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Muscle Tension in Generalized Anxiety Disorder During a Stressful Mental Arithmetic Task

Direct Original Research

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Abstract

Introduction: The purpose of this study was to compare muscle tension between individuals with and without generalized anxiety disorder (GAD) during a resting state and a stressful mental arithmetic task.

Methods: A total of 95 undergraduate students (68 females and 27 males; mean age=19.6, *SD*=3.5) completed an online survey on GAD symptoms and pathological worry, a diagnostic interview, and two laboratory tasks (resting and mental arithmetic tasks) while electromyography (EMG) signals were being recorded.

Results: We found a significant main effect of condition, $F(1,93) = 24.13$, $p<.001$, and group, $F(1,93) = 4.55$, $p=.036$. Furthermore, there was a significant interaction effect between condition and group, $F(1,93) = 5.85$, $p=.017$. A post-hoc analysis revealed that the increase in EMG activity from the resting period, 95% CI [.002398 .003474], to the mental arithmetic task, 95% CI [.003850 .005086], was significant for the GAD group, but not for the non-GAD group.

Conclusions: Individuals with and without GAD did not show significant differences in physiologically measured muscle tension at baseline. However, the GAD group showed higher levels of muscle tension during stressful situations when compared to the non-GAD group.

Key Words: Generalized anxiety Disorder, electromyography, stress

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Introduction

Muscle tension commonly manifests as a physiological symptom of anxiety[1-5]. Research utilizing electromyography (EMG) has found that individuals experiencing chronic anxiety have elevated EMG levels at baseline and during stress-inducing tasks, suggesting a significant relationship between muscle tension and anxiety[5,6]. Muscle tension is one symptom criterion for generalized anxiety disorder (GAD)[7]. Chronic and pathological worry, a cardinal feature of GAD, and mental distress were found to contribute to elevated muscle tension[8].

According to an avoidance model of GAD[9,10], people with GAD engage in maladaptive cognitive strategies, such as pathological worry, as a coping mechanism to dampen the emotional impact of perceived threat. A consequence of pathological worry is cognitive overload, which leads to negative affective appraisals of daily challenges and increases in psychological distress, muscle tension, and muscle pain[11]. However, the current literature is mixed regarding situation-specific changes in muscle tension among people with GAD. For example, Hazlett et al.[12], recorded electromyography (EMG) signals from the frontalis and gastrocnemius muscles and found higher EMG activities for the GAD group at baseline and during stressful tasks. On the other hand, a study

involving muscle biofeedback and muscle relaxation therapy reported no significant correlations between EMG activities and anxiety symptoms[13].

The current study aimed to reconcile the discrepancies in the literature regarding muscle tension in GAD. Individuals with GAD engage in worry in an effort to avoid unwanted emotional experiences, which may increase psychological distress and maintain heightened muscle tension. Thus, we hypothesize that the GAD group will show higher levels of pathological worry and greater muscle tension during a stressful task compared to the non-GAD group.

Scientific Methods

Participants

A total of 95 undergraduate students (68 females; mean age=19.59, *SD*=3.50) from a public university in the South completed an online survey, a diagnostic interview, and two laboratory tasks. Written informed consent was obtained from all participants and the university's Institutional Review Board approved the study.

Protocol

Participants completed an online survey and provided demographic information via Qualtrics. The symptomatology of general anxiety disorder (GAD) was assessed using the 7-item GAD-7[14] on a 4-point scale ranging from 0 (*not at all*) to 3 (*nearly every day*) (Chronbach's Alpha=0.84). Trait pathological worry was evaluated using the 16-item Penn State Worry Questionnaire (PSWQ; Chronbach's Alpha=0.81). The MINI International Neuropsychiatric Interview 7.0[15] was used to confirm the current diagnosis of GAD. Then, two Ag/AgCl electrodes were attached next to each other on the non-dominant trapezius muscle and the ground electrode placed on the left ankle. Unlike other muscles, trapezius muscles remain sensitive after repeated exposure to stressful events and thus can provide a more reliable measurement of muscle tension[16]. EMG data were recorded at a sampling rate of 500 Hz via the MP35 Data Acquisition system (Biopac Systems Inc.). The raw EEG signal was band-pass filtered from 1 Hz to 200 Hz, and the root mean square (RMS) was computed to yield the index of muscle tension[17]. Participants remained seated and calm and then completed a mental arithmetic task where they subtracted serial 7s from 3000, with each task lasting for 5 minutes.

Statistical Analysis

A repeated measure analysis of variance (ANOVA), with condition (resting and mental arithmetic task) as the repeated measure, group (GAD and non-GAD) as the between-subject factor, and RMS as the dependent variable was performed using the SPSS V 28.0.1.1. Assumptions of a repeated measure ANOVA were evaluated and a Greenhouse-Geisser adjustment was used to correct for violations of sphericity. The level of statistical significance was set to 0.05 (two-tailed).

Results

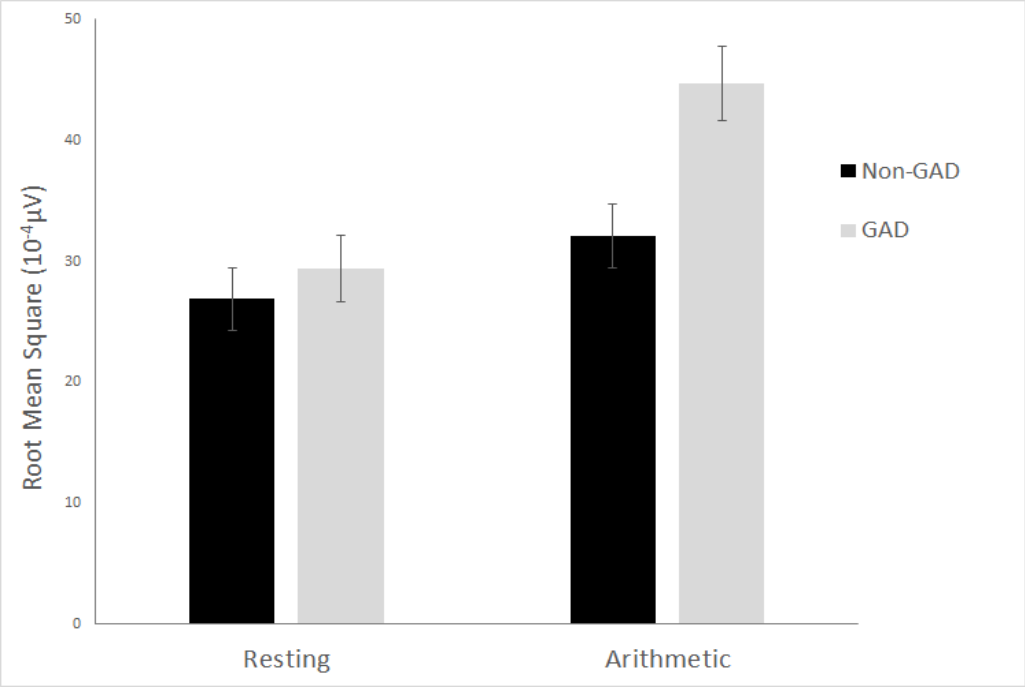
Results

Among 95 participants interviewed, 47 were diagnosed with GAD. The GAD group (*M*=11.77, *SD*=4.22) reported higher levels of GAD symptomatology compared to the non-GAD group (*M*=6.90, *SD*=4.13), *t* (93)=-5.69, *p*<.001. Furthermore, The GAD group (*M*=67.51, *SD*=10.19) reported higher levels of pathological worry compared to the non-GAD group (*M*=53.50, *SD*=14.04), *t* (93)=-5.56, *p*=.008. As shown in Table 1, the analyses indicate a significant main effect of condition, *F* (1,93) = 24.13, *p*<.001, and group, *F*(1,93) = 4.55, *p*=.036.

Table 1. Repeated Measures ANOVA Results.

	df	***F***	***p***	**Partial η_2**
Within-subjects effects				
Condition	1	24.13	<.001	.21
Condition x Group	1	5.85	.017	.06
Error	93			
Between-subject effects				
Intercept	1	353.93	<.001	.792
Group	1	4.55	.036	.047
Error	93			

Figure 1. EMG activity by condition and group.



Furthermore, there was a significant interaction effect between condition and group, $F(1,93) = 5.85$, $p=.017$ (see Figure 1). A post-hoc analysis revealed that the increase in EMG activity from the resting period, 95% CI [.002398 .003474], to the mental arithmetic task, 95% CI [.003850 .005086], was significant for the GAD group, but not for the non-GAD group. Additionally, greater EMG activity during the mental arithmetic task was observed for the GAD group, 95% CI [.003850 .005086], compared to the non-GAD group, 95% CI [.002597 .003820].

Discussion

The current study aimed to evaluate muscle tension among individuals with GAD during a resting period and a mental arithmetic task. The results indicate no significant difference in resting state EMG activity between individuals with and without GAD. However, the GAD group showed a significant increase in EMG activity during the mental arithmetic task while a non-significant change in EMG activity was observed in the non-GAD group.

An avoidance model of worry suggests that people with GAD engage in worry to avoid unwanted emotional experiences[9,10].Because worry requires greater use of cognitive resources, excessive worry can increase cognitive load, which in turn results in increases in stress and muscle tension[8]. The current study demonstrated heightened levels of muscle tension when patients with GAD were asked to complete the stressful mental arithmetic task, suggesting a moderating effect of stress on muscle tension. Given that cognitive resources have a limited capacity, chronic worry can increase cognitive load and deplete cognitive resources which would otherwise be available for processing task-related information. Furthermore, a diminished amount of cognitive resources can disadvantage GAD patients in their ability to perform goal-relevant tasks and increase stress and muscle tension.

Contrary to our findings, there are reports that GAD participants showed elevated muscular tonus compared to non-anxious controls[12,18]. One possible explanation is due to the different sites of EMG measurement. We measured EMG activity of the trapezius muscle, while other studies utilized the frontalis and gastrocnemius muscle[4,12,19]. It is also noteworthy that the participants in previous studies were evaluated according to the DSM III criteria, which are significantly different from the current version in terms of symptom duration, the number of physiological symptoms, and characteristics of excessive worry[20]. Thus, further replications of our original findings that obtain EMG measurements from multiple sites are warranted.

One clinical implication of these findings is the importance of reducing muscle tension in GAD. A systematic review of 14 controlled studies found that muscle relaxation therapy and cognitive behavioral therapy (CBT) are the most

effective in treating muscle tension and pathological worry[8]. For example, the combination of CBT, progressive relaxation training, and frontalis EMG biofeedback showed superior pre-post improvements in self-reported anxiety symptoms and frontalis EMG activity among individuals diagnosed with GAD[21]. However, a study by Raskin et al.[13], found no significant link between relaxation techniques and reductions in anxiety symptoms. Thus, more research is needed to explicate the mechanisms underlying muscle relaxation techniques in GAD.

Two limitations of the current study are noteworthy. This study was conducted with a college population. To improve the generalizability of our findings, research including different age groups is needed. Next, although the mental arithmetic task is commonly used to induce stress in laboratory-based experiments, its ecological validity could improve if situations and stimuli that GAD patients frequently encounter are used.

Conclusions

In the current study, individuals with and without GAD did not show significant differences in physiologically measured muscle tension at baseline. However, the GAD group showed higher levels of muscle tension during stressful situations when compared to the non-GAD group. These results illuminate the functional importance of muscle tension among people with GAD who undergo stressful life events.

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