ISSN: 2586-6028
Website: http://accesson.kr/jsas
doi: http://dx.doi.org/10.13106/jsas.2024.vol8.no3.1

Does Acute A-tDCS (Anodal Transcranial Direct Current Stimulation) Improve Golf Performance of Professional Golfers?

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Received: September 06, 2024. Revised: September 06, 2024. Accepted: September 18, 2024.

Abstract

Purpose: This study aims to verify the effectiveness of acute anodal transcranial direct current stimulation (A-tDCS) using Halo Sport headset device on golf performance in professional golfers. **Research design, data, and methodology*:*** Eight professional golfers who voluntary participated in high-level golf tournaments were recruited in this study. They attended one single-session intervention which was stimulated by Halo Sport headset device (n=8). The A-tDCS halo sport session lasted for 20 minutes and stimulated on the motor control area of the cortex (M1). Four golf swing performance tasks (driver, iron, 100-yard shot, 50-yard shot) were performed before and after halo intervention. Key indicators of golf swing performance (Club Speed, Face Angle, Ball Speed, Smash Factor, Spin Rate, Side, Carry, Total) were collected by Trackman launch monitor. **Results:** In Halo session, there were no found statistical significance in driver, iron and approach (100, 50 yards) after intervention ($P<0.05$). Even some of variables (face angle, smash factor, carry and total distance) in driver, distance accuracy of 100 yards and direction accuracy of 50 yards were slightly improved tendency, but it was not significant ($P<0.05$). Meanwhile, there was any enhance all of variables in iron. **Conclusions:** As a result, the current study concludes that the acute A-tDCS halo sport intervention has no effect on the positive golf performance improvement for professional players. Further implications were discussed.

Keywords: A-tDCS, Acute, Golf performance, Professional golfer, Trackman

JEL Classification Code: H53, H72, I31, L83

1. Introduction

Golf swing was considered as one of the most complicated movements while adjusting of the musculoskeletal control, appropriate coordination of the kinetic chain, and precise judgment to the target (Hume, Keogh, & Reid, 2005). Generally, the golf players usually have similar playing strategy at each hole. Long driving distance would take an advantage to the hole cup while remaining short approaching. Then, the consistent iron or wedge swing mechanism could be a fundamental capability to score in golf. Therefore, many of researchers and coaches have been endeavored to improve golf performance in many respects for decades. For example, golf biomechanical analysis has developing to verify swing movement efficiency with three dimensional motion capture, kinetic chain with ground reaction force, muscle participation with electromyography, and measure ball or club data with a radar launch monitor device (Mahadas, Mahadas, & Hung, 2019; McHardy & Pollard, 2005). However, still many other areas of research to enhance golf skill and performance are suffering lack of scientific trial and evidence.

Transcranial direct current stimulation (tDCS) a representative non-invasive brain stimulation (NIBS) method has been conducted in animal and human experiments for several decades, to modulate brain physiology, cognitive functions, and motor behavior with controversial remaining in ethical and legal implications. There has been a long history of applying tDCS within the realm of clinical medicine and psychiatry (Herrera-Melendez, Bajbouj, & Aust, 2020), with an outstanding effect in curing stroke, schizophrenia, and other neurodegenerative disorders (González-Rodriguez, Serradell-Ribé, Viejo-Sobera, Romero-Muñoz, & Marron, 2022; Salehinejad, Ghanavati, Glinski, Hallajian, & Azarkolah, 2022). Human activity is controlled by different cerebral cortices (Power, Cohen,

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Nelson, Wig, Barnes, Church, Vogel, Laumann, Miezin, Schlaggar, & Petersen, 2011), thus the target area of stimulation would result in the variation of intervention outcomes. In addition to patient treatment effects, there have been reports that tDCS has also improved among healthy people. Meanwhile, the interest in NIBS have been grew to develop performance in many different sport categories. In pursuit excellence, already athletes have experience to use it direct or indirectly influence the brain in their own training and practice level. In the recent papers have questioned the effectiveness of tDCS to improve various sports performance in cycling with enhancing peak power and reduced heart rate (Marcelo, Massaru, Henrique, Maurizio, Sergio, Felipe, & Ricardo, 2015), elite athletes with potential competitive advantage (Borducchi, Gomes, Akiba, Cordeiro, Borducchi, Valentin, Dias, 2016), professional swimmers with reducing mental fatigue (Nikooharf Salehi, Jaydari Fard, Jaberzadeh, & Zoghi, 2022), volleyball with increasing spiking velocity and consistency (Park, Han, Hong, & Lee, 2023).

Sport performance is a complex body movement combination under the specific mission task which is accompanied by highly developed cognition and technique (Nevill, Atkinson, & Hughes, 2008). However, the procedure of tDCS in the laboratory could be an inefficient and uncomfortable process for elite athlete. Especially, golf is a typical outdoor sport, and most training, tournament, and warm-up session before the competition are hardly provided to verify acute effects of tDCS on golf performance. So, we are focusing Halo sport wearable headset which is commercially designed while using tDCS to deliver weak direct currents over the scalp through surface electrodes with the intention of inducing changes in both sides of the motor cortex. There are rarely explored the effect of Halo sports, although the functional effects of tDCS have been proven in many past research. Nevertheless, some of PGA players using Halo sports device on warm-up practice phase before tee-off reported.

In this respect, the current study is considered worthwhile to verify acute effects on golf performance for professional golfers.

Among the few studies of golf, there was a report that the putting task experiment which was 48 novice golf players participated revealed no significant effects on the study. Even the tDCS improved motor learning process of the participants by M1 area stimulation, the final result was dependent on the player's initial performance (Parma, Profeta, Andrade, Lage, & Apolinário-Souza, 2021). Overall, although bunch of previous studies demonstrated that tDCS could improve sports performance in various aspects, there is a lack of research on whether it is effective in complicated movement mechanism such as golf. To the best of our knowledge, there were no studies investigating the effects of tDCS between golf swing performance and specific variables of the professional golfers.

Therefore, the purpose of this study was motivated by the practical effects of tDCS using halo sports on the effect of golf specific performance change. Furthermore, the halo sports as a portable and light weight wearable headset device used in the current study would be welcome to all level of golf plyers to develop golf performance in the respect of convenience and inexpensive, if the validity would be verified. Finally, we are expecting the result of the study would be applicable in many of golf field by coaches, researchers, and players.

2. Methods

2.1. Subjects

Nine professional golfers who are competing at the CPGA (Chinese Professional Golf Association) and CLPGA (Chinese Ladies Professional Golf Association) participated in the study. Data from 8 golfers who completed all experimental sessions were collected for analysis (4 males and 4 females; Mean ± SD: age, 22.3 ± 2.0 years, height, 176.63 ± 10.94 cm, and body mass 74.38 ± 15.24 kg, right-side dominant players). Before the study, all participants were fully informed of the experiment procedures and the possible risks before providing informed consent. The study obtained written consent from all participants, and all research procedures received approval from the institutional review board at Shanghai University of Sport.

2.2. Experimental Design

The study was consisted of one single sessions for acute effects of A-tDCS Halo Sports device (Halo Neuroscience Inc., San Francisco, CA, United States). Before the experiment start, each participant was fully adjusted at the place and warm-up with their own clubs at the same time for 15 min, then collected every club performance variable as a pre-measurement data. During the Halo Sports device stimulation session, all participants were asked to sit comfortably on a chair then received the same intervention in the indoor golf screen room. The pads were fully soaked by saline attached on the target cortex position (M1), then stimulation lasted for 20 min while asked participant's restricted movement as possible as during the stimulation. The device was controlled by application paired between the device and smart phone. After stimulation, the participants immediately asked to warm-up as a final stage before golf performance measurement with three different clubs (driver, 7# iron, wedge) within 5 min. The whole process to measure golf performance after stimulation did not over half an hour. All participants completed tDCS intervention and all the tasks. No side effects or injuries were reported. The experimental depiction of the Halo Sports stimulation is shown in <Figure 1>.

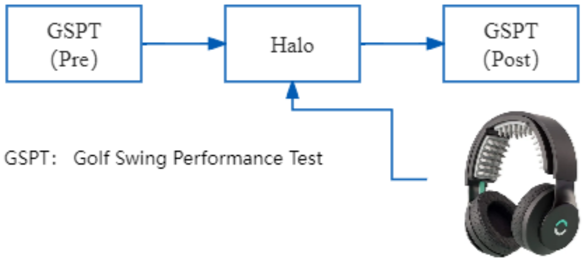

Figure 1: Experiment depiction of the study design

2.3. Data Collection (golf performance variables)

The measurement of golf performance was conducted in an indoor screen golf room with a while thick curtain (5 m-wide × 3.5 m-high) at the target direction. The Trackman Doppler radar device (Trackman, ISG A/S, Denmark), which was placed 3 meters behind toward the striking position according to the manual, was used for monitoring the trajectory of club and ball flight with the visualization software (Trackman V-2.2.161.0, ISG A/S, Denmark) to determine the quality of each attempt and collect the data <figure 2>. Participants were asked to use their own golf clubs (driver, 7# iron, and wedge) for the golf performance measurement. Shoes and gloves used their own during the process as well. The ball used the experiment was provided a specialized three pieces ball provided with aluminum circle stickers attached on the ball surface for correct ball launch data. Every single participant completed at each club (driver, 7# iron, 100 yard, and 50 yards with wedge) for 5 times trials and the average of three data which was eliminated the highest and lowest were used to analysis. As following, the main variables obtained from golf performance measurement were divided into two main categories: club data (club speed, face angle) and ball data (flight time, spin rate, ball speed, smash factor, carry, side total). The characteristics and definitions of golf performance variables by the Trackman were indicated on the <table 1>.

Table 1: Characteristics and definitions of golf performance variables by the Trackman

Contents	Definition	Type of data	Display
Club Speed (mph)	- Club Speed is the speed the club head is traveling immediately prior to impact.	Club variable	Distance
Face Angle (deg)	- The direction the club face is pointed (right or left) at impact.	Club variable	Accuracy
Flight time (s)	- The total flight time of ball from the start at impact to land on the ground.	Ball variable	Distance
Spin rate (rpm)	- Amount of ball spin after impact.	Ball variable	Accuracy Distance
Ball Speed (mph)	- The speed of the golf ball immediately after impact.	Ball variable	Distance
Smash Factor	- Calculated value of ball speed divided by club speed. - Amount of energy transferred from the club head to the golf ball.	-	-
Carry (yards)	- The distance the ball travels through the air.	Ball variable	Distance
Side (yards)	- The distance the absolute deviation to the target (right or left) when the ball land.	Ball variable	Accuracy
Total (yards)	- The carry distance added to the roll distance.	Ball variable	Distance

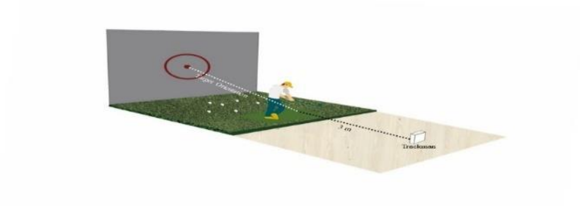

Figure 2: Indoor screen golf experiment depiction

2.4. Statistical Analysis

The reliability of Trackman monitor has been proved in previous study (Shaw, Gould, Oliver, & Lloyd, 2023). The swing performance data (clubhead speed, face angle, ball speed, smash factor, spin rate, side distance, carry distance, total distance) was exported from the visualization software and managed by Microsoft Excel. The data was analyzed using the SPSS (Version 29.0.1.0, IBM). For the Halo session, paired sample t-tests compared the pre and post data to evaluate the effectiveness of Halo stimulation. All results are reported as Mean ± Standard Deviation. The statistical significance level was <0.05.

3. Results

3.1. Driver Performance Variations after Halo Sports Stimulation

The result of driver performances comparison between pre and post are shown in <table 1>. The only statistical significance was found in club speed among other driver's variables (p<.05). Although some variables were indicated slightly to improve tendency in face angle, ball speed, smash factor, carry and total distance, it was not validity for statistical significance (p>.05).

Table 2: The result of driver performance variations

Variables	Pre (Mean ± SD)	Post (Mean ± SD)	t	*P*
Club Speed (mph)	100.13±13.29	100.80±13.14	1.32	.007*
Face Angle (deg)	0.54±1.42	0.36±1.67	.20	.585
Ball Speed (mph)	149.19±19.81	149.64±18.73	.24	.523
Smash Factor	1.49±0.03	1.5±0.02	.39	.303
Spin Rate (rpm)	2346.25±474.29	2318±289.07	.13	.723
Side (yards)	-6.74±12.6	-7.07±10.83	.04	.903
Carry (yards)	242.81±35.65	243.64±36.51	.14	.714
Total (yards)	269.42±31.77	270.01±34.77	.09	.816

Note. **p<.05*

3.2. Iron (7#) performance Variations after Halo Sports Stimulation

The iron performance variation was similar with driver task. The only club speed was revealed statistical significance after stimulation (p<.05). Also, other variable such as ball speed, carry, and total distance was shown to improve tendency likewise driver, but there was no statistical significance found (p>.05). As an accuracy indication, meanwhile, face angle and side have shown decreased tendency, but still no statistical significance found (p>.05).

Table 3: The result of iron performance variations

Variables		Pre (Mean ± SD)	Post (Mean ± SD)	t	*p*
Club Speed (mph)		82.25±8.36	83.33±8.91	.85	.047*
Face Angle (deg)		-1.33±1.4	-2.26±1.91	.60	.135
Ball Speed (mph)		114.06±11.56	114.89±11.37	.41	.281
Smash Factor		1.39±0.04	1.39±0.03	.29	.442
Spin Rate (rpm)		6346.75±620.81	6205.75±642.21	.44	.257
Side (yards)		-4.98±3.45	-8.4±4.86	.57	.154
Carry (yards)		157.58±18.9	158.41±17.86	.23	.544
Total (yards)		165.81±19.09	166.02±17.19	.05	.900

Note. **p<.05*

3.3. Wedge (100, 50 yards) Performance Variations after Halo Sports Stimulation

The post outcome of wedge performance on both of two different target distance (100, 50 yards) found to improve tendency in accuracy of distance and direction control compare with pre-measurement. However, there was no statistical significance found (p>.05).

Table 4: The result of wedge performance variations

Variables		Pre (Mean ± SD)	Post (Mean ± SD)	t	*p*
100 yards	Side (yards)	-4.07±2.81	-3.96±2.03	.041	.911
	Carry (yards)	97.9±7.54	98.35±4.26	.096	.794
50 yards	Side (yards)	-2.6±1.3	-2.47±0.52	.096	.793
	Carry (yards)	36.81±2.92	38.25±7.45	.246	.510

Note. **p<.05*

4. Discussion

The current study was designed to evaluate the acute effectiveness of tDCS using halo sports device on the golf performance variation which was consisted of driver, iron (7#), and wedge (100, 50 yards). In this study, we are focusing on two different fundamental indications in golf, such as long driving distance, and accuracy to the target after stimulation whether it could be effect to improve for these.

The ability of long driving distance is not only considered as one of key factor to achieve successful accomplishment, but also its importance is growing in the modern golf competition (Joyce, Burnett, Cochrane, & Ball, 2013). Also, the club head speed has been considered as a main variable for a long driving distance (Hume, 2012). In this matter, the result of current study found significant club head speed improving in both of driver and iron after stimulation (p<.05). Additionally, other post outcomes which were related with driving distance like ball speed, carry, and total distance in both of driver and iron were revealed develop tendency as well, but it was not statistically significant. These finding are an important to state that tDCS respectfully harbors the potential to improve golf performance and physical capabilities. In previous studies, there were some reports to enhance muscle peak power, endurance, and decrease fatigue with tDCS (Angius, Mauger, Hopker, Pascual-Leone, Santarnecchi, & Marcora, 2017; Borducchi, et al., 2016; Okano, Fontes, Montenegro, Farinatti, Cyrino, Li, Noakes, 2015). In this matter, the increased club head speed of the study may have influenced on improved neuromuscular efficiency as reflected by modulate brain excitability. Generally, golfers have to work a lot of time to increase driving distance while working out physical training, modifying swing mechanism, and practice in the driving range. Therefore, it may worth to consider applying tDCS as a training strategy in warm-up and practice stage for increasing head speed for golfers.

The accuracy as another crucial requirement in golf was measured in order to verify the effects of tDCS through comparing relative variables like club face and side between pre and post outcomes. However, there has no statistical significance found in both of driver and iron, but slightly improve tendency for it. Moreover, the experiment of two different target (100, 50 yards) used by wedge to see distance and direction accuracy control shown just enhanced tendency, there was no significance found after stimulation. At this matter, some of previous study provided negative or no significant effect about the tDCS(Furubayashi, Ugawa, Terao, Hanajima, & Kanazawa, 2000; Kan, Dundas, & Nosaka, 2013). Also, when the tDCS applied to complex movement, its precise mechanisms and effects remain unknown (Angius, et al., 2017). Additionally, the high levels skilled professionals who participated in the study might affect to have significance on the acute advantage of tDCS.

As far as we know, it is the first study to examine the acute effect of tDCS using Halo Sports device on the specific golf performance in relation with long driving ability and shot accuracy to the target. Even most of post variables did not find significant variation, but we could find the positive phenomenon which were presented improved of club speed and other variables developed tendency through the current study. It might have an applicable possibility to improve golf performance for golfers with combined conventional method and tDCS. Also, the design of Halo Sports device is a portable, wearable, and inexpensive. Therefore, it could have advantages to apply for golf training and coaching in driving range and field.

5. Conclusion

The aim of present study is to examine the acute effects of tDCS using Halo Sports device on golf swing performance with ability of long driving distance and accuracy toward the target. The study found a positive result in club head speed of driver and iron (#7), and other relative variables revealed improved tendency as well. As a limitation of the study, however, a design of experiment may not enough to verify the effects due to its small sample size and one single stimulation session. Thus, we expect that future studies will focus more on increased sample size with various skill level golfers and long-term cross over study plan respectively.

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