Revista Eletrônica
Acervo Saúde
Electronic Journal Collection Health ISSN 2178-2091

Use of neurofeedback as a non-pharmacological therapeutic resource for migraine in adolescents and young adults

Utilização do neurofeedback como recurso terapêutico não farmacológico na migrânea de adolescentes e adultos jovens

Utilização do neurofeedback como recurso terapêutico não farmacológico na migração de adolescentes e adultos jovens

Thiago Nunes de Azevedo Ferraz de Carvalho[1,2], Camila Medeiros Araujo[2], Ruanna Ketyllin Gonçalves de Freitas[2], Marilia Franciely De Mesquita Soares[2], Rosalie Barreto Belian[2].

ABSTRACT

Objective: To evaluate results obtained by brain training using Neurofeedback in adolescents and young adults with migraine diagnosis as a non-pharmacological therapeutic alternative. **Methods:** As an open clinical trial, twenty-one migraine suffering participants with and without aura were screened for brain training with neurofeedback following quantitative electroencephalography + hemoencephalography. The entire research process was described involving the use of neurofeedback and the encountered adherence treatment difficulties. **Results:** Of the 21 participants, 10 were male and 11 female, after 20 sessions, the trained participants presented stabilization of new crisis and significant reduction on complaints regarding frequency, intensity and duration of pain. **Conclusion:** The present study reports clinical improvement of the studied population, linked to the therapeutic modality applied. The results show the potential use of neurofeedback for migraine treatment in young public, evidencing the importance of carrying out large scale, controlled and randomized studies in noninvasive neurotherapy to treat migraine and other chronic diseases or progressive disorders.

Keywords: Migraine, Cephalea, Neurofeedback, Adolescent.

RESUMO

Objetivo: Avaliar os resultados obtidos pelo treinamento cerebral utilizando Neurofeedback em adolescentes e adultos jovens com diagnóstico de migrânea como alternativa terapêutica não farmacológica. **Métodos:** Como um ensaio clínico aberto, vinte e um participantes com migrânea, com e sem aura, foram triados para treinamento cerebral com neurofeedback após eletroencefalografia quantitativa + hemoencefalografia. Todo o processo de pesquisa envolvendo o uso do neurofeedback foi descrito e as dificuldades encontradas na adesão ao tratamento. **Resultados:** Dos 21 participantes, 10 eram do sexo masculino e 11 do sexo feminino. Após 20 sessões, os participantes treinados apresentaram estabilização de novas crises e redução significativa nas queixas relacionadas à frequência, intensidade e duração da dor. **Conclusão:** O presente estudo relata melhora clínica da população estudada, relacionada à modalidade terapêutica aplicada. Os resultados mostram o potencial uso do neurofeedback para o tratamento da enxaqueca no público jovem, evidenciando a importância da realização de estudos em larga

[1] Faculdade Integrada do Recife (FIR), Recife – PE.
[2] Universidade Federal de Pernambuco (UFPE), Recife – PE.

SUBMETIDO EM: 6/2025 | **ACEITO EM: 7/2025** | **PUBLICADO EM: 10/2025**

escala, controlados e randomizados em neuroterapia não invasiva para tratar enxaqueca e outras doenças crônicas ou progressivas.

Palavras-chave: Enxaqueca, Cefaléia, Neurofeedback, Adolescente.

RESUMEN

Objetivo: Evaluar los resultados obtenidos mediante entrenamiento cerebral con Neurofeedback en adolescentes y adultos jóvenes con diagnóstico de migraña como alternativa terapéutica no farmacológica. **Métodos:** En un ensayo clínico abierto, veintiún participantes con migraña, con y sin aura, fueron evaluados para entrenamiento cerebral con neurofeedback tras electroencefalografía cuantitativa + hemoencefalografía. Se describió todo el proceso de investigación, incluyendo el uso de neurofeedback y las dificultades encontradas para la adherencia al tratamiento. **Resultados:** De los 21 participantes, 10 eran hombres y 11 mujeres. Tras 20 sesiones, los participantes entrenados presentaron estabilización de la nueva crisis y una reducción significativa de las quejas sobre frecuencia, intensidad y duración del dolor. **Conclusión:** El presente estudio reporta una mejoría clínica en la población estudiada, relacionada con la modalidad terapéutica aplicada. Los resultados muestran el potencial del neurofeedback para el tratamiento de la migraña en jóvenes, lo que evidencia la importancia de realizar estudios a gran escala, controlados y aleatorizados sobre neuroterapia no invasiva para el tratamiento de la migraña y otras enfermedades crónicas o trastornos progresivos.

Palabras clave: Migraña, Cefalea, Neurofeedback, Adolescentes.

INTRODUCTION

Migraine (Mi) is characterized by painful manifestations, generally disabling for children and adolescents, limitating daily activities. Normally followed by nausea and/or vomiting symptoms, sometimes by transient neurological manifestations, characterizing the aura, and photophobia and phonophobia may also be presented (THADANI VM, 2015; AMERICAN HEADACHE SOCIETY, 2012; VECCHIA D, PIETROBON D, 2012; NEY BL, STOKES DA, LAPPIN MS, 2010). Manifestations of increased intensity, frequency and duration usually presents at youth (STOKES DA, LAPPIN MS, 2015; NESTORIUC D, et al., 2008; HAMMOND DC, 2006; VERNON D, 2003). It is characterized by central nervous system increased excitability (NEY BL, THADANI VM, 2015; TEGELER CH, et al., 2012) and poor balance regulation between excitation and inhibition during cortical activity (NEY BL, THADANI VM, 2015).

The primary treatment goal is pain relief and reducing new crisis frequency (SIMKIN DRS, 2014; DIAS ÁM, 2010; COLLURA TF, 2008). Biofeedback devices (BFB) are used in Mi related pain management and perceived as promising alternatives to medicament therapy (AMERICAN HEADACHE SOCIETY, 2012).

The neurofeedback equipment (NFB), which is a type of BFB, uses a quantitative electroencephalogram training tool (QEEG), mapping brain wave patterns to define electroencephalographic correlations with clinical complaints (RIBAS VR, et al., 2016; NIV S, 2013; HEADACHE CLASSIFICATION SUBCOMMITTEE OF THE INTERNACIONAL HEADACHE SOCIETY, 2013; TEGELER CH, et al., 2012; DIAS ÁM, 2010; AKYOL A, et al, 2007). NFB sessions to Mi treatment utilize the QEEG and hemoencephalogram (HEG) as intervention and evaluation clinical tools (RIBAS VR, et al., 2016; NIV S, 2013; HEADACHE CLASSIFICATION SUBCOMMITTEE OF THE INTERNACIONAL HEADACHE SOCIETY, 2013; DIAS ÁM, 2010; AKYOL A, et al., 2007). The NFB works the autoneuroregulation, seeking the conscious generation of healthier QEEG standards, through the operant conditioning. The training allows the respiratory posture and concentration modeling of the patient, thus enabling a brain electrical activity change (LE H, et al., 2011; WIENECKE T, et al, 2008).

The patient's mental and emotional state is always evaluated after training (DIAS ÁM, 2010).

Digital technology made possible to associate brain wave pickup with operant conditioning in a very precise and adequate way. Special programs associate a region brainwave ranges, generating

reinforcement whenever the training reaches the preset designed goals. Reinforcement consists of a sound, the sharpness or size of an image, the speed of a puzzle or a score (HAMMOND DC, 2006).

Literature reports that a patient with Mi presents an imbalance in waves quantity and quality in specific areas of the brain related to their electrophysiological activity. Therefore, it is plausible that interventions involving QEEG and HEG may be beneficial (STOKES DA, 2010; SAVI R, 2008; LIPTON RB, et al., 2004). NFB good results in adults and children treatment with other diseases suggest the possibility of using NFB for Mi treatment in adolescents, a period of life in which the brain's functions plasticity can be beneficially exploited (LIPTON RB, et al., 2004).

It is important to emphasize that although there are no reports of cure to Mi in literature to date, there are reports of preventive treatments with NFB and other modalities of BFB (TEGELER CH, et al, 2012; BIGAL ME, et al., 2007). This study goal is to evaluate the results obtained regarding the stability of frequency, intensity and duration of seizures in adolescents and young adults with Mi diagnosis, with brain training using NFB and a control group, as a non-pharmacological therapeutic alternative. Physiotherapy can now promote functional work on the central nervous system (CNS), influencing the mind and consequently striving for better levels of functionality and productivity, may it be academic, personal and professional fields, promoting productivity, broadening the definition of functionality and its relevance as a non-pharmacological therapeutic resource used by outpatient level physiotherapy (BIGAL ME, et al., 2007).

METHODS

This study presents an open clinical trial, previously approved by the Human Research Ethics Committee of the Federal University of Pernambuco (UFPE), registered in Plataforma Brasil and the Brazilian Registry of Clinical Trials (REBEC) under CAAE number: 42787515.9.0000.5208 and parecer 2.515.495, following resolution 466 of 2012 of the Ministry of Health / National Health Council.

Young individuals of both genders were recruited, with ages between 10 and 24 years, age group associated with adolescents and young adults by the UN (United Nations), Ministry of Health of Brazil and WHO (World Health Organization). Participants were screened at the Pediatric Outpatient Clinic of Instituto de Medicina Integral Professor Fernando Figueira (IMIP), Osvaldo Cruz University Hospital and Hospital das Clínicas at Federal University of Pernambuco, in Recife.

Participants with Mi medical diagnosis, with or without aura and presence of at least one Mi crisis per month, were included for the study. All participants started from a baseline: presence of crisis episode, having to wait an episode appearance to start intervention.

Another criteria adopted was in the presence of pain, patients would only be under the use of an pain abortive medication (analgesic), taken exclusively in the presence of Mi and that does not contain caffeine, barbiturates, narcotics or psychotropic drugs associated with the analgesic.

Participants with the following traits were excluded from the study: 1) Previous diagnosis of mental illness, which could promote alterations in perception, interaction and response to the commands required for brain training; 2) Amputation of limbs, due to the presence of phantom limb pain; 3) Participating in another clinical trial; 4) Presence of genetic syndromes, due to possibility of neuropsychomotor development delay; and, 5) Temporomandibular joint dysfunction, promoting perception and pain threshold alterations. All participants and legal guardians signed terms of assent and free and informed consent.

The screened subjects in the hospitals were referred to the doctor's office with the medical diagnosis of Mi with or without aura, according to the international headache classification criteria (MORIYAMA TS, et al., 2012).

All participants' transportation and food resources were funded through extension and culture office research funding (PIBEX 2015). Participants answered a brief anamnesis and pain characterization questionnaire, and then performed an NFB evaluation. The workouts lasted approximately 1 hour and 20 minutes.

Pain intensity was evaluated using a visual analogue scale, with the objective of quantifying and observe its relation with the daily limitations imposed by migraine. The frequency and duration of crisis were monitored by a Mi evolution daily report. We followed the NFB evaluation process, through the HEG and QEEG. After previous explanation of the procedure (placement of the head band and cap containing gel on each electrode), the trainer began the sessions with the HEG, during 3 minutes for the right cerebral hemisphere, forehead and left cerebral hemisphere evaluation.

For the QEEG, the participant's head circumference was measured and the electrodes placed in an international standard 10-20 compatible cap, using conductive gel on each cap electrode. Sessions were performed in a comfortable chair with armrest, placing the participant in front of the monitor where the evaluation was carried out using the *The Learning Curve* (TLC) 7.2ap software.

Data acquisition was performed on four sites (points). The reading was carried out simultaneously in homologous groups' sites (C3-C4, F3-F4, etc.), in three steps with one minute each: eyes closed, eyes open and performing task.

Once processed, the data were compared to normative databases for the report / diagnosis production. TLC 7.2ap was selected for producing a circuit training plan for the brain, allowing work in multiple areas, retrieving artifacts, reporting on client standards, with an individualized training plan, suggesting (and recommending) assemblies and protocols for 5 training sessions.

Literature wise, the study proposes training with 20 sessions (TEGELER CH, et al., 2012), 2 times a week, always together (HEG + QEEG), with the same design standardization for HEG, developed for NIR HEG, called *Life*. Furthermore, the bioexplorer software and TLC 7.2ap were used which allowed customized training, wave mapping and artifact removal during wave analysis. *Life* is a virtual game, used to aid the prefrontal cortex perfusion of participants in training. After the training, the caps were sanitized with each electrode cleaned with cotton, flexible cotton rods and 70% alcohol.

The technicians involved in the research were capacitated to use the TLC brain training technique with the patients in a standardized way. This technique is based on the investigative protocol developed by Peter M. Van Deusen (JENSEN R, STOVNER LJ, 2008) which includes the management of the technique, the NFB apparatus, analysis and interpretation of the data involving the bioexplorer and TLC 7.2ap software.

The data collected were tabulated in Excel® 2013, to standardize the findings regarding the frequencies and amplitudes of waves, found before and after treatment. The data were descriptively analyzed through absolute and relative (percentages) frequencies for categorical and statistical variables: mean, standard deviation and median; and inferentially by F test (ANOVA) for repeated measurements with multiple comparisons of Bonferroni or Friedman test with comparisons of the test.

Such test was selected because the variable is discrete and the variability is quite high. The used margin of error in the statistical test decisions was 5%. The data were entered in the Excel® worksheet and the statistical program used to obtain the statistical calculations was the IBM SPSS® (Statistical Package for the Social Sciences) in version 21.

RESULTS

Neurofeedback Positive Characteristics

Being a therapeutic resource that uses virtual games, videos and music as an interface between the brain and the computer, it can be observed that the *fun pattern* percentage was higher in the group that actually participated in the study (**Table 3**).

Characterization of the sample

In total, 21 participants of both genders, who fitted this study inclusion criterion, were screened for brain training with neurofeedback (**Table 1**). Of this total, only 7 patients completed the 20 planned NFB training sessions.

Table 1 - Total of screened patients grouped by Mi profile.

Variables	n *(Total=21)*	%
Sex		
Male	10	47,6
Female	11	52,3
Migraine		
With Aura	3	14,2
Without Aura	18	85,7

Source: Carvalho TNAF, et al., 2025.

Characterization of symptoms

The data relevant to the Mi percentage found in the studied sample, in relation to the Mi attacks before the training, were collected through directed questions during anamnesis and summarized in **Table 2**.

Table 2 - Total of screened patients and anamneses acquired variables of interest.

Variables	n *(Total=7)*	%
Age group		
10 to 14	4	57,1
15 to 24	3	42,9
Sex		
Male	3	42,9
Female	4	57,1
Schooling		
Elementary	4	57,1
High School	1	14,3
College	2	28,6
Do not exercise paid activity	7	100,0
Father do not exercise paid activity	7	100,0
Mother do not exercise paid activity		
Yes	3	42,9
No	4	57,1
Doença associada		
Yes (Epilepsy)	1	14,3
No	6	85,7
Restrição alimentar		
Yes	3	42,9
No	4	57,1
Diet		
Yes	1	14,3
No	6	85,7
Entertainment profile		
Games	3	42,9
Open doors activities	1	14,3
Reading	2	28,6
Television	1	14,3
Migraine		
With Aura	1	14,3
Without Aura	6	85,7
Pain frequency (per week)		
Twice	2	28,6
Three times	4	57,1
Four times	1	14,3

Source: Carvalho TNAF, et al., 2025.

Electrical activity and cerebral perfusion pattern found in sample

Regarding the clinical response to the training, it was observed an electroencephalographic profile that emphasized the high fast waves (beta) synchronicity for all participants at: Fp1 / Fp2 and F3 / F4 points; in 1 participant it occurred at F7 / F8 point; in 4 participants at O1 / O2; and in 2 participants in the P3-P4 point. All seven had alpha dominance on the left side at all points measured in the cap, with lower prevalence for the O2 / O1 points.

Table 3 shows the hemoencephalographic profile results by session and location. From this table it is highlighted that: the averages of the points in each session were correspondingly higher in the center and lower in the left side. However, for the fixed margin of error (5%), the only significant difference ($p < 0.05$) was recorded in the tenth session and, through the multiple comparisons tests (between pairs of locations), a significant difference was verified between the center and each one two sides; in each location, the averages increased from the first to the tenth evaluation and reduced from the tenth to the twentieth, being correspondingly higher in the tenth evaluation and lower in the first evaluation, however the only difference between the evaluations occurred in the center, showing a significant difference of this one with each of the other two evaluations.

Table 3 - Hemoencephalographic profile statistics by session and location described in Mean ± Standard Deviation (Median).

Session	Localization			*p-value**
	Right	Center	Left	
First	182,14 ± 83,26 (180,00)	285,71 ± 125,78 (280,00) [(a)]	154,29 ± 151,64 (90,00)	*p = 0,134*
Tenth	222,86 ± 106,30 (160,00) [(A)]	506,43 ± 267,87 (445,00) [(B, b)]	227,00 ± 100,31 (205,00) [(A)]	***p = 0,039***
Twentieth	197,14 ± 49,15 (200,00)	293,57 ± 251,09 (245,00) [(a)]	137,14 ± 30,39 (150,00)	*p = 0,183*
p-value*	*p = 0,628*	***p = 0,016****	*p = 0,336*	

(*): "*p-value*" determined by the F test (ANOVA) for repeated measures with paired Bonferroni comparisons.
(**): Significant difference at 5% level, indicated by distinct capital letters between locations and lower case letters between the corresponding sections in parentheses.
Source: Carvalho TNAF, et al., 2025.

Crisis pain outcome, intensity and frequency of sample

The results of the frequencies, intensity and duration of the visual analogue scale evaluation per session are presented in **Table 4**, where it is pointed out that: the frequency of pain was three times a week for 4 surveyed patients, two times for other two patients and 4 times a week for 1 patient; all patients declared absence of pain in the tenth and twentieth evaluations. In the first evaluation, intensity and duration averages were 6.71 and 6.43 hours and were null in the other two evaluations. Significant differences were verified between the first and each of the other two evaluations.

Table 4 - Evaluation of absolute and relative frequency of absence crisis, pain intensity by visual analogue scale (VAS) and duration according to the session.

Variable	Sessions			*p-value*
	First	Décima	Twentieth	
Absence: *n (%)*				
Twice per week	2 (28,6) [(A)]	7 (100,0) [(B)]	7 (100,0) [(B)]	*$p^{(1)} < 0,001$**
Three times per week	4 (57,1)	-	-	
Four times per week	1 (14,3)	-	-	
Intensity: *Mean ± Standard Deviation (Median)*	6,71 ± 1,11 (7,00) [(A)]	0,00 ± 0,00 (0,00) [(B)]	0,00 ± 0,00 (0,00) [(B)]	*$p^{(2)} < 0,001$**
Duration: *Mean ± Standard Deviation (Median)*	6,43 ± 7,96 (4,00)	0,00 ± 0,00 (0,00)	0,00 ± 0,00 (0,00)	*$p^{(1)} < 0,001$**

(*):Significant difference at 5% level.
(**):Not determined due to the difference in category numbers between sessions.
(1): "*P-value*" determined by Friedman test with multiple comparisons of said test.
(2): "*P-value*" determined by F test (ANOVA) for repeated measures with Bonferroni multiple comparisons.
Obs.: Distinct capital letters between sessions in parentheses assures a significant difference between corresponding sessions.
Source: Carvalho TNAF, et al., 2025.

Patient behavior Pattern of the sample

Of the selected participants, 10 were male and 11 female. 6 subjects were excluded from the study, 1 due to mild mental retardation, according to the report and evaluation of the attending physician, 2 subjects were under 10 years of age, and 1 participant had continuous headaches for more than 10 consecutive days, being oriented to pharmacological treatment and medical reassessment. One participant did not present Mi crisis for more than a year, and yet had an interest in looking for the study.

Finally, 1 of the participants started the sessions and interrupted the training for work related personal reasons. These participants who started and did not finish the sessions for different reasons are called nonresponders in the literature (TEGELER CH, et al., 2012).

DISCUSSION

The effect of NFB on pain outcome (intensity, duration and frequency) in patients suffering from Mi was observed in this study. Patients trained by BFB presented skills that are gradually developed to crisis control (VERNON D, 2003; VECCHIA D, PIETROBON D, 2012) demonstrating early good results with the NFB (QEEG + HEG) training since 10th session (VERNON D, 2003; HAMMOND DC, 2006; VECCHIA D, PIETROBON D, 2012). Other studies have already portrayed theories in which attention, emotion and pain disorders are related to a super or underactivity of brain states, and NFB is effective for a variety of signs and symptoms by promoting the brain's ability to regulate these brain states (VECCHIA D, PIETROBON D, 2012; AMERICAN HEADACHE SOCIETY, 2012).

The NFB device makes use of video games to perform the brain training. Digital games are appealing to young people. Seduced by the ludic and technological aspect, they can remain long periods engaged in the challenges and fantasies of these media artifacts (SAVI R, ULBRICHT VR, 2008; NIV S, 2013; LARSEN S, SHERLIN L, 2013). The used games as interface can become important auxiliaries in the process of teaching and learning the brain through the practice of NFB (SAVI R, ULBRICHT VR, 2008).

In the case of Mi without aura, our study presented 18 screened individuals, reinforcing the findings of the literature (AMERICAN HEADACHE SOCIETY, 2012) in which it portrays Mi without aura as the most frequent among children and adolescents (COLLURA TF, 2010; SIMKIN DRS, 2014). The frequency and intensity of pain are important factors and should be taken into account in Mi suffering children. In our study, it was verified that the pain presents more frequently, affecting 4 individuals of the training group. Compared to another study (STOKES DA, LAPPIN MS, 2010), it was found that younger children experienced more intense pain and the older ones, generalized pain "in tightness". Children with Mi experience more intense and disabling pain regardless of gender (STOKES DA, LAPPIN MS, 2010).

Our results on the outcome of pain in the studied population were positive, as in other studies that also used NFB and other modalities of BFB for the treatment in Mi affected adolescents and young adults. Stokes and Lapin selected 37 participants from their study, where 7 completed brain training. This small number showed improvement of pain symptoms (intensity, frequency and duration) in the crisis follow-up after 6 months of training. Reducing pain frequency may contribute to the training usefulness in preventing disease progression and its chronification (STOKES DA, LAPPIN MS, 2010).

From the moment that there are no anatomical brains changes, neurophysiological studies are of great relevance in the findings of dysfunctional brain electrical activity of the Mi sufferers. A study (GUNKELMAN JD, JOHNSTONE J, 2005), already demonstrate the vulnerability of the Mi suffering brain and its reflection on brain excitability. Confirmed by Stokes and Lapin, they portray in their study that environmental and personal stressors contribute to trigger an early stimulation of Mi (GUNKELMAN JD, JOHNSTONE J, 2005).

Using the TLC evaluation worksheet, the electrical activity found in this studied population's brain showed high synchronization of fast beta waves at points Fp1/Fp2, F3/F4, frequency that represents the extremely focused, attentive, logical, problem solving, being the basis of cognition. When activating this frequency, neural networks consume high levels of energy, being important that it only occurs when necessary and, more importantly, that it be deactivated as soon as the task ends, returning to rest (VERNON D, et al., 2003;

COLLURA TF, 2010; STOKES DA, LAPPIN MS, 2010; AMERICAN HEADACHE SOCIETY, 2012; VECCHIA D, PIETROBON D, 2012; NEY BL, THADANI VM, 2015; RIBAS VR, RIBAS, RMG, MATINS HÁ, 2016). Similar characteristics were found in another study (GUNKELMAN JD, JOHNSTONE J, 2005), which portray stress susceptibility as an agent that evokes Mi crisis, before a real attack.

Patterns of abnormal behavior like hypersensitivity and perfectionism are characteristics common to Mi suffers. This pattern refers to the psychological characteristic as a result of innate cortical hypersensitivity. At the O1/O2 points, trained individuals presented high synchronization of beta and fast beta waves, collaborating with the literature findings when they portray that beta hyperactivity in the posterior part of the cortex configures an analytical, critical and judgmental mind, characteristic behavior of anxiety states, with low tolerance to stress, sleep problems and depression, that may be associated (VERNON D, 2003).

All seven individuals showed alpha frequency dominance on the left side of the brain at all points measured in the cap, setting up an inversion as described by other authors (SIMKIN DRS, THATCHER RW, LUBAR J, 2014). This alpha asymmetry between cerebral hemispheres in children with Mi, are also found in suffering adults (GUNKELMAN JD, JOHNSTONE J, 2005). These inversions in alpha are mostly related to a negative view of life experience, depression tendencies and avoidance behavior with predominant negative thoughts in emotional stress situations (LARSEN S, SHERLIN L, 2013; ARAGÃO MS, et al., 2015; ROCHA TPO, 2015). Pizzagalli (2005) does not specifically speak of depression, but about people who move away from experiences, which is a common symptom of depression (only observes the risks, not the opportunity).

These findings reinforce the described associations by literature between depression and Mi, being a common comorbidity in Mi suffering patients to present depression (AKYOL A, 2007; DIAS ÁM, 2010; LE H, 2011; NIV S, 2013). Previous studies have shown a bidirectional association between depression and Mi, reporting that Mi sufferers present a 5-fold increased risk of depression compared to the conventional population, as well as other comorbidities such as obesity and anxiety (BIGAL ME, 2007). According to other authors (GUNKELMAN JD, JOHNSTONE J, 2005; COLLURA TF, 2008; RIBAS VR, RIBAS, RMG, MATINS HÁ, 2016), different geographical areas of the brain seem to work best with specific frequencies depending on whether the work is to integrate information or process information. The left cerebral hemisphere promotes a brighter, more positive view of the life experience (HAMMOND DC, 2006). The right hemisphere sees things more negatively. The posterior part of the brain integrates sensory information and produces a unified, constantly mutating picture of experiences that are sent to the prefrontal cortex (HAMMOND DC, 2006). The anterior part of the brain processes this material and organizes actions (HAMMOND DC, 2006). Asymmetries across the hemispheres (anterior vs. posterior and left vs. right) for integrative (alpha wave) and processing (beta waves) frequency levels may correlate with a variety of mood and performance problems (HAMMOND DC, 2006).

The results presented in **Table 3**, referring to the training session scores using the *Life* game, show in the training with Hemoencephalography (HEG - NIR) that the averages points were correspondingly higher in the center and lower on the left and right sides. However, for the fixed margin of error (5%), the only significant difference ($p < 0.05$) was recorded in the tenth session and through the multiple comparisons tests (between pairs of locations) between the center and each one two sides.

This result would be related to the focus in the training sessions involving the first 10 sessions, because after subjective and apparent improvement of each participant, they presented faults, compromising the training that followed. It must be emphasize that the brain controls its blood supply by directing it to more active areas through its autoreurregulation (LARSEN S, SHERLIN L, 2013). This perfusion leads us to know where the brain uses the oxygen and glucose carried by the blood stream (LARSEN S, SHERLIN L, 2013). In addition to this information, another study shows that the electrical activity of the brain has specific correlations with cerebral perfusion (LARSEN S, SHERLIN L, 2013). Given the relationship between the amplitude of a particular wavelength at a specific cortex site and the metabolism rate of this cortical structure, NFB allows the individual to act on their neural electrical activity (COLLURA TF, 2008; DIAS ÁM, 2010; LARSEN S, SHERLIN L, 2013). EEG normalization through training promotes an opportunity for the individual to find a more stable neuronal configuration. It allows the brain to find a dynamic stability

alternative, in which the individual can use in the course of a thought and actions (COLLURA TF, 2008; DIAS ÁM, 2010; LARSEN S, SHERLIN L, 2013; NIV S, 2013).

These findings reinforce the studies (NESTORIUC Y, MARTIN A, RIEF W, ANDRASIK F, 2008; COLLURA TF, 2010) that indicates an association between inversions of alpha waves and depression comorbidity, even associated with hypometabolism of brain regions. There is a hypercoherence predominance of this frequency type (alpha - integrative) in depression and may be related to a neural network supersaturation trying to overcompensate the inefficiency of the neural network itself in not being able to process emotional information appropriately, especially in adolescents.

In the topic related to **Table 4**, our results were promising, despite the short period of training. Our goal was achieved in 20 brain training sessions. Other authors (VECCHIA D, PIETROBON D, 2008; TEGELER CH, 2012; NEY BL, THADANI VM, 2015), however, show that the number of sessions to cause lasting results varies between 30 and 40, but may vary due to the severity of the disease. In other studies (YEAW J, et al., 2009; STOKES DA, LAPPIN MS, 2010; GOMES RP, et al., 2015), promising results have been shown when using NFB associated with other forms of BFB, reaching its improvement goals in 20 training sessions, as in our study.

CONCLUSION

In this study, NFB appears to promote stress resilience and susceptibility to Mi crisis in participants. Possibly due to the increase of self-regulation brain mechanism, learned from training. It was concluded that trained participants remained without headaches even after 5 months after the end of research. This information will guide future work. We emphasize that is this work considered the Mi definition after Ney and Thadani, 2015, that is a functional brain disease, caused by an imbalance between excitation and cortical inhibition. Moreover, our results are in line with the claims of other authors (TEGELER CH, et al., 2012; AZARPAIKAN A, TORBATI HT, SOHRABI M, 2014) in which brain training can provide modifications to the synapses and the release of mediators or neurotransmitters, possibly balancing brain function, thus reducing the frequency, intensity and duration of Mi crisis with training through the NFB (QEEG + HEG). Therefore, through reflex stimulation of the autonomic nervous system, in a non-invasive way (SCHESTATSKY P, SIMIS M, FREEMAN R, PASCUAL-LEONE A, FREGNI F., 2013), physiotherapy would access to the CNS and promote a functional work of the system on the mind influence, aiming for better levels of functionality, productivity and modulation of pain for the individual in training.

REFERENCES

1. AMERICAN HEADACHE SOCIETY. The 2012 AHS/AAN guidelines for prevention of episodic migraine: A summary and comparison with other recent clinical practice guidelines. Headaches. 2012;52:930-45.
2. ARAGÃO MS, MASCARENHAS TS, COSTA, JPL, CORRÊA RGCF, BRITO LMO. Anxiety, depression and stress in women with chronic pelvic pain. Rev Pesq Saúde.2015;2:85-9.
3. AZARPAIKAN A, TORBATI HT, SOHRABI M. Neurofeedback and physical balance in Parkinson's patients. 2014;40:177-81.
4. AKYOL A, KIYLIOGLU N, AYDIN I, ERTURK A, KAYA E, TELLI E, et al. Epidemiology and clinical characteristics of migraine among school children in the Menderes region. Cephalalgia. 2007;67:2005-14.
5. BIGAL ME, LIPTON RB, WINNER P, REED ML, DIAMOND S, et al. Migraine in adolescents: Association with socioeconomic status and family history. Neurology.2007;69:16-25.
6. COLLURA TF. Neuronal Dynamics in Relation to Normative Electroencephalography assessment and Training. Biofeedback. 2008;36:134-39.
7. DIAS ÁM. Tendências do neurofeedback em psicologia: Revisão sistemática. Psicologia em estudo. 2010;15:811–20.

8. GUNKELMAN JD, JOHNSTONE J. Neurofeedback and the brain. Journal of Adult Development. 2005;12:93-8.
9. HAMMOND DC. What is neurofeedback? Journal of Neurotherapy. 2006;10:25-36.
10. HEADACHE CLASSIFICATION SUBCOMMITTEE OF THE INTERNACIONAL HEADACHE SOCIETY. Internacional classification of headache disorders. Cephalalgia. 2013;33:629-808.
11. JENSEN R, STOVNER LJ. Epidemiology and comorbidity of headache. Lancet Neurol. 2008;7:354-61.
12. LARSEN S, SHERLIN L. Neurofeedback: An Emerging Technology for Treating Central Nervous System Dysregulation. Psychiatr Clin N Am. 2013;13:163-68.
13. LE H, TFELT-HANSEN P, SKYTTHE A, KYVIK KO, OLESEN, J. Association between migraine, lifestyle and socioeconomic factors: A population-based cross-sectional study. J Headache Pain. 2011;12:157-72.
14. LIPTON RB, BIGAL ME, STEINER TJ, SILBERSTEIN SD, OLESEN J. Classification of primary headaches. Neurology. 2004;63:427-35.
15. MORIYAMA TS, POLANCZYK G, CAYE A, BANASCHEWSKI T, BRANDEIS, D, ROHDE LA. Evidence-based information on the clinical use of neurofeedback for ADHD. Neurotherapeutics. 2012;9:588-98.
16. NEY BL, THADANI VM. Migraine and Epilepsy: Review of the Literature. Headache. 2015;55:359-80.
17. NESTORIUC Y, MARTIN A, RIEF W, ANDRASIK F. Biofeedback treatment for headaches disorders: A comprehensive efficacy review. Appl Psychophysiol Biofeedback.2008;33:125-40.
18. NIV S. Clinical efficacy and potential mechanisms of neurofeedback. Personality and Individual Differences. 2013;54:676-86.
19. RIBAS VR, RIBAS, RMG, MATINS HA. The learning curve in neurofeedback of Peter Van Deusen: Review Article. Dementia Neuropsychol. 2016;10:98-103.
20. ROCHA TPO, NETO JAF, FERNANDES DR, SANTANA EEC, ABREU JER, CARDOSO RLS, et al. A comparative study among different treatment adherence methods in hypertensive patients. Internacional Journal of Cardiovascular Sciences.2015;28:122-29.
21. SAVI R, ULBRICHT VR. Digital educational games: benefits and challenges. Novas tecnologias na educação. 2008;6.
22. SIMKIN DRS, THATCHER RW, LUBAR J. Quantitative EEG and neurofeedback in children and adolescents. Child Adolesc Psychiatric Clin N Am. 2014;23:427-64.
23. STOKES DA, LAPPIN MS. Neurofeedback and biofeedback with 37 migraineurs: a clinical outcome study. Behavioral and brain functions : BBF. 2010;6:1-10.
24. TEGELER CH, KUMAR SR, CONKLIN D, LEE SW, GERDES L, TURNER DP, TEGELER CL, FIDALI BC, HOULE TT. Open label, randomized, crossover pilot trial of high-resolution, relational, resonance-based, electroencephalic mirroring to realive insomnia. Brain and Behavior. 2012;2:814-24.
25. VECCHIA D, PIETROBON D. Migraine: a disorder of brain excitatory-inhibitory balance? Trends in Neurosciences. 2012;8:507-520.
26. VERNON D, EGNER T, COOPER N, COMPTON T, NEILANDS C, SHERI A, GRUZELIER J. The effect of training distinct neurofeedback protocols on aspects of cognitive performance. Internacional Journal of Psychophysiology, 2003;47:75-85.
27. WIENECKE T, OLESEN J, OTURAI PS, ASHINA M. Prostacyclin (epopostrenol) induces headache in healthy subjects. Pain. 2008.
28. GOMES RP, MICHAELSEN SM, RODRIGUES LC, FARIAS NC, SILVA R. Scientific research with individuals post stroke: difficulties in recruitment, allocation and adherence on two different protocols of physiotherapy intervention. Fisiot Pesq. 2015;22:34-40.
29. YEAW J, BANNER JS, WALT JG, SIAN S, SMITH DB. Comparing adherence and persistence across 6 chronic medication classes. J Manag Care Pharm. 2009;15:728-40.
30. WORLD HEALTH ORGANIZATION [Internet]. R: Adherence to long-term therapies: evidence for action. Switzerland; 2003 [cited 2003]. Avaliable from: http://whqlibdoc.who.intpublications/2003/9241545992.pdf2003