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Gamma waves tremors in gymnastics: research on junior gymnastic athletes' anxiety levels

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Abstract

Introduction. Gymnastics involves complex movements coordination, and demands a high level of concentration. Achievements in gymnastics are greatly influenced by athletes' mental health, especially anxiety. This is especially true for junior gymnastic athletes as their training environment significantly shapes a training process they undergo and their motor development. Additionally, a human brain exhibits a phenomenon known as gamma waves tremors, with gamma brain waves acting as an important factor in experiencing increased anxiety by athletes. Aim of Study. The present research aims to gather empirical data on gamma waves tremors in novice gymnastic athletes, who experience anxiety, by employing electroencephalography (EEG) technology on a frontal cortex area. Material and Methods. The research utilized an ex post facto method, and an EEG analysis was conducted using a Emotiv Epoc X device and EmotivPro v2.7.2.316 software, with >30 Hz of gamma detection. A saturated sampling technique was implemented, involving 19 junior gymnastic athletes aged from 13 to 18 years. The collected data underwent a statistical analysis, using a linear regression test with p-value set at 0.05. XLSTAT v2021.3.1 software was also employed. Results. The results show that there was a significant positive correlation between gamma waves and anxiety of (r = 0.503) and a coefficient of determination of (r^2 = 0.253 × 100%). The findings show that changes in gamma waves tremors by 25.3% influence anxiety levels with the p-value of 0.028. The positive correlation between an independent variable (gamma waves vibrations) and a dependent variable (anxiety levels) indicates a parallel relationship between the two variables. Conclusions. Increased gamma waves tremors activity, which is an indicator of high brain activity, is correlated with increased anxiety levels in athletes. This suggests that brain activity, specifically frequency of gamma waves vibrations, plays an important role in experiencing anxiety by athletes during preparation for or performing in gymnastics competitions.

KEYWORDS: anxiety, gymnastics, tremor, gamma wave.

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Introduction

Sports activities that are characterized by speed and require a high level of accuracy, such as gymnastics, tend to have a significant impact on psychological well-being, which can increase stress and anxiety [6, 12]. Gymnastics itself, which is taught from preschool through college, is one of the sports that has these characteristics, requiring a high level of accuracy and motor coordination [11]. It is not uncommon for children and adolescents to experience difficulties in acquiring skills required in gymnastics due to relatively high complexity of its movements.

In gymnastics, complex movements coordination and high concentration are essential to achieve optimal performance [5]. Psychological factors, particularly anxiety, can have a significant impact on gymnasts' performance [1, 2], especially in young athletes, who are still in their motor and mental development stage. Anxiety, as an emotional response to perceived threats, often arises in a context of demanding sport competitions

where performance is judged by the public, and can affect athletes' self-image. Anxiety experienced by young gymnasts not only affects their psychological aspects, but can also interfere with the motor skills required to perform gymnastic movements with precision. Previous studies have shown that anxiety can inhibit cognitive functions, such as attention and decision-making, which are crucial in sports that require quick reactions and complex coordination [17, 27, 28].

Cognitive functions are related to brain functions and activity, including gamma waves, which play an important role in information integration, attention, and decision-making [4]. Under conditions of high anxiety, gamma waves activity can be disrupted, often leading to difficulties in maintaining focus and coordination [10]. Previous studies have shown that brain functions and activity, including gamma waves, are associated with emotional responses, particularly in individuals facing stressful situations [20]. For example, gamma waves activity tends to increase in athletes under conditions of high stress or anxiety that can lead to increased alertness, but also to a disruption of focus and composure needed to make quick and accurate decisions.

Brain activity, particularly gamma waves, plays an important role in emotions and anxiety processing [29]. Gamma waves, which are in a frequency range from 30 to 100 Hz, are generated by interactions of neurons in the central nervous system, and are often associated with negative emotions processing [8]. At high levels of intensity, gamma waves can be an indicator of heightened anxiety. If athletes cannot control themselves due to excessive anxiety, it has a negative impact on their performance. This phenomenon becomes increasingly interesting to study in sports, especially in young athletes, where a training environment and competitive pressure can trigger changes in anxiety-related gamma waves activity.

Thus, optimizing gamma waves activity may have significant benefits in supporting calmness, focus, and movement precision required in gymnastics. Understanding gamma waves patterns may be crucial to managing anxiety responses during training and competitions, particularly for junior athletes who are still in the skill and psychological development phase [30]. As noted by Cheron et al. [3], a brain that is able to maintain gamma waves balance enables athletes to manage important cognitive aspects, such as self-control, memory, attention, goal setting, and decision-making, that impact athletic performance. Further research by Negara et al. [18] has demonstrated a negative correlation between gamma waves and hitting ability, with a decrease in potentially performance-impairing gamma waves by as much as 24.5%. Conversely, excessive gamma waves can lead to a loss of attention and concentration when performing tasks such as hitting [18].

Although many studies have examined the relationship between anxiety and athletic performance, few studies have specifically examined a direct relationship between gamma brain waves activity and anxiety levels in young athletes. Deeper understanding of brain mechanisms, such as gamma waves, is essential [26], particularly in gymnastics, which requires motor coordination, high concentration, and precision in movements execution. In this context, gamma waves tremors have great potential as an indicator of anxiety and concentration, especially in athletes who are in the early stages of motor and mental development. Therefore, the aim of this study was to investigate the correlation between gamma waves tremors and anxiety levels in junior gymnastics athletes, hoping to provide new insights into a role of brain activity in anxiety management in young athletes.

Aim of Study

The purpose of this research is to investigate the relationship between gamma waves tremors and anxiety levels in junior gymnastic athletes.

Material and Methods

Participants

This ex post facto study received approval from the Ethics Committee of Indonesian University of Education, in collaboration with West Java Gymnastics Federation (12 VII 2023) and according to the Declaration of Helsinki. This research involved members of Tera Gymnastics Club and West Java Student Sports Center, with a total of 19 athletes. The demographic data of the subjects is presented in Table 1. A saturated sampling

Table 1. Research subjects' demographics

Characteristics	n	Percentage (%)
Number of subjects	19	100
Gender		
men	19	100
Age (years)		
average	16.11	
range	13-18	
Training experience (years)		
3-5 years	7	36.84
>5 years	12	63.16
Body mass index		
normal	19	100

method has been employed to select participants based on specific inclusion criteria. These criteria included a minimum of three years of exercise experience, male gender, no history of chronic diseases, a normal body mass index (BMI), consent to participate in the research, and willingness to volunteer by completing a consent and ethical information form. The research was conducted over a period of three months, in strict adherence to established research procedures.

Instruments

Two instruments were used in this study. The first instrument was a wireless helmet Emotiv Epoc [14], a tool often used in electroencephalography (EEG) to observe brain waves activity (Figure 1), which is possible due to sensors located on the helmet. The sensors are named after a brain region being measured, namely AF for antero-frontal region, F for frontal region, FC for fronto-central region, T for temporal region, P for parietal region and O for occipital region [13]. Odd numbers are used to represent the left hemisphere, while even numbers represent the right hemisphere. In addition, a black dot in the context indicates a location of a reference electrode, which can also be referred to as "device grounding" or "chassis ground" (Figure 2). Measurements were taken using an EmotivPro v.2.7.2.316 application, which is compatible with Mac operating systems. The app shows quality of a sensor signal in each brain area with a color code: black for no signal, red for poor signal, orange for poor signal and green for good signal (Figure 3) [15]. One of its advantages is the ability to detect gamma brain waves in the frontal region with a frequency range between 32 Hz and 100 Hz. EEG data is obtained in a form of electrical currents generated by a brain in response to an environment, with the lowest frequency being 0 microvolts.

The second instrument was a self-report questionnaire, a translated and validated in Indonesia version of the Competitive State Anxiety Inventory-2 (CSAI-2) [21]. Based on the theory of competitive anxiety developed by Martens, Vealey, and Burton, the latest version of CSAI-2 consists of 17 items divided into three main subscales to assess anxiety related to sports performance: cognitive anxiety, somatic anxiety, and self-confidence. Each item has four response options: (1) not at all, (2) somewhat, (3) moderately, and (4) extremely. This instrument provides a comprehensive view of a level of anxiety athletes feel before and during competitions, and helps coaches and sport psychologists to develop strategies to manage such anxiety.

Figure 1. Wireless helmet Emotiv Epoc

Figure 2. Electrodes placement of the wireless helmet Emotiv Epoc

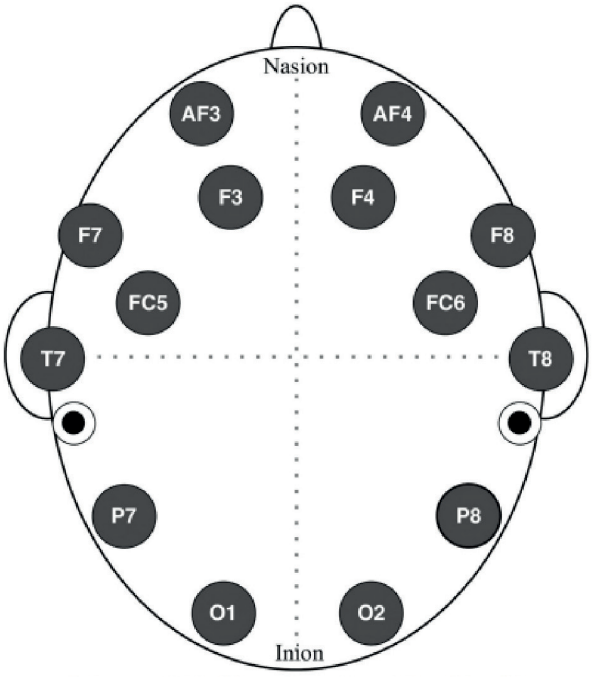
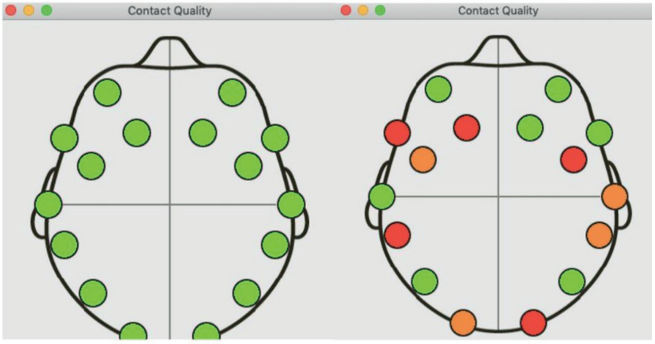


Figure 3. Contact quality of sensor connection



Procedures

This study involved the participants who had previously given written consents to participate, after being given

detailed information about a purpose, benefits, and procedures of the study. Each participant completed the anxiety questionnaire provided in Google Form, followed by the gamma brain waves measurements performed using the Emotiv Epoc X device. The measurements were taken in two conditions: with eyes open and eyes closed, and the aim was to see differences in gamma brain waves activity in relaxed conditions and in the face of anxiety. The measurement procedure began with a 3-second preparation period accompanied by a countdown to ensure that the participants were ready. After preparation, gamma brain waves activity was recorded for 15 seconds in the eyes-open condition, accompanied by a countdown to maintain time consistency. The session ended with a 2-second end marker screen to indicate completion of the recording under these conditions. The 3-second preparation time was then provided to switch to the eyes-closed condition. The measurements in the eyes-closed condition were then taken for 15 seconds, again with a countdown to maintain procedural consistency. At the end of the eyes-closed session, a final marker screen was displayed for 2 seconds. Only one repetition was performed for each condition to avoid any training or fatigue effects on the participants.

Data analysis

Statistical Package for the Social Sciences – Version 25.0 (SPSS 25.0) was used to analyze statistical data. The outcome measures were first examined using a descriptive statistical analysis. Data normality was assessed using the Shapiro–Wilk test, which confirmed that the data was normally distributed. The collected data was then analyzed using XLSTAT software version 2021.1.1 and linear regression tests with a significance level of p-value set at <0.05.

Results

The obtained data consisted of the gamma brain waves scores and anxiety of junior gymnastics athletes, serving as samples in the research (Table 2). Gamma brain waves reached a mean value of 7,328,891.877 microvolts, a standard deviation of 1,507,945.893 microvolts, a maximum value of 6,288,508.63 microvolts, and a minimum value of 0.375 microvolts. On the other hand, anxiety reached a mean value of 60.684, a standard deviation of 12.414, a maximum value of 78 and a minimum value of 42. The results showed that there was a significant positive correlation between gamma waves and anxiety of (r = 0.503) and a coefficient of determination of (r2 = 0.253 × 100%) (Table 3, Figure 4). The findings show that changes in gamma waves tremors by 25.3% contribute to anxiety levels with a statistical p-value of 0.028. The positive correlation between the independent variable gamma waves vibrations and the dependent variable anxiety levels indicates a parallel relationship between the two variables. The higher the athletes' gamma waves vibration value, the higher the athletes' perceived anxiety level.

Table 2. Summary of data on gamma waves activity and anxiety in gymnasts

Variable	Minimum	Maximum	$\bar{x} \pm$ SD
GWT	0.375	6,288,508.63	7,328,89.877 ± 1,507,945.893
Ax	42	78	60.684 ± 12.414

Notes: GWT – gamma waves tremors, Ax – anxiety

Table 3. Linear regression test

Variable	Correlation		Contribution (%)	p
	r	r^2		
GWTA	0.503	0.253	25.3	0.028

Notes: GWTA – correlation between gamma waves tremors and anxiety

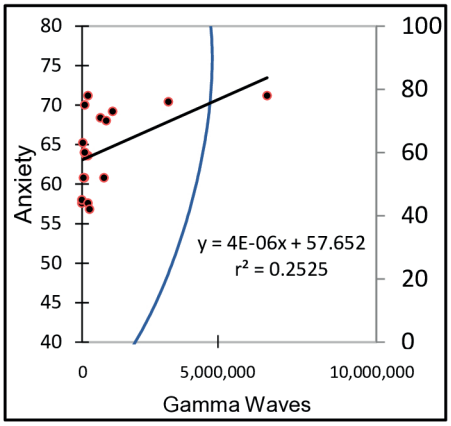


Figure 4. Prediction of gamma waves correlated with anxiety

Discussion

The purpose of this study was to examine the relationship between gamma waves activity and anxiety in junior gymnasts. The results showed that increased gamma waves activity correlated with increased anxiety. This is consistent with previous studies suggesting that gamma waves are associated with increased alertness and concentration [23, 25], but may also be the indicator of stress or anxiety in stressful situations [20]. Gymnastics athletes, who are under high pressure to maintain optimal

levels of motor precision and coordination, may feel this impact more intensely, especially in a group of young athletes who are still in the developmental stage of motor skills and emotional regulation. This is reinforced by an analysis that athletes participating in individual sports have higher levels of anxiety than those participating in team sports due to higher demands for independence and performance pressure [21]. This emphasizes importance of psychological support for young athletes in individual sports to help them manage anxiety and competitive pressure for optimal performance.

Theories of self-regulation and emotion control in the context of sport performance can provide a basis for understanding this relationship. Based on the emotion control theory [7], emotion regulation plays an important role in anxiety management, particularly for athletes under competitive conditions. This process involves athletes' ability to recognize and control their emotional responses in order to maintain focus and psychological stability during competitions. High gamma waves activity, particularly under stressful conditions, has potential to disrupt this emotional regulation ability, which can negatively impact athletes' performance if not managed properly.

The literature suggests that high levels of anxiety can affect athletic performance by interfering with concentration and motor control [19]. When athletes feel anxious, their gamma waves activity increases, disrupting brain's stability in maintaining focus. This disruption is particularly evident in brain activity under eyes-open conditions, where athletes are expected to integrate a variety of visual information that may trigger heightened vigilance and attention. Particularly in the context of competitive sports (e.g., gymnastics competitions), raised levels of gamma waves are associated with increased stress, which – if not properly regulated – may impair performance and even increase a risk of injury [24]. In contrast, non-competitive sports (such as yoga or leisure walking) [14], which often focus on wellness and physical activity in the absence of competitive pressure, typically have a lower risk of increased anxiety and spikes in gamma waves activity.

However, research showed that anxiety does not always have a negative impact on an individual's exercise performance. As shown in a study of Masaki et al. [16], individuals with high levels of exercise anxiety did not show a decrease in performance during an assessment. In other words, they did not "choke" under pressure. These findings suggest that anxiety does not automatically lead to poor exercise performance, especially when a task is relatively simple. Another study [9] also showed that the relationship between self-perception of "choking" and reduced performance may not occur in simple tasks. Even when confronted with a phobic object, behavioral responses remained stable in these rapid tasks. This suggests that anxiety is not the sole determinant of performance, and that under some conditions, performance of individuals with high anxiety levels remains optimal.

This study has several limitations that should be noted. First, the study population was limited to male athletes, so the findings may not be fully applicable to female athletes or other age groups. Future research should include subjects with a wider demographic variation to explore whether similar effects occur in other groups. Second, the measurement of gamma waves activity was performed under laboratory conditions, which may not fully reflect conditions in real competitions. Measurements taken in an actual training or competition environment would be more relevant for practical applications. In addition, this study opens the door for further research into interventions that can support anxiety management in junior gymnasts, particularly interventions that focus on controlling gamma waves activity, such as mental training, meditation or other relaxation techniques.

Conclusions

The results of this study highlight the important relationship between gamma waves tremors activity in a brain and anxiety levels in adolescent gymnasts. In other words, increased gamma waves tremors activity, which is the indicator of high brain activity, correlated with increased levels of anxiety in athletes. This suggests that brain activity, particularly in the frequency of gamma waves tremors, has the significant role in experiencing anxiety by athletes during preparation for or performing in gymnastics competitions. These findings provide important insights into the complex interactions between brain activity and psychological responses in adolescent gymnastics athletes, which can be used to improve training approaches and anxiety management in the context of gymnastics.

Acknowledgments

This research aims to contribute to the progress and development of junior gymnasts in West Java. The project is funded by the Research Institute of Indonesian University of Education.

Conflict of Interest

The authors have no conflicts of interest to report.

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