Effect of transcranial direct current stimulation with handgrip strength training in amateur badminton players

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ABSTRACT

Objective. The objective of this study was to explore the effect of tDCS with the hand grip strengthening exercises in amateur badminton players.

Materials and method. The study was a participant blinded randomized controlled trial. 30 amateur badminton players of age group 8-20 years with a minimum playing experience of 6 months were included in the study. The measurements of hand grip strength (HGS) were assessed at the baseline, Day 1, 4, 8 and 12.

Result. The result of the present study showed insignificant difference in hand grip strength when between groups comparisons were done. The overall interaction effect between the groups was found to be insignificant ($p = 0.722$) whereas, overall interaction effect within the group was found to be significant (p = 0.011*). Result of multiple comparisons showed maximum improvement in HGS at 12 from the baseline value.

Conclusion. The application of anodal tDCS along with the HGS training was ineffective in improving the hand grip strength in amateur badminton players.

Keywords: hand strength, non-invasive brain stimulation, racquet sport

INTRODUCTION

Transcranial direct current stimulation (tDCS) is gaining significant attention in the sports world. While initially developed for clinical applications in various neurological and musculoskeletal conditions, its use has gained traction in the sports community as a potential tool for enhancing athletic performance and recovery [1,2]. Transcranial direct current stimulation (tDCS) is a non-invasive brain stimulation technique that applies a low electrical current to the scalp, modulating neuronal activity, potentially enhancing physical performance, cognitive function and recovery.

The application of tDCS as an ergogenic aid in various sports has also been investigated [3]. The use of anodal tDCS is reported to be valuable in improving muscle power, endurance and strength [4,5]. A single session of anodal tDCS over M1 in combination with the voluntary grip exercises produces two fold increase in the motor evoked potentials [6]. An increase in maximal voluntary isometric contraction (MVIC) of the shoulder rotators in hand ball players and knee extensors in soccer players was also observed following the application of tDCS [7,8]. A transient increase in the maximum leg pinch force has been observed with the application of anodal tDCS in healthy individuals [9]. In addition to this, anodal tDCS with the strength training improves muscle strength in healthy individuals [4]. The role of tDCS has also been explored on skilled motor performance and motor functions in terms of power and fatigue. Its application showed improvement in the scores related to activities of daily living reflecting improvement in motor activity [10]. Similarly, improvement in the motor performance of upper and lower limb was also reported in stroke patients with the application of tDCS [11,12].

While the use of tDCS is considered safe and has the ability to regulate brain activity broadly, it is yet unclear if it can actually enhance elite sports performance. The application of tDCS offers exciting possibilities for enhancing sports performance, but it should be approached cautiously. Athletes considering its use should consult with professionals to ensure safety and efficacy.

Badminton is a fast paced racquet sport requiring players to have excellent footwork, rapid change in direction, and imparting powerful shots. A Badminton player holds the racket and uses prehensile grip forces to execute different strokes by altering the positions of the wrist to manipulate the racquet for projecting the shuttlecock. The grip force is one of the important motor skill in the game of badminton. A strong hand musculature influences the handgrip strength and enhances the velocity of the smashes impacting the overall performance of a player [13].

Previous researches have explored the role of tDCS on motor skills and motor function of upper and lower limbs in various conditions. However, there is a dearth of research examining the impact of tDCS on hand motor function, particularly hand grip strength in sports like badminton where hand grip strength is crucial. Therefore, the present study was undertaken to explore the role of tDCS given in combination with the hand grip strengthening exercises in Amateur badminton player. Therefore, the goal of this study is to investigate the effect of tDCS, when combined with hand grip strengthening in amateur badminton players.

MATERIALS AND METHODS

Participants

The present study was a participant blinded randomized controlled trial. The study was conducted on players at Shuttle Masters Badminton Academy in Hisar city, Haryana, India. The ethical approval for the study was taken from the Institutional Ethics Committee vide letter no. PTY/2022/155. The trial was also registered in Clinical Trial Registry of India (CTRI/2022/06/043591) and was performed as per declaration of Helsinki 2013. The inclusion criteria for the study was girls and boys of age 8-16 years, amateur badminton players with a minimum playing experience of 6 months and willing to participate. The exclusion criteria was players with history of any injury on elbow, wrist or hand in last 3 months, consuming any pain medication, history of epilepsy and recreational players.

Procedure

A total of thirty nine players were screened for participation in the study. Thirty participants were selected following the inclusion and exclusion criteria for the study and were randomly allocated to Group A (Active tDCS) and Group B (Sham tDCS) using lottery method. A written informed consent was obtained from all the participants prior to their participation in the study.

Participants in Group A (Active tDCS) were given single session of tDCS for 20 minutes along with hand grip strengthening exercises for 4 days per week for 3 weeks. The participants in Group B (Sham tDCS) were given sham stimulation for 20 minutes followed by the hand grip strength training four days per week for 3 weeks. Figure 1 shows the flow chart of the study. The outcome variable for the study was hand grip strength measured at Day 1, 4, 8 and Day 12.

Transcranial direct current stimulation

The application of tDCS was given through a battery powered device. A current of 2 mA was given by a pair of circular sponge electrodes covered with sponges soaked in normal saline. The anode was placed on primary motor cortex (M1, C3 or C4) on the left side of the brain as per 10/20 International electroencephalogram EEG system and the cathode was placed on right supra orbital area. For sham stimulation, with the same electrode placement the current was given for initial 30 seconds, and then was turned off.

Hand grip strengthening

All the participants performed a warm up session of 5 minutes which included gentle stretching of upper limb followed by the hand grip strengthening as per the protocol mentioned in Table 1.

Hand grip strength evaluation

The assessment of hand grip strength was done using a hand held dynamometer (Jamar). The participants were seated on a chair with shoulder adducted and elbow flexed at 90˚, forearm in neutral position, wrist in 30˚ dorsiflexion and 15˚ ulnar deviation. They were then asked to squeeze the dynamometer thrice and the average of the three readings was noted.

The evaluation of hand grip strength was done at baseline and at Day 1, 4, 8 and 12 post stimulation.

DATA ANALYSIS

The data was analyzed using SPSS (version 21.0). The data was presented as mean and standard deviation. Unrelated t-test was used for between group comparisons and related t-test for within group comparisons of the outcome variables. Repeated measure ANOVA was used to see the overall interaction effect of intervention between and within the group at various time points. The level of significance was set at $p<0.05$.

RESULTS

The demographic characteristics of all the participants were recorded at the baseline (Table 2). The present study had 80% male and 20% females of age group between 15-20 years. The mean age of the participants were 18.43±1.68 years and the mean experience of play was 12.30±5.17 months, the mean weekly training hours was 19.13±3.20 hours. The result of the present study showed no improvement in hand grip strength at any time point of assessment when between group comparisons were done. Table 3 shows the between group comparison of hand grip strength.

The result of repeated measure ANOVA also showed no significant interaction effect of the intervention at any time points of assessment between the groups ($p=.722$). However, the within group interaction effect were found to be significant ($p=.011$**). The post hoc comparisons for within group effect of the intervention showed maximum improvement in the hand grip strength at day 12 MD=-1.591, 95%CI(-2.135,-1.047) as compared to the baseline value showing that the repeated application of tDCS improved the hand grip strength. The result of paired t-test for within group analysis showed improvements in hand grip strength in both the groups irrespective of the active and sham tDCS application suggesting that the application of tDCS might not have any influence on the HGS rather it is the hand grip strength exercises that have improved the HGS in both the groups.

Table 4 shows the values of multiple comparisons of the outcome variable at various time point using repeated measure ANOVA.

DISCUSSION

The present study aimed to investigate the effects of tDCS along with hand grip strength training on the hand grip strength in amateur badminton players. The result of the study showed no improvements in the hand grip strength when compared between the groups. However, the improvements in HGS were found to improve HGS when within group comparisons were done. The post hoc comparisons showed maximal improvement in HGS at day 12 from the baseline value.

The insignificant improvement in handgrip strength observed in the present study can be ought to the incongruous stimulation site and the arrangement of electrodes used in the study. The present study used anodal stimulation of left side of the brain and cathode on right supraorbital area, this arrangement of electrodes might not be able to induce the changes in the cerebral cortex and to cause facilitation of the left M1 motor pathway. In contrast to this, findings from a study also suggests that the tDCS stimulation over right cathode and left anode (RcLa) area significant improvement in unimanual and bimanual grip strength as compared to right anode and left cathode (RaLc) and sham stimulation [14]. This suggests that the stimulation site used in our study was inappropriate.

In addition to this, another possible reason for no improvements in HGS could be the stimulation intensity used in the study. The present study used stimulation intensity of 2 mA which might not be effective in inducing changes in the hand grip strength. A study that has also suggested that the application of tDCS at higher intensities i.e of more than 1.5 mA may not necessarily increase the excitability of the cortex, and recommends to use lower intensity to attain the desired effect of the stimulation [15].

There are various studies that suggest cathodal tDCS over M1 produces the changes in the excitability of the cortex regardless of the polarity [16, 17]. An improvement in time to exhaustion was reported in knee extensors when anode was placed over left motor cortex and cathode above the shoulder as compared to anode on left motor cortex and cathode on contralateral forehead [18].

Bilateral anodal tDCS also increases the corticospinal excitability regardless of the side stimulated suggesting the role of polarity of electrodes [19]. Therefore, the site, polarity of electrode and the intensity of stimulation might not be appropriate to produce changes in the hand grip strength in the present study.

Similar to the finding of present study, there are studies that showed no improvement in hand grip strength in cerebellar disorder patients and in patients with unilateral cerebral palsy [20, 21]. A review had also suggested that the application of tDCS had no significant effect on the upper limb strength, but showed improvement in the endurance in healthy individuals [22]. Another study in post stroke hemiplegia patients had also suggested improvement in motor function but no improvement in the hand grip strength [12]. In contrast, there are studies that have shown the positive effect of tDCS on motor function of the hand and displayed the motor learning effect of the intervention.

The application of anodal tDCS has been shown greater improvement in the metronome assisted task and speed accuracy tradeoff function of hand in healthy individuals displaying the motor learning effect [23]. The application of dual tDCS has also shown improvement in the precision hand grip and digital dexterity in paretic hand after stroke [24]. The application of bilateral tDCS produces greater improvement in the grip strength and supports its use in sports requiring bilateral coordination of upper limb [26]. Similar findings were suggested by another study that also showed improvement in grip forces with the application of tDCS in healthy older adults [25]. A positive effect was also displayed by the use of anodal tDCS with strength training on muscle power [26]. It was also reported that anodal tDCS applied over primary motor cortex enhances the precise movement of the hand in healthy participants [27].

Various studies have explored the role of tDCS on stroke and cerebellar patients and have shown improvement in the motor performance of upper and lower limb. It sequels the modulation in the neural activation and plasticity of the synapse and increase the activity of the cerebral cortex thereby, promoting the functional recovery in these patients [9, 10, 11, 12]. Thus, the result of these studies reflects the varying results on motor learning effect induced by tDCS. Thus, it can be interpreted from the results that the application of tDCS is effective in improving the motor skills but has no influence on the HGS.

The present study encounters some limitations such as small sample size and single blinded nature of study. Thus, future researches on larger sample size and double blinded randomized controlled trials using different stimulation site, intensity and polarity can be done to further explore the effect of tDCS on hand grip strength in badminton players.

CONCLUSION

Transcranial direct current stimulation with hand grip strength training was ineffective in improving the hand grip strength in amateur badminton players.

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TABLE 1: Hand Grip Strengthening Training Protocol

Exercises	Weeks		
	Week 1	**Week 2**	**Week 3**
Ball Squeezing	2 sets (20 reps)	3 sets (20 reps)	4 sets(20 reps)
Hand Grippers	2 sets (15 reps)	3 sets (15 reps)	4 sets(15 reps)
Wrist flexion with dumbbells	2 sets (20 reps)	3 sets (20 reps)	4 sets(20 reps)
Wrist extension with dumbbells	2 sets (15 reps)	3 sets (20 reps)	4 sets(20 reps)

*reps=repetitions

TABLE 2: Demographic Characteristic of the study participants

Group		**N**	**Mean**	**Std. Deviation**	**t-value**	**p-value**
Height (cm)	**Group A**	15	164.13	6.47	.328	.745
	Group B	15	163.40	5.75		
Weight (kg)	**Group A**	15	59.73	6.89	.956	.347
	Group B	15	57.73	4.27		
BMI	**Group A**	15	21.82	1.29	.499	.621
	Group B	15	21.59	1.30		
	Group A	15	19.13	3.20	1.890	.069

Weekly Training (hours)	**Group B**	15	16.80	3.55		

TABLE 3: Between group comparison of the Handgrip Strength

Hand Grip Strength		**N**	**Mean**	**Std. Deviation**	**t-value**	**p-value**
Baseline	**Group A**	15	41.18	14.70	.348	.730
	Group B	15	39.23	16.03		
Day 1	**Group A**	15	41.55	14.87	.274	.786
	Group B	15	40.01	15.92		
Day 4	**Group A**	15	41.93	14.93	.275	.785
	Group B	15	40.37	15.93		
Day 8	**Group A**	15	42.55	15.03	.364	.718
	Group B	15	40.46	16.37		
Day 12	**Group A**	15	43.04	14.91	.441	.663
	Group B	15	40.55	15.94		

TABLE 4: Multiple comparison of the outcome variable at various time points using Repeated measure ANOVA

Pairwise Comparisons						
Hand_Grip_Strength		Mean Difference	Std. Error	p-value	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Baseline	Day 1	-0.580*	.127	.002**	-1.006	-.154
	Day 4	-0.945*	.145	.0001**	-1.429	-.461
	Day 8	-1.301*	.162	.0001**	-1.842	-.761
	Day 12	-1.591*	.163	.0001**	-2.135	-1.047
Day 1	Day 4	-0.365	.151	.475	-.871	.140
	Day 8	-0.721*	.152	.001**	-1.229	-.213
	Day 12	-1.011*	.142	.0001**	-1.486	-.537
Day 4	Day 8	-0.356	.153	.581	-.868	.156
	Day 12	-0.646*	.152	.005**	-1.155	-.137
Day 8	Day 12	-0.290	.111	.306	-.662	.082