Using EEG biofeedback in karate: The relationship among anxiety, motivation and brain waves

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C Statistical Analysis
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Hakan Kolayis

Sakarya University, School of Physical Education and Sport, Sakarya, Turkey

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Abstract

Background and Study Aim: The aim of the study was to investigate the comparison of anxiety, motivation and brain waves according to gender and education levels. In addition, the study also examined the relationship among anxiety, motivation and brain waves in kareteists.

Material/Method: Sixty one participants voluntarily participated in the study. CSAI-2 (Competitive State Anxiety Inventory), STAI (State Trait Anxiety Inventory), Sport Motivation Scale and Pro-Comp Infinity Biofeedback Device were used for data collection. The data was analysed in SPSS 13.0 package program.

Results: As a result of the study; While a significant difference between education levels was observed for the values of somatic anxiety and theta wave ($p<0.05$), there was no significant difference in trait anxiety, cognitive anxiety, somatic anxiety, self-confidence, intrinsic motivation, extrinsic motivation and amotivation ($p>0.5$). Pearson's correlation test revealed that there was only a significant positive correlation between the values of age and theta brainwave (r: 0.654, $p<0.05$), whereas, there was no significant correlation between other variables ($p>0.05$).

Conclusions: EEG biofeedback procedure is employed for reducing anxiety and increasing motivation and self confidence. The present study helps to arrange these psychological patterns for athletes and coaches.

Key words: anxiety • motivation • brain waves • self cofidence • karateist

Author's address: Hakan Kolayis; Sakarya University, School of Physical Education and Sport; Esentepe Campus, 54187, Sakarya, Turkey; e-mail: hkolayis@sakarya.edu.tr

An electroencephalogram (EEG) – is a test that measures and records the electrical activity of your brain.

Background

The brain-body issue has always been a subject of human interest. Every physiological change whatsoever is accompanied by a parallel change in mental and /or emotional state [1] Green, Green and Walters (1970) have formulated this central psychophysiological principle as follows: "every change in the physical state is accompanied by an appropriate change in the mental emotional state, conscious or unconscious, and conversely every change in the mental emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state". Essentially, this statement reflects a very deep, firm view concerning the "eternal" brain-body issue [2].

The electroencephalogram (EEG) is a complex bioelectric signal that reflects the functional status of large pools of cortical neurons and their modulation by sub cortical regulatory influences. The interpretation of this signal requires a comprehensive knowledge of both the technical aspects of EEG recording and neurophysiology of central nervous system. Thus, the application this modality in the biofeedback context must be conducted or supervised by properly trained and experienced professional [3].

The human brain produces a continuous output of minute electrical signals. The magnitude of these signals is so small that it is measured in microvolts (μv), or millionths of a volt. However, the signals can be accurately detected and recorded. To do this, the signals must

Anxiety – is a generalized mood condition that can often occur without an identifiable triggering stimulus.

first be picked up by electrodes attached to the surface of scalp and then amplified and filtered many thousands of times before they can be analyzed. If these amplified signals will appear as a continuous wave of varying frequency and amplitude-the EEG [4].

The number of EEG cycles occurring within a given time internal is called its frequency and measured in hertz (Hz) or cycles per second (CPS). The greater number of per second, the higher the frequency. The EEG appears to contain four major frequency bands: beta (above 13 Hz), alpha (8–13 Hz), theta (4–7 Hz), and delta (0.5–3.5 Hz). And EEG is not useful for determining specific brain functions, but for discerning more general states arousal, which are identified as: delta: deep sleep; theta: period of dreaming; alpha: relaxed awareness; beta: full alertness [4–8].

Motivation – is the driving force by which humans achieve their goals.

Research has shown that intrinsic motivation (IM) and extrinsic motivation (EM) are important concepts for understanding motivational processes in sport settings [9,10]. IM refers to "doing an activity for its inherent satisfactions and pleasures rather than for some separable consequence" [11]. On the other hand, EM reflects behaviors that are performed not for their own sake, but to achieve some separate goal (e.g., receiving a reward, avoiding punishment, and maintaining contingent self-worth). Finally, amotivation refers to the absence of IM or EM and is considered central to understanding motivated behavior [9]. As such, it is perceived that one's actions have no control over outcomes and that forces beyond one's individual control determine behavior [12]. Previous research has shown that more self-determined motives are positively associated with various cognitive, affective, and behavioral outcomes in sport settings [10–14].

Karateist – an athlete who does a Japanese art of self-defense in which sharp blows and kicks are administered to pressure-sensitive points on the body of an opponent.

The level of the individual's motivation gain to control over his/her psychophysiological process needs to be considered when selecting subject for research and when developing a research design. If the individual lacks the motivation to engage in change, biofeedback will be ineffective since the efficacy of such a technique ultimately lies within the individual. For this reason, the extent to which the individual is motivated to alter his/her psychophysiological responses is a potential confounding variable that should not be neglected. The potential influence that an individual's level of motivation may have biofeedback research out comes led Ancoli and Kamiya (1978) to suggest that researchers should document (a) the exact manner of participant recruitment, including the selected individual's motive for participation and criteria for rejection of other individuals; and (b) the individual's previous experience and knowledge of biofeedback [15].

Anxiety is defined as a negatively-valenced psychological state which arises under threatening circumstances and it leads to affective, physiological, and cognitive changes [16]. Anxiety is also defined as an unpleasant emotional state and it is often accompanied by fatigue, exhaustion and some physiological symptoms [17].

According to Martens et al. [18] anxiety is comprised of two parts which are somatic and cognitive anxiety. Somatic anxiety refers to physiological and affective components of anxiety which develop directly due to autonomic arousal and cognitive anxiety is the mental component of anxiety which is caused by negative expectations about success [18]. Moreover, Depending on the degree to which anxiety is experienced, it could decrease athletes' performance [19–21]. Moreover, Trait anxiety involves the general tendency to experience anxiety symptoms across a wide variety of stressful situations [22].

According to Moran (1996), biofeedback training in sport psychology has been used most extensively in the treatment of performance anxiety. High level of anxiety can be detrimental to motor learning, performance, and participation in completion. One way to build self confidence and reduce competition anxiety is to improve performance skill. This can be accomplished over time by providing athletes with biofeedback on their skill improvement, effort and if warranted their performance outcome. An attempt to reduce state anxiety and improve balancing performance on a stabilometer was conducted in a study by Teague (1976) [4].

The purpose of this study was to examine how karateists' motivation, anxiety and brain waves are affected by gender and education level. This study employed three approaches to shed light on this issue. First, a comparison of sport motivation, anxiety and brain waves between male and female. Second, a comparison of sport motivation, anxiety and brain waves between university and high school. Third, a relationship among anxiety, motivation and brain waves.

Material and Methods

Participants

Sixty one participants (37 male made of 60.7% of participants and 24 female made of 39.3% of the participants) voluntarily participated in this study. The mean of their age was x: 18.15±2.09 year, the mean of their training age was 7.97±2.39 year, education level of 21 of the participants (34.4%) was university and 40 of the participants (65.6%) reported their educational level as high school.

Measures

CSAI-2 (Competitive State Anxiety Inventory)

Competitive state anxiety inventory is used to measure cognitive anxiety, somatic anxiety and self confidence. It was formed by Martens, Burton and Vealey in 1981 and there are 27 questions in this inventory. CSAI-2 was translated into Turkish and validity and reliability were reported by Koruç in 1998. Translation reliability was for cognitive anxiety;.925, somatic anxiety;.928, self confidence;.950. Test retest reliability was found to be; cognitive anxiety;.961, somatic anxiety;.929, cognitive anxiety;.929, self confidence;.949. In the result of the comparison, a significant difference was not found between STAI and CSAI-2, ANOVA {F(26, 1)=.69;8>.05}.. This finding was received as criterion validity. Inventory loses decision near competition as construction validity. It was found for two weeks with row,.561,.672,.541, end of two days with row,.230,.223,.321 [23].

STAI (State Trait Anxiety Inventory)

State Trait Anxiety Inventory was developed by Spielberger et al. (1970) and in the present study. The inventory was adapted into Turkish in 1985 by Öner and Le Compte. The scale determines how an individual would feel, independently of a particular situation he was in. The inventory is made up of 20 items and provides a four-point Likert type assessment (1 is for almost never, 4 is for almost always) and was used for overlap validity in the present study. Cronbach's alpha of the scale was between.83 and.87 and test- retest reliability was reported to be between 34 and.72 [24].

Sport Motivation Scale

The Sport Motivation Scale (SMS; [25]) was used to measure the motivation from multidimensional perspectives based on the self-determination theory. SMS consists of seven subscales that measure three types of Intrinsic Motivation (IM; IM to Know, IM to Accomplish Things, and IM to Experience Stimulation), three forms of regulation for Extrinsic Motivation (Identified, Introjected, and External), and Amotivation. There were four items in each subscale with a total of 28 items. The stem question for all items was "Why do you practice your sport". The participants responded on a 7-point subscale ranging from 1 (*does not correspond at all*) to 7 (*corresponds exactly*). Example items include "… Because it allows me to be well regarded by people that I know (Extrinsic Motivation), "… For the pleasure I feel while improving some of my weak points (Intrinsic Motivation)", and "It is not clear to me anymore; I don't really think my place is in sport (Amotivation)". The reliability and validity evidences of the SMS for Turkish sample were obtained in a study carried out by Kazak [26] IM to Know and IM to Accomplishment subscales combined in one factor in the Turkish version of the scale. The alpha coefficients for the present sample ranged from 0.55 (IM to Experience Stimulation) to 0.84 (To Know/Accomplishment).

Pro-Comp Infinity Biofeedback Device

The Pro-Comp Infiniti is a new 8 channel, multi-modality encoder (Figure 1) that has all the power and flexibility you need for real-time, computerized biofeedback and data acquisition in any clinical setting. The first two sensor channels provide ultimate signal fidelity (2048 samples per second) for viewing RAW EEG, EMG and EKG signals. The remaining six channels (256 samples/sec) can be used with any combination of sensors (Figure 2), including EEG, EKG, RMS EMG, skin conductance, heart rate, blood volume pulse, respiration, goniometry, force, and voltage input. Pro-Comp Infiniti™ offers internal, user-activated calibration to ensure that you can always obtain the highest quality signal, without the costly downtime associated with factory re-calibration. In short, the Pro-Comp Infiniti covers the full range of objective physiological signals used in clinical observation and biofeedback. Housed in an ergonomically designed case and requiring only a USB port, ProComp Infiniti can be used with any IBM-compatible laptop or desktop PC. What's more, Pro-Comp Infiniti can capture data in real time by connecting directly to the PC via fiber-optic cable, or it can store data on a Compact Flash memory card for uploading later to the PC. ProComp Infiniti comes complete with: 14 bit resolution, eight-channel Pro-Comp Infiniti encoder unit. TT-USB interface unit. Fiber-optic cables (1'and 15'). Four alkaline"AA"batteries. Sleek fabric storage and carrying case.

Figure 1. Pro-Comp Infinity Encoder.

Figure 2. EEG sensors.

Table 1. The difference between education levels according to anxiety, motivation and brain waves.

Variables	Education level	N	Mean	SD	p
Cognitive anxiety	University	21	21.384	5.04	0.965
	high school	40	21.33	4.54	
Somatic anxiety	University	21	18.05	4.07	0.049*
	high school	40	16.00	3.84	
Self confidence	University	21	26.76	6.09	0.994
	high school	40	26.75	5.49	
Trait anxiety	University	21	45.81	8.17	0.542
	high school	40	46.93	5.89	
Theta wave (μv)	University	21	19.26	5.65	0.08
	high school	40	22.73	9.77	
Alfa wave (μv)	University	21	20.99	9.54	0.409
	high school	40	22.92	8.09	
Beta wave (μv)	University	21	6.07	1.69	0.001*
	high school	40	8.35	3.45	
Intrinsic motivation	University	21	4.13	1.23	0.079
	high school	40	4.75	1.39	
Extrinsic motivation	University	21	4.29	1.15	0.883
	high school	40	4.25	1.14	
Amotivation	University	21	3.55	0.98	0.293
	high school	40	3.91	1.38	

*p<0.05.

Self-confidence – is the expected probability that a person will achieve a goal in a certain situation.

Data collection

The questionnaires were collected form participants before daily training. Athletes, who received standardized verbal instructions, were assisted by the researcher. They were encouraged to answer honestly and were assured that their responses were confidential. The brain waves were measured in a dressing room by researcher. EEG biofeedback involves the measurement of brainwave activity. EEG activity was recorded at the scalp. Participation was voluntary, and relevant permissions were obtained from athletes.

Data analysis

In this study, descriptive statistical techniques and independent simple t test were used. The simple correlations among anxiety, motivation, and brain waves were tested by Pearson Product Moment Correlation. The data were analyzed using SPSS statistical program. An Alpha level of.05 was used all statistical tests.

Results

Significant difference between education levels was observed for the values of somatic anxiety and theta wave ($p<0.05$), there was no significant difference in trait anxiety, cognitive anxiety, somatic anxiety, self-confidence, intrinsic motivation, extrinsic motivation and amotivation ($p>0.5$) (Table 1).

A significant difference between males and females was not observed for the values of trait anxiety, cognitive anxiety, somatic anxiety, self-confidence, intrinsic motivation, extrinsic motivation and amotivation ($p>0.05$) (Table 2).

Pearson's correlation test revealed that there was only a significant positive correlation between the values of age and theta wave (r: 0.654, $p<0.05$), whereas, there was no significant correlation between others variables ($p>0.05$) (Table 3).

Discussion

The present study examined the comparison of anxiety, motivation and brain waves according to gender and education levels. In addition, the study also examined the relationship among anxiety, motivation and brain waves in karateists. First hypothesis; anxiety, motivation and brain waves difference were dependent on kareteists' education

Table 2. The difference between genders according to anxiety, motivation and brain waves.

Variables	Gender	N	Mean	SD	p
Cognitive anxiety	Male	37	21.49	4.89	0.771
	Female	24	21.12	4.43	
Somatic anxiety	Male	37	16.32	3.91	0.361
	female	24	17.29	4.15	
Self confidence	Male	37	27.41	5.12	0.268
	female	24	25.75	6.38	
Trait anxiety	Male	37	47.51	5.98	0.162
	female	24	45.04	7.60	
theta wave (μv)	Male	37	21.35	9.54	0.845
	female	24	21.80	7.37	
alfa wave (μv)	Male	37	22.06	8.65	0.821
	female	24	22.57	8.67	
beta wave (μv)	Male	37	7.06	2.79	0.140
	female	24	8.28	3.54	
Intrinsic motivation	Male	37	4.62	1.32	0.565
	female	24	4.41	1.44	
Extrinsic motivation	Male	37	4.33	1.21	0.566
	female	24	4.16	1.02	
Amotivation	Male	37	3.85	1.23	0.638
	female	24	3.69	1.34	

Table 3. The correlation among anxiety, age, training age, motivation and brain waves.

		Age	Training age	Cognitive anxiety	Somatic anxiety	Self confidence	State anxiety	Trait anxiety	Intrinsic motivation	Extrinsic motivation	Amotivation
Theta wave	r	0.058	–0.024	–0.18	–0.133	0.019	–0.16	–0.15	–0.03	0.09	–0.09
	p	0.654*	0.857	0.175	0.308	0.884	0.208	0.259	0.798	0.49	0.483
Alfa wave	r	–0.06	0.026	0.082	0.09	–0.102	–0.13	–0.19	–0.09	0.021	–0.27
	p	0.675	0.843	0.528	0.491	0.433	0.331	0.149	0.469	0.87	0.036
Beta wave	r	–0.15	–0.163	–0.2	–0.153	–0.02	–0.1	–0.13	0.013	–0.13	–0.05
	p	0.256	0.209	0.126	0.24	0.879	0.443	0.309	0.923	0.335	0.726

level. Results of the present investigation indicated that any difference was not found in anxiety, motivation and brain waves between high school and university level except somatic anxiety and beta wave (Table 1). According to Tenenbaum et al. [14] research in sport not to mention relationship psychology and education but Kolayiş & Sari [23] supported the findings of this research. The difference of somatic anxiety between high school and university could be interpreted as that athletes with university degree feel the pressure over them to accomplish certain things due to the expectations from significant others. This could be the reason of why athletes with university degree reported significantly higher somatic anxiety. Another result of this study showed that there was a significant difference of beta brain-wave between education levels. In the current study, athletes with university degree reported significantly higher beta brain-wave. Higher beta brain-waves were activated by listening, thinking, solving analytical problems, making a decision. If it is thought that people with university level have these cognitive processes, the present study supported this information.

Second hypothesis was that there would be a significant difference of anxiety, motivation and brain waves

between males and females. Previous literature supported this result and reported that there was not a significant difference between males and females according to state anxiety, cognitive anxiety, and somatic anxiety points [24]. However, result of some of previous studies [25,27–30] contrasted with present results.

The last hypothesis was there would be a significant correlation among age, training age, anxiety, motivation and brain-waves. But, according to the results of the study there was only positive significant correlation between age and theta wave. Theta brain waves are defined as deep meditation, deep inward thought. Theta brain waves are associated with life-like imagination, high state of mental concentration, a magical mind, internal pictures/visualization, intuition, inner guidance, access to unconscious material and dreaming.

Conclusions

Combat sports requires optimal levels of anxiety, motivation and self confidence. Combat situations in judo, karate, taekwondo, boxing may change within extremely short period of time: accordingly, emotional states during combat matches are subject to extreme fluctuations. It is often difficult for the competing athlete to attack and to defend at the same time. Psychological preparation for combat sport should therefore be derived from making decisions under time pressure, and being flexible in tactical movements [31]. EEG biofeedback procedure is employed for reducing anxiety and increasing motivation and self confidence. The present study helps to arrange these psychological patterns for athletes and coaches.

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