Effects of Concentration Training with Brainwave Biofeedback on Tennis Performance

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Abstract

This article presents evidence of effectiveness of 12-week concentration training program with brainwave biofeedback on concentration ability and tennis performance. Eight male tennis players were divided into two groups (Experimental and Control). Experimental group (n = 4) completed a series of training program using the Q-Jump computer system. Experimental task was one-set tennis singles with no-ad scoring system. The participants responded to the Korean version of the Test of Attentional and Interpersonal Style (TAIS) before and after the experiment. The results revealed that the concentration training program (a) was effective in improving concentration intensity and duration, (b) led to significant impact on attentional style, and (c) helped to improve tennis performance. Correlational analyses revealed negative relationships between concentration indices and unforced errors. Overall, these findings suggest that concentration is critical mental skill in tennis and can be improved through systematic training program.

Key Words: Concentration training, Brainwave, Biofeedback, Tennis

Ⅰ. Introduction

Ability to focus or concentrate is one of the critical characteristics of successful athletes. Empirical evidences from studies with elite athletes support that concentration is associated with peak performance. Specifically, successful athletes are absorbed in the

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present with no thoughts about the past or future. In addition, they are mentally relaxed with high degree of concentration (e.g., Garfield & Bennett, 1984). Comparisons between successful and less successful athletes also suggest that ability to concentrate is important in discriminating the two groups (Gould, Eklund, & Jackson, 1992). These findings appear to have cross-cultural generality. For example, research with Korean tennis players revealed that successful athletes are more likely to maintain high level of focus, as opposed to becoming distracted by irrelevant thoughts (e.g., Bae, 1999).

Relative to the importance of concentration in successful sport performance, it is surprising that little effort has been directed to demonstrate efficacy of concentration training programs for athletes. There exist many attentional training programs developed to help athletic performance (e.g., Nideffer, 1985). However, little work has been done to provide empirical evidence for effectiveness of concentration training programs or devices. The main purpose of this study was to examine the effects of concentration training procedures using brain wave regulation on athletes' ability to focus and tennis performance.

Ⅱ. Methods

Eight male tennis players (ages 20 to 21, mean years of experience 8.5), representing a university in Korea, participated in this study. Pretest league match was held in order to rank the eight players. Based on the results of the match, eight players were divided into two groups (Experimental and Control) so that the groups are similar in terms of their tennis performance. Experimental group participated in the 12-week concentration training program designed to improve concentration. The concentration training program employed a computer system called Q-Jump (Korean Research Institute of Jungshin Science, 2000) for inducing and monitoring brain wave activities. Q-Jump allows the players to perform a series of computer-based games designed to enhance ability to concentrate. While playing several types of computer games, the players' brain activities were instantly provided through visual and auditory monitoring system. They were asked to score higher points by focusing their attention using the brainwave biofeedback. The system calculates concentration intensity (strength of brainwave responsible for concentration), endurance (time spent on target), and channeling ability (number of successful shift of attentional focus) for each player. The players in the experimental group participated in the training 4 days per week. Each session lasted about 20 minutes.

All participants completed the Korean version of the Test of Attentional and Interpersonal Style (TAIS; Nideffer, 1976) before and after the training and three times during the training. Tennis performance was also measured at the time when the Korean version of the TAIS was administered. The number and percentage of unforced error were counted for each player while playing one-set tennis match with no-ad scoring system. Each player completed four matches with a player in the other group. For example, an athlete in the experimental group competed against each of the four athletes in the control group. Unforced errors were defined as errors made by a player when theopponent did not make any effective shots (e.g., double fault in serve, mistake in ground strokes and passing shot, and- out-of-bound shot).

To determine the effectiveness of the concentration training program, descriptive statistics and repeated measure analysis of covariance (ANCOVA) were performed for attentional style, concentration (intensity, endurance, and channeling ability), and tennis performance. Correlations between concentration and tennis performance were also calculated for the experimental group. Patterns of changes in concentration and tennis performance were examined for the experimental group.

Ⅲ. Results

Means and standard deviations for the three indices of concentration scored with Q-Jump simulation exercises are displayed in Table 1. The experimental group showed rapid increases in all of the three concentration indices. Specifically, the posttest scores for the experimental group were approximately 5 times greater than the pretest scores. This result suggests that concentration training with brainwave biofeedback was effective in improving the players' concentration. Notably, the players in the experimental group showed rapid increases in the 3rd and 6th weeks. This suggests that the players were able to regulate their brainwave patterns even after a short period of training. For the control group, slight increases in the three indices of concentration were found.

A series of analysis of covariance (ANCOVA) with repeated measures were employed to determine the effectiveness of the concentration training across the pretest and posttest. The results of ANCOVAs for the intensity and endurance were statistically significant, indicating considerable improvement of players' concentration for the experimental group [F (1, 5) = 10.46. $p < .05$; F (1, 5) = 6.06, $p < .05$]. The result of ANCOVA for the channeling was not significant.

Table 1. Changes in Concentration Indices for Experimental and Control Group

Group	Concentration	Pretest M (SD)	3rd week M (SD)	6th week M (SD)	9th week M (SD)	Posttest M (SD)
Experimental	Intensity	15.5 (18.9)	46.0 (24.1)	64.7 (11.7)	66.7 (12.8)	73.5 (8.6)
	Endurance	15.7 (11.1)	37.8 (31.1)	54.7 (32.1)	63.3(24.5)	72.7 (17.5)
	Channeling	1.5 (1.2)	3.9 (2.0)	6.5 (0.7)	5.9 (0.9)	6.5 (1.2)
Control	Intensity	27.0 (23.7)	35.5 (32.0)	34.5 (24.3)	38.0 (29.5)	35.7 (25.2)
	Endurance	21.7 (32.1)	26.7 (25.1)	25.7 (37.8)	32.2 (22.5)	27.7 (23.1)
	Channeling	2.0 (1.8)	3.5 (3.2)	1.2 (0.9)	4.2 (2.9)	4.0 (4.8)

Note: Means for intensity and endurance can range 0 to 100. Means for channeling can range 0 to 15.

Table 2 displays means and standard deviations of the TAIS subscales for the experimental and control groups across the time of testing. Overall, the experimental group showed moderate increases in the BET, BIT, and NAR subscales of the TAIS. In addition, examination of the scores for the OET, OIT, and RED revealed similar trends of increases in attentional style. The control group, however, showed slight fluctuation in the TAIS subscales across the time of testing.

ANCOVAs were performed on the six TAIS subscales with the pretest and posttest scores. The results were significant for the BET [$F(1, 5) = 9.43$, $p < .05$], OIT [$F(1,5) = 8.85$, $p < .05$], and RED [$F(1,5) = 8.25$, $p < .05$]. While the BET and RED represent desirable attentional styles, the OIT involves negative aspect of attentional focus. Thus, the results of ANCOVAs suggest that the 12-week brainwave-based concentration training was effective in changing attentional styles toward more desirable patterns. ANCOVAs for the OET, BIT, and NAR were not significant.

Table 2. Changes in TAIS Subscales for Experimental and Control Group

Group	Variable	Pretest M (SD)	3rd week M (SD)	6th week M (SD)	9th week M (SD)	Posttest M (SD)
Experimental	BET	3.0 (0.6)	3.2 (0.4)	3.3 (0.3)	3.6 (0.5)	3.9 (0.3)
	OET	3.0 (0.7)	3.1 (0.5)	2.8 (0.3)	2.6 (0.5)	2.8 (0.3)
	BIT	2.4 (0.8)	3.1 (1.4)	3.3 (1.0)	3.3 (0.6)	3.4 (0.3)
	OIT	3.3 (0.6)	3.1 (0.5)	3.3 (0.9)	3.0 (0.7)	2.0 (0.6)
	NAR	3.1 (0.5)	3.4 (0.5)	3.4 (0.5)	3.6 (0.5)	3.6 (0.5)
	RED	3.1 (0.6)	3.1 (0.6)	2.8 (0.6)	2.6 (0.5)	1.8 (0.3)

Group	Variable	Pretest M (SD)	3rd week M (SD)	6th week M (SD)	9th week M (SD)	Posttest M (SD)
Control	BET	3.1(0.9)	3.0(0.4)	3.1(0.9)	3.3(0.9)	3.1(0.5)
	OET	3.2(0.4)	3.3(0.6)	3.1(0.6)	2.8(0.5)	2.9(0.5)
	BIT	2.8(1.3)	2.6(1.3)	2.9(0.8)	3.3(0.5)	3.3(0.5)
	OIT	3.1(0.3)	3.5(0.6)	3.4(0.8)	3.4(0.8)	3.6(0.5)
	NAR	2.9(0.3)	3.0(0.4)	3.0(0.9)	3.1(0.5)	3.3(0.6)
	RED	3.0(0.4)	3.4(0.8)	3.1(0.8)	2.8(0.9)	3.0(0.4)

Note: BET: Broad external attentional focus. OET: Overloaded by external stimuli. BIT: Broad internal attentional focus. OIT: Overloaded by internal stimuli. NAR: Narrow attentional focus. RED: Reduced attentional focus. Low scores on OET, OIT, and RED represent desirable attentional style. Scores for TAIS are on 5-point scale.

Table 3 displays the means and standard deviations for percentage of points scored and unforced errors across the time of testing. High percentage of points and low percentage of unforced errors represent better tennis performance. Overall, the experimental group showed increases in the percentage of points. Likewise, percentage of unforced errors decreased over the time, reflecting better game performance in tennis. The control group, however, remained almost unchanged throughout the training.
An ANCOVA was performed on the pretest and posttesterror percentages to determine the effectofthebrainwavebiofeedback trainingontennisperformance. Significantresult was found, $F(1,29) = 6.86$, $p < .05$. Examination oftheerrorpercentage revealed thatthe players in the experimental group tended to make unforced errors less frequently. The players in the control group showed relatively stable patterns of error throughout the training. Correlational analyses revealed negative relationships between concentration indices and unforced errors. Taken together, these findings suggest that the concentration training with brainwave biofeedback was effective in improving concentration, and, in turn, tennis performance.

Table 3. Changes in Unforced errors and Points Scored for Experimental and Control Group

Group	Variable	Pretest M (SD)	3rd week M (SD)	6th week M (SD)	9th week M (SD)	Posttest M (SD)
Experimental	Points (%)	20.4(12.1)	25.2 (12.4)	21.0 (9.9)	23.6 (7.2)	33.2 (13.2)
	Errors (%)	79,6 (12.1)	74.7 (12.4)	79.0 (9.9)	76.4 (7.2)	66.8 (13.2)
Control	Points (%)	15.1 (7.4)	15.7 (10.0)	16.1 (4.0)	13.7 (6.0)	14.0 (6.1)
	Errors (%)	84.9 (7.4)	84.3 (10.0)	83.9 (4.0)	86.3 (6.0)	86.0 (6.1)

Note: Points in percentage are calculated using this formula: [the number of points / (the number of points + the number of unforced errors)] * 100. Similarly, errors in percentage are calculated using this formula: [the number of unforced errors / (the number of points + the number of unforced errors)] * 100.

Ⅳ. Discussion

The current study was an attempt to provide evidence of effectiveness of a concentration training program with brainwave biofeedback on tennis performance. The participants were given 12-week simulation training with Q-Jump brainwave biofeedback system. The system allowed the participants to regulate their brainwave patterns in order to achieve peak concentration pattern. The results were encouraging: the tennis players showed considerable increases in attentional style as well as concentration measured by Q-Jump system. After completing the concentration training, the players in the experimental group made unforced errors less frequently compared to those in the control group. These results demonstrated (a) the effectiveness of concentration training with Q-Jump brainwave biofeedback system on concentration and attentional style, and (b) the importance of concentration in tennis performance.

Although the brainwave biofeedback system (Q-Jump) used in this study is not sport-specific concentration training device, it is indeed effective in improving ability to concentration. In addition, the system seems to be more versatile in terms of simulation, display, and data manipulation compared to other commercially available devices such as the Peak Achievement Trainer (Cowan, 1999). Some technical issues were raised by the participants: they wanted the brainwave biofeedback system to have more tennis-specific simulations. In conclusion, this study highlighted the need to use the ever-changing biofeedback technology in sport psychology practice. Development and refinement of more sport-specific brainwave biofeedback device would help athletes achieve better mental skills.

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