and SCTR non-dominant side was r=0,80 (p=0,01) and is shown in figure 4.

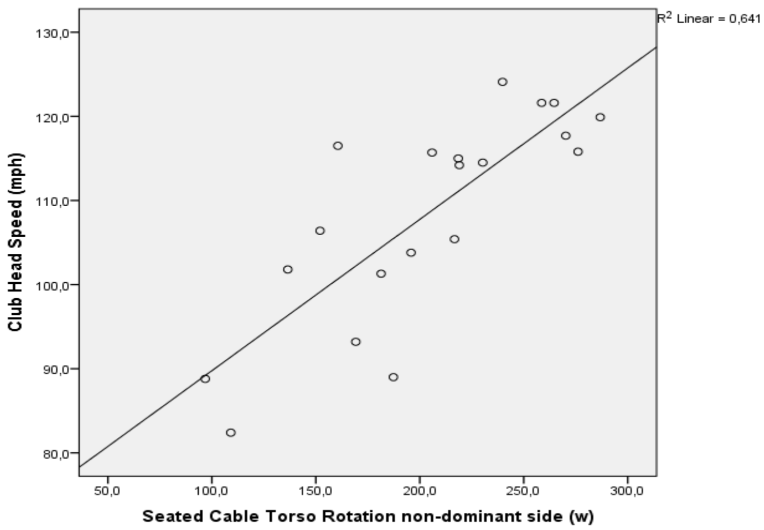

Figure 4. Scatterplot CHS & SCTR non-dominant side.

Significant correlations were also reported between BS and MBST (r=0,80 p=0,01), BS and SCTR dominant side (r=0,79 p=0,01) as well as BS and SCTR non-dominant side (r=0,80 p=0,01).

Discussion

The results of this study show a significant high correlation between the SCTR, MBST and CHS in the golf drive.

Mean CHS was 108,44 mph (±12,35). The CHS reported in our study is similar to the CHS reported by other studies examining golfers with similar level of skill (Fletcher et al., 2004, Read et al., 2013). Read et al. (2013) reported a similar CHS using the same sort of golf club (mean 106,7 mph ±6,7). Gordon et al. (2009) reported a lower mean CHS (42,4 mph, ±3,5) due to the use of a different type of golf club. This shows that when measuring CHS as a result of power produced in the swing, the leverage arms over which the forces act has to be taken into consideration. The Driver used by Read et al. (2013) has a longer shaft than the five iron used by Gordon et al. (2009). This changes the swing mechanics and is the main reason for the higher CHS.

Average throwing length in the MBST was 8,86 meters (±1,34). The MBST using a 3kg medicine ball has been used by both Read et al. (2013) (9,6m ±1,7) and Gordon et al. (2009) (8,0m ±0,9). Ikeda et al. (2009) used the same throw although with a medicine ball of a different weight, 4kg (11,2m ±2,0). All three studies showed similar throwing lengths as our study. Andre et al. (2012) reported a mean peak power of 28±11,3 watts, which is much lower than the results presented in this study (190,69w ± 47,37). Andre et al. (2012) used a cable pulley system with an unknown gear ratio, whereas the cable pulley system used in our study had a gear exchange ratio of 1:1. This might explain the difference in the power.

Our study found a strong correlation between CHS and SCTR (r=0,80 p=0,01). The SCTR has not been previously validated as a way of measuring trunk rotational power specifically for golf, although other studies have found a strong relationship between torso rotational power and CHS. This result is supported by the literature (Adler-Henerud, 2006, Keogh et al., 2009, Yoon, 1998) and implies that the SCTR is a valid test for rotational power in our subject group.

Our study also found a strong significant correlation between CHS and MBST (r=0,80 p=0,01). Previous studies have shown a moderate significant correlation between CHS and MBST. Read et al. (2013) investigated the relationship between CHS and MBST and found a linear correlation of r=0,67 (p=0,01). Gordon et al. (2009) found the relationship to be r= 0,54 (p=0,05) for total body rotational power measured by a MBST. However, the golf club used by Gordon et al. (2009) was a five-iron with a shorter club length which as previously stated was the main reason for the lower CHS. Since they compared CHS to total body rotational power, a lower CHS might weaken the relationship with rotational power, although there is still a significant correlation between CHS and rotational power regardless of which club is used. A possible cause for our statistically higher correlation between the MBST and CHS compared to earlier studies could be our subject group’s familiarity with the test. All test subjects had previously performed the MBST, which could have resulted in a more efficient throw.

Surprisingly, the MBST showed a similar correlation to CHS as the SCTR, rejecting our hypothesis that the SCTR had a stronger correlation with CHS than the MBST. This would implicate that the MBST is an good field-test for measuring rotational power in competitive amateur golfers due to its validity and simplicity. Arguments can be made that it is a more efficient and user-friendly test for measuring rotational power in athletes. The MBST also has more underlying research to support it as a field-test than the other tests mentioned in this study, including the SCTR.
Despite the subjects familiarity with the MBST, no significant correlation was found between CHS and the non-dominant MBST while CHS and the non-dominant SCTR correlated strongly (r=0,80 p=0,01). A potential cause could be the SCTR requiring less skill than the MBST as well as the somewhat higher test-retest reliability of the SCTR.

Our study further strengthens the applicability of the MBST as a good field-test for rotational power in golf. It implies that the MBST could yield similar results as more rigorous lab tests. Therefore, the MBST should be considered a valid and reliable field-test for testing rotational power in golfers.

Method discussion

The main concern regarding the cable rotation test was of course how to minimize interference from the lower body of the test subjects while measuring upper body rotational power. To eliminate lower body interference the test subjects could simply lift their legs up of the ground while sitting on a bench instead of keeping their feet towards the ground in accordance with the test procedure used by Andre et al. (2012). However, Newton's third law of motion states that "every action has an equal and opposite reaction" (Hall, 2011). Thus keeping the feet of the ground would mean that the test subjects would have to be strapped to the bench in order to isolate and generate force in one direction without the lower body rotating in the other direction. In order to keep the tests simple and user friendly, the authors decided to apply the same testing protocol in the SCTR as described by Andre et al. (2012), though a complete isolation of the upper body could provide even more reliable results for future testing (Bosco et al., 1995). Another possible source of error could be that we let each subject rotate towards the same side first, leading to a possible Post Activation Potentiation (PAP) benefiting the second series of rotations. (Baechle & Earl, 2008). Familiarization with the test could also yield a better result on the side tested last. It would be beneficial to individualize the rotation, letting each subject rotate towards either their dominant or non-dominant side first.

In regard to the MBST, the authors made note of the inconsistency of the length and displacement of the throws. The test could be further standardized by video recording the point of ball impact with the ground for a precise measurement of throwing length. Another possible solution would be to use a sand field to get an exact impact point. During the test the point of ball impact with the ground was captured by eye measurement of the place of impact and thereafter measured with measurement tape, which could have affected the test results. These potential changes to the test protocol would however negatively alter the tests practicality by requiring more specific equipment and locations.

Conclusion

Our study suggests that the medicine ball side throw is a good field-test for measuring rotational power in golfers. Although an equally strong correlation was found between the seated cable torso rotation and club head speed, the medicine ball side throw should be the desired choice when considering time and cost efficiency.

Suggestions for further research

Future research could focus on establishing the test-retest reliability of the seated cable torso rotation as well as the medicine ball side throw in correlation to golf performance measurements of a swing. Also, the seated cable torso rotation could be further standardized for future testing. Future research could also focus on applying the testing procedures used in this study on elite level golfers.

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