ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 07, Issue, 10, pp.15837-15843, October, 2017

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

INFLUENCE OF *ALPINIA ZERUMBET* ESSENTIAL OIL IN THE KINESIOTHERAPEUTIC TREATMENT OF PATIENTS WITH SYNDROME PYRAMIDAL

***[1]Janaína Farias Cândido, [2]Rebeca Moreira de Andrade Lopes, [3]Lauro Xavier-Filho And [1,2,3,4]Edna Aragão Farias Cândido**

[1]University Tiradentes, Masters Health and Environment, Aracaju/SE, Brazil
[2]University Tiradentes, Aracaju/SE, Brazil
[3]Biological study Laboratory and Natural Products, Institute of Technology and Research (ITR), Aracaju/SE, Brazil
[4]Renorbio – Northeast Biotechnology Network. Recife/PE. Brazil

ARTICLE INFO

Article History:
Received 19th July, 2017
Received in revised form
05th August, 2017
Accepted 27th September, 2017
Published online 10th October, 2017

Keywords:
Muscle spasticity;
Surface Electromyography;
Kinesiotherapy.
Alpinia

ABSTRACT

Essential oil of *Alpinia zerumbet* (EOAz) demonstrated action to improve the spastic muscle contraction performance in patients with cerebral vascular disease. Stroke, Cerebral Palsy and Spinal Cord Injury part of in the Pyramidal Syndrome (PS) features muscle tone change. Purpose of this study was investigate contraction muscle quality in the treatment with EOAz and its with Kinesiotherapy association in the patients with Syndrome Pyramidal. This study is a Clinical trial type II, monocentric, prospective randomized parallel-group, with volunteers (N = 60) adults with spasticity. *Modification of the Modified Ashworth Scale* (*MMAS)*, Surface Electromyography (sEMG) and Systemic Arterial Pressure (SAP) were evaluated, before and after application of essential oil (33%) in the dose 05mL/2Kg or 0,05mL/4Kgin cases oftetraparesis, hemiparesis or paraparesis during 10 days of procedures. Results showed significantly decrease spasticity in pathological legs during best muscle contraction (*ANOVA* or *Kruskal-Wallis test*, p<0,05). In conclusion, association of kinesiotherapy with EOAz demonstrates efficiency in improving muscle recruitment of people with spasticity who need to perform motor rehabilitation.

****Corresponding author***

Citation: Janaína Farias Cândido, Rebeca Moreira de Andrade Lopes, Lauro Xavier-Filho and Edna Aragão Farias Cândido. 2017. "Influence of *alpinia zerumbet* essential oil in the kinesiotherapeutic treatment of patients with syndrome pyramidal", *International Journal of Development Research*, 7, (10), 15837-15843.

INTRODUCTION

Lesions central nervous system (CNS) caused people's movement disorders of tone and posture. This group consists of the Stroke, Cerebral Palsy and Spinal Cord Injury. Syndromic findings (Pyramidal Syndrome- PS) change muscle tone (spasticity) limiting movement and function motor the individual (Li; Francisco, 2015). Hyperexcitability in the sarcoplasmic reticulum (SR) is the most plausible mechanism for spasticity (Li, 2017). In the presence of spasticity, muscle stay hyperactive, causing alterations of muscle fiber, resulting in muscular contraction change with resistance in the passive joint movement.

Consequently, there will be an increase in the passive tension levels and the intrinsic properties of this muscle for the muscular contraction, also involving the connective tissue, titin and cellular matrix. Pingel *et al*. highlight the many factors that influence the muscles contracted, citing changes of cellular homeostasis mechanisms, genetics and epigenetics (Pingel *et al*., 2016). Hyperactivity is a pathologic condition found in spinal reflex pathways. Situations that have prolonged periods of depolarization are justified by the alteration of the L-type calcium channels located in the peripheral motoneuron (Bennett *et al*., 1999; Bennett *et al*., 2004). In spastic striated musculature, altered L-type calcium channels are also found. Binding of this calcium and myosin heavy chain elucidates the influence of the same to express changes in the myosin heavy

chain (Smith *et al*., 2009), resulting in the inadequate contraction that Pingel *et al*. reported previously (Pingel *et al*., 2016). To measure this spasticity, it is necessary to use the *Modified Ashworth Scale* (EEA). It is a worldwide scale used to measure spastic muscle tone. Score ranges from zero (0) the four (4) (Bohannon; Smith, 1987). However, Ansari *et al*. (2008) modified the scale modified for improve its reliability, renaming it for *Modified Modified Ashworth Scale* (MMAS) which also ranges from zero to four, without variation of the score 1 and 1+ (Ghotbi *et al*., 2011). Kinesiotherapy is a set of exercises that improve voluntary motor control, tension and strength, as well as coordination, balance and orthostatic posture. Repetitive activation of muscle induces inactivation of the calcium channels, the level presynaptic, modifications and adaptations the reflex activity by changes in neurotransmission activity at the cellular level. Exercises are essential to the rehabilitation process of spastic patients, mainly treated with combined therapy (Moraru; Onose, 2014).

Facilitation and modulation of neural plasticity through rehabilitation strategies, as well as pharmacological agents are important to promote motor recovery after stroke. And individualized rehabilitation protocols could be developed to avoid inadequate neural and muscular plasticity, such as hyperexcitability of SR during motor recovery (Li, 2017). Phytotherapy is the target of pharmacists and biotechnologists because it is considered as a therapeutic possibility due to the active principles of plants (Victório, 2011). As a possibility herbal therapy has the Alpinia zerumbet or speciosa (K. Schum (Zingiberaceae)), plant easily found in brazilian northeast, popularly known as “colony” indicated by present action sedative; antifungal; molusciscida; larvicide and antiulcerogênica (Mendonça *et al*., 1991; Laranja *et al*., 1991; Laranja *et al*., 1992; Prudent *et al*., 1993; Bezerra*et al*., 2000). Its hypotensive action was evidenced by Mendonça *et al*. (1991); Laranja *et al*. (1992); Mpalantinos *et al*. (1998); Nascimento *et al*. (2005). This action was justified by reduce the activity of sympathetic muscle tone by inhibiting contraction induced by potassium and nonspecific blockade acetylcholine and inhibition of Ca2+. As action hypotensive of the composts found in essential oil of Alpinia zerumbet (EOAz), terpene-4-ol and 1,8 cineol, were reported by Koh *et al*. (2002) and only the 1,8 cineol it was reported by Lahlou *et al*. (2002). Characteristics the sample of EOAz utilized in this study were reported by Santos *et al*. (2011) presenting his main monoterpenes found, being they: terpinen-4-ol (37.62%), 1,8-cineole (17.58%), gamaterpinen (11,77%) and e para-cimeno (10,67%). In the same study, Santos *et al*. (2011) showed modulation L type Ca2+ channel ($I_{Ca,L}$) through for EOAz. Antispasmodic action in the EOAz in striated muscle study was evidenced by Maia *et al*. (2016). However, action has not evidenced with EOAz in the concentration of 33% in striated muscle study. Hypotensive action also was not measured for assess whether the EOAz induces hypotension when modulates the muscle tone of spastic muscles. Modulation in the muscle tone was combined with kinesiotherapy treatment on the patients with PS.

MATERIALS AND METHODS

Plant material and chromatographic analysis of *Alpinia zerumbet:* Plant was cultivated and collected for the voucher specimenin the city of Aracaju (Sergipe, Brazil, 10°55's, 37°03'w) in June of 2003, and exposed in the Herbarium the Federal University of Sergipe (ASE # 8245).

Fresh leaves and branches of *Alpinia zerumbet* were collected in Aracaju city, northeast of Brazil. For extraction and characterization of EOAz obtaining makes, leaves were submitted to a steam distillation. EOAz yield was 1% (Baser, 2010). Identification of these oil compounds was performed by gas chromatography/mass spectrometry (GC/MS), and the results have previously been published (Santos *et al*., 2011; Maia *et al*., 2016). Then, oil was stored in an amber bottle under refrigeration during the clinical research.

Study Desing and Participants

This research constitutes a study monocentric (Motor Rehabilitation Center of one University), prospective and analytical, with type controlled trial clinical, parallel-group and random. Distribution of participants in groups was determined by http://www.randomization.com. Selection criteria were participants who presented clinical diagnosis of Stroke and Spinal Cord Injury with compromised tetraplegia (involvement of lower and upper limbs), paraplegia (involvement of lower limbs) or hemiplegia (involvement of upper and lower limb in the same side of the body). Exclusion criteria were: participants that presented dermal allergies to the OES and/or were hypotensive (systemic arterial pressure equal to or less than 100 / 60mmHg); in addition to presenting arthrogenic contractures. Attendants who would begin their kinesiotherapy treatments at a University Rehabilitation Center were invited to participate in the research. Within the inclusion and exclusion criteria were selected 60 individuals, male and female. Volunteers were separated into 2 groups. First group (EOAzK) was referred to EOAzK group, submitted to combined dermal use of EOAz and kinesiotherapy; and second group, its control (KC), dermal use only of EOAz diluent (vegetable oil sunflower) and kinesiotherapy (Figure 1).

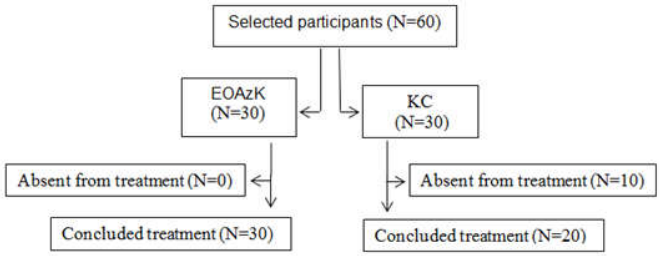

Figure 1. CONSORT of attendees of study. Of the attendees who accepted participate of study, 100% goers the Motor Rehabilitation Center of one University after criteria Inclusion and exclusion, N=60 were selected. Distribution was (N=30) for the group of combination therapy of EOAz associated with Kinesiotherapy; and your control (N=30), Kinesiotherapy associated with vegetable oil. Were excluded the patients which had allergies dermal and/or to EOAz and hypotensive. The dropouts were no apparent reason

Dosage and treatment

Essential oil of *Alpinia zerumbet* (EOAz) was diluted in another vegetable oil (sunflower oil), concentration of 33% essential oil (v/v). Both EOAz and its diluent (vegetable oil) showed similar odor and appearance, being packed in identical 10 ml glass vials, amber, with dropper cap ready for use and kept in cooled air at 6 ° C, while unused. Concentration of this treatment was based on previous studies by Santos *et al.* (2011), which found the best inhibitory effect about calcium channels of EOAz at doses of 25 and 250 µg/mL. Dose EOAz

was 0,05mL/2Kg in cases of tetraparesis (whole body committed to spasticity). Participants who showed commitment of hemiparesis (half of the body committed to spasticity) or paraparesis (legs committed to spasticity), dose was halved (0,05mL/4Kg). Area of application, of bioproductor its diluent, was specifically spastic muscles groups, where the total dose was divided through the quantity of these muscles groups of the upper and lower limbs.

Procedures

Activities were started after submission of the research project and its approval by the Research Ethics Committee the University Tiradentes, Aracaju/SE, Brazil. (Protocol nº 210308). Selected volunteers were clarified about the objectives and methodology of the study, consulted on the interest in their participation. After reading and having agreed, they signed Free and Informed Consent Term. Volunteers from the combined therapy group of EOAz associated with kinesiotherapy (EOAzK) underwent dermal applications with EOAz at the onset of kinesiotherapy and the second group (KC) of their control, was submitted only to dermal applications of the diluents (vegetable oil sunflower). The exercise applied regardless of the use or non-use of the EOAz. Treatment equated to 10 sessions with duration of 1 hour, on alternate days, that referred to a month of kinesiotherapy associated with the application of EOAz or its vehicle. Exercises consisted of: exercises to control axial movements, scapular and pelvic girdle; exercises of appendicular selective movements; as well as closed chain exercises to get up, starting from the seated; step and inverted bicycle. This kinesiotherapy was applied regardless of the use or not of EOAz.

Muscle Tone Assessment (*Modification of theModified Ashworth Scale- MMAS*; Ansari *et al.* (2008): In both groups, muscle tone was assessed by *MMAS* before and after to 10 sessions of kinesiotherapy and compared the results with its control. Muscle tone evaluated by *MMAS*, followed the guidelines. Patient should be instructed to relax. Testing was conducted with patient positioning supine. First, it was done a flexion and extension, and then, the spastic muscle stretching test. Score based on the classification below: 0 = No increase in muscle tone; 1 = Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension; 2 = Marked increase in muscle tone, manifested by a catch in the middle range and resistance throughout the remainder of the range of motion, but affected part(s) easily moved; 3 = Considerable increase in muscle tone, passive movement difficult; and 4 = Affected part(s) rigid in flexion or extension.

Electromyography (sEMG) Analysis: Protocol adopted followed the guidelines of Surface Electromyography for the Non – Invasive Assessment of Muscles (SINEAM project - preparation of the volunteer's skin and placement/positioning/fixing of the sensor), just it was adapted posture to the standing position. Evaluation of electromyography was performed in participants who were able to stay in the orthostasis posture. Assessment was in the gastrocnemius muscle for plantar flexion, and both readings. The sEMG System 200 C (MG Systems, Inc. Sao Paulo, Brazil) was used for registrations (Hermens *et al*., 2000). Bioelectrical potentials in the sEMG assess neuromuscular activity that occur in the cell membranes of muscle striated fibres during at maximum contraction (Gila *et al*., 2009). Readings were taken treatment end after the application of the essential oil association with Kinesiotherapy according to the parameters of the previous study in the Maia *et al*. (2016) for the absorption of terpenes. Action potential was evaluated by quantification the Square Root the Middle (Root Mean Square - RMS), three contractions of 5 seconds each, in microvolts (μV), interspersed with periods of relaxation were used as calculation method for analyzing the electrical potential captured during the course of muscle contractions (Kallenberg; Hermens, 2008). Electromyography utilized was the type sEMG System 200 C (MG Systems, Inc. Sao Paulo, Brazil), adjusted to configuration of gain of 4400 filters with low frequency between 20Hz e 500Hz, in scientific standards to ensure amplification required for analog process to digital conversion. Acquisition rate of sEMG signal was 2000 Hz per channel of 12-bit resolution. Two electrodes were placed on each portion of the medial and lateral GM, with the first just above the region of greatest cytometric value in the leg and the second (2 cm distance) just below the electrode previously placed. Electrical signal, collected by bipolar electrodes simple differential active surface pre-amplifier with a gain of 20 times and the Rejection Ratio in Common Mode (RRCM) > 100db. Values of records of root means square (RMS) were calculated by the program sEMG. Median power frequency and the maximum amplitude were also evaluated.

Evaluation of Systemic Arterial Pressure

Systemic Arterial Pressure (SAP) was assessed at the same times to check the safety of systemic effect of dose utilized the tonic modulation, because studies show that products derived from *Alpinia zerumbet* induce hypotension arterial (Laranja *et al*., 1992; Bezerra *et al*., 2000; Mpalantinos *et al*., 1998; Lahlou *et al*., 2002). Like this, the SAP was collected in two moments, before and after treatments. Was utilized equipment of model Missouri Brandi (in accordance with the specifications approved by the Ministry the INMETRO / Brazil, Dimel n º 017 in 07122001 and registered by ANVISA / Brazil under nº 8.0047920025).

Statistical Analysis

Test of Kolmogorov-Smirnov it was used to analyze the normality of the variables studied; it was used *KRUSKAL-WALLIS pos-test Dunn's multiple comparisons test* or ANOVA ONE-WAY *pos-test Tukey mutiple comparisons test*. Statistical significance was set at $p < 0.05$.

RESULTS

Of patients the treated with EOAz group (n=30) none gave up treatment. Group control, of 20 participants, 10 gave up of treatment. There were 367 muscle groups evaluated in the EOAzK group, while in the CK group there were 231 on muscle groups. In Figure 2, result of the tonic modulation of the EOAzK groups and your control (CK) was presented. Mean and standard error of the EOAzK group before treatment it was 2,54 (±0,62) and after treatment 1,19 (±0,11); already in the CK group it was 2,22 (±0,07)., after treatment. Difference between the groups showed that the group treated with EOAzK before to treatment was more spastic than the CK group after treatment, significantly ($p<0.05$); and after

treatment with EOAz presented significant results of p=0.0001, compared EOAzK before; and when compared to its control CK, both treated for 10 sessions. In the assessment in figure 3, was presented the result the sEMG of EOAzK groups and your control (CK).

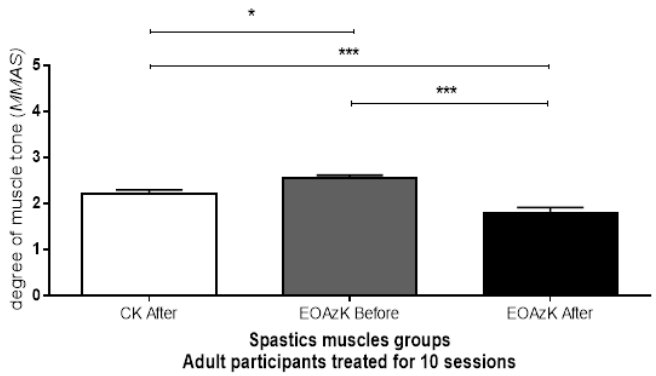

Figure 2. Mean and standard deviation scores Muscular Tone Assessment spastic, second *Modified Modified Ashworth Scale–MMAS* when treated with essential oil the *Alpinia zerumbet* (0,05 ml/2Kg) for each body hemibody associated with therapeutic exercise in adult participants treated for 10 sessions. * p<0,05; ** p<0,01; *** p<0,001; *Kruskal-Wallis test* and after *Dunn's test*, after 10 sessions of Kinesiotherapy + EOAz (EOAzK) and your control (CK) treatment after

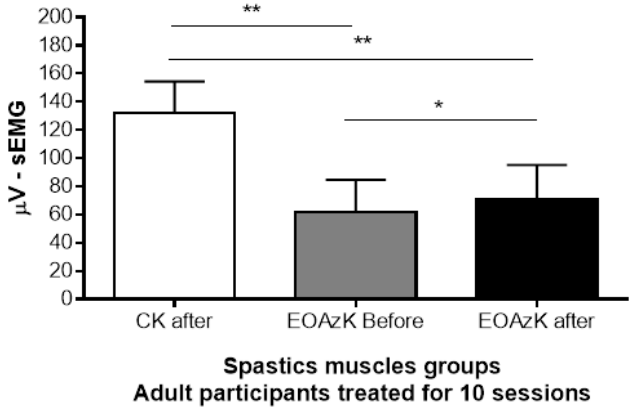

Figure 3. Mean and standard deviation reading surface electromyography spastic gastrocnemius muscle and its control (gastrocnemius sound), after treated with essential oil *Alpinia zerumbet* (0,05 ml/2Kg) for each body hemibody, in adult participants treated for 10 sessions. * p<0,05; ** p<0,01; *** p<0,001; *ANOVA ONE-WAY test* and after *Tukey test*, after 10 sessions of Kinesiotherapy association with EOAz (EOAzK) and your control (CK) treatment after

Mean and standard deviation of the EOAzK group before treatment it was 62,04 (±22,72) and after treatment 70,87 (±24,4). CK group after treatment it was 131,8 (±22,68). Difference between the groups showed that treaty group with EOAzK before treatment was more spastic than CK group after the treatment, significantly (p<0.01), and before vs. after treatment with EOAz showed significant results (p<0.05). For blood pressure assessment in the group treated with kinesiotherapy associated with EOAz (EOAzK), was evaluated mean and standard error of systolic pressure 136,7 (±3,95) and diastolic pressure 87,5 (±3,71). After treatment with EOAzK, average systolic blood pressure dropped to 127,5 (±4,28) and diastolic pressure for 80,00 (±3,01), what results in no significant difference when compared to the CK group who got average the systolic pressure 141,8 (±4,63) and diastolic pressure 83,64 (±2,78),getting the average of these values within the normal range, without inducing hypotension. Induction only take place if the minimum value of blood systemic pressure exceeded the considered normal 100/60 mmHg, as reported V Joint National Committee (1993) (Figure 4).

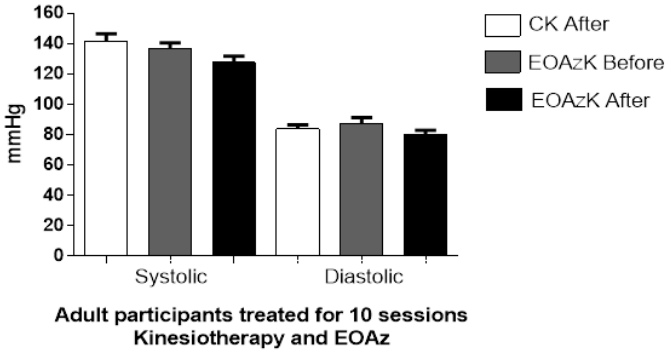

Figure 4. Pressure behavior by test control group mean comparison (Systolic and Diastolic) adult, after and before 10 sessions of kinesiotherapy and its control group in patients with Pyramidal Syndrome (STROKE). * p<0,05; ** p<0,01; *** p<0,001; *Kruskal-Wallis test* and after *Dunn's test* after 10 sessions of Kinesiotherapy + EOAz (EOAzK) and your control (CK) treatment after

DISCUSSION

Herbal action has been a priority in several areas, mainly in health. According to Maciel *et al*. (2002), therapeutic benefits improved herbal medicine are strengthened as alternatives feasible for the production of medicaments for the treatment of various diseases, also agreed with the World Health Organization, since 2002, following the example of chronic neurological diseases, part of this is priority this study. This study present assessment in the improvement in muscle tone and skeletal muscle contraction in post-stroke spasticity. For this, was studied MMAS, sEMG and blood pressure in the adults with unilateral hemiparesis treated with EOAz. MMAS, according Ansari *et al*. (2008), is a reliable and valid clinical tool, essential to verify the effect of therapeutic interventions aimed to improve function by reducing spasticity. And, according Ghotbi *et al*. (2011), before already recognized worldwide, became significantly reliable. This scale revealed treatment EOAz associated Kinesiotherapy modulated of muscle tone significant in the treatment for one month, result shown in Figure 2. Results in the present study (Figure 3) showed values of all studied variables in sEMG were significantly decreased in pathological legs, when compared to the pathological before the treatment during contraction in both lateral and medial GM (Maia *et al*., 2016). It is reforced to the observation that spasticity causes altered contractile properties (Gao; Zhang, 2008) suggesting reduced number of sarcomeres along the fascicles and/or reduced sarcomere length poststroke and changes biomechanical properties of the soleus and gastrocnemius muscle (Lee *et al*., 2015), beyond modified sEMG signals in the post-stroke GM (Picelli *et al*., 2014). Reading of both spasticity and blood pressure scores (Figures 2 and 3) was performed at least 1 hour after application of the bioproduct, because absorption of these terpenes applied by the body is 10 to 20% (Cal, 2006). Being woken up that time of application and activity pharmacokinetics also by Koh *et al*. (2002) and Khalil *et al*.

(2004). And Sapra *et al*. (2008) the use of terpenes, such as 1,8-cineol, can be used for the purpose of better absorption of transdermal drugs, since they interact with lipids and keratin, in addition to allowing greater solubility to the drugs. Another justification for the use of the dermal route in this study is the ease of direct application to the spastic muscles, since the bioproduct researched in this study is topical. Pathologically, regarding of nervous system lesion, in cases where there are no compensatory mechanisms activated for modulation of excessive cellular Ca2 +, expression will be produced with more generation of L-type Ca2 + and sodium in spinal motoneuron (Li *et al*., 2004); and Ca2+ L-type and potassium channel in striated muscle (Smith *et al*., 2009). In this case the compensatory mechanism for modulating the persistence of Ca2+ influx through up regulation of the enzyme Ca2+ - ATPase pump doesn't it happens. Another option for regulatory control of the Ca2+ changes is the regulation of potassium pump (K+) through Ca2+ channels dependent of the ATP-K+ channel- without allowing a potential of cell membrane suitable. These control mechanisms of excess Ca2+ are also found in modified myoblasts (Jorquera *et al*., 2013). However, the amount of Ca2+ depends directly on the descendants of motor neuron impulses that SP is changed as result of injury (Bennett *et al*., 1999; Bennett *et al*., 2004) besides himself excessive Ca2+ L-type channel this releasing Ca2+ excessively. Continuity of this excessive activity extends to the striated muscle which also presents its Ca2+ L-type channel (Smith *et al*., 2009).

These findings are likely to be treated by EOAz associated with therapeutic exercise, once the EOAz was submitted by Santos *et al*. (2011) as modulator as Ca2+ L-type channel. In this case the compensatory mechanism for modulating the persistence of Ca2+ influx by passive regulation enzyme Ca2+-ATPase pump it is to catalyze the transport of two Ca2+ bound to one mole of ATP, generating a disproportionate electrochemical gradient. And when the concentration of Ca2+ in the resting cytoplasm goes from 10^{-7}M for 10^{-6}M induces a structural change of thin filaments sarcomere facilitating interaction of crossed bridges, sequentially has the cleavage of ATP with contractile tension triggering. Activation of the Ca2+ generate oxidative metabolic activities by supply of ATP to slow-twitch fibers tonic, while the metabolism of fast fibers will glycolytic (Jorquera *et al*., 2013). In Figure 2 and 3, has verified the possibility the EOAz associated with therapeutic exercise modular spasticity. Effective treatment of spasticity was observed significantly in just 1 month of treatment. Decrease in spasticity was compared to the same group one month before treatment. And when compared with the control group it was also perceived improvement significantly. EOAzK group before treatment was more spastic than CK group.

This study presents results supported in preclinical research published by Santos *et al*. (2011) with EOAz, demonstrating that the o EOAz modulates Ca2+ L-type channels dose-dependent manner. In normal conditions, tonic and phasic tone are determined by frequency of neural stimuli in striated muscle (Beijer *et al*., 2015). Titin, intrafusal structure responsible for the passive tension, is also directly involved with muscle tone (Labeit; Kolmerer, 1995). In addition to tone, passive tension also acts on muscle contraction of Ca2 + - dependent form. This idea is shared by Joumaa *et al*. (2007) and Kronbauer; Castro (2013) when they report being the titina responsible for the increase of the force after active stretching, resulting in induction of titin stiffness when the muscle is activated. Influence of the myofilaments to Ca2+ occurs in the M region of the titin and is directly linked cross bridges in the muscle regulation for the generation of force. And in the absence of healthy titin there will be a reduction of passive tension by a decrease in the sensitivity to calcium, affecting the kinetics of the crossed bridges that influence the basic mechanism of the length of striated muscles (Ottenheijm*et al*., 2012). Roy *et al*. (2011) reported muscle changes, towards the upper motor neurons from injury in spastic muscles with excessive increase in passive tension in every muscle. Higher passive tension is also enhanced by Bakheit *et al*. (2011) and Roy *et al*. (2011). Already Ranatunga (2011) expose the influence on the increase of passive tension as a result of changes of the extracellular matrix and shortening of the muscle. However, involvement of passive tension is due to functional changes and stiffness of the extracellular matrix.

Gao *et al*. (2009) reported that considering the muscle medial gastrocnemius fascicle length is found reduced post stroke, justified by higher passive tension muscle under the condition which may be associated with the spastic muscles. This alteration induces simultaneous changes in fascicles, ROM and difficulty in performing movements. Study by Robinson *et al*. (2013) indicated that there is reduction of the mitochondria in the presynaptic nerve endings and increase of the postsynaptic space, which justifies decrease of muscular activity. Smith *et al*. (2012) suggested that increased extracellular matrix volume was associated with an increase in its passive stiffness in muscle tissue, which led to a decrease in the area of mitochondrial myofilaments. Cerqueira *et al*. (2015) showed that use of phytomedication in the long term proved effective in reversing the changes in the thickness and organization of collagen caused by spasticity. As well, as in the clinical study in the Cândido and Xavier-Filho (2012), demonstrate optimization of EOAz in Kinesiotherapy of children with CP, with improved functional performance in only 1 month of treatment. The clinical study of Maia *et al*. (2016) also reinforces the claim that EOAz improves recruitment of muscle strength when it demonstrates reading of sEMG with significant increase. In conclusion, association of kinesiotherapy with EOAz demonstrates efficiency in improving muscle recruitment of people with spasticity who need motor performance in Neurofunctional physiotherapy. Probably, the best efficiency of muscle contraction is involved with the best quality of muscle tone and decrease in passive tension of the muscle fibers.

REFERENCES

Ansari, N.N., Naghdi, S., Younesian, P., Shayeghan, M. 2008. Inter- and intrarater reliability of the Modified Modified Ashworth Scale in patients with knee extensor poststroke spasticity. *Physiother Teoria Pract.,* 24, 205-13.

Bakheit, A.M.O., Fheodoroff, K., Molteni, F. 2011. Spasticity or reversible muscle hypertonia? *Journal Rehabil Med.,* 43, 556–557.

Baser, K.H. 2010. Handbook of Essential Oils: Science, Technology, and Applications / K. Hüsnü Can Baser, Gerhard Buchbauer. ISBN 978-1-4200-6315-8. Universitat Wien, Austria;

Beijer, A., Degens, H., Weber, T., Rosenberger, A., Gehlert, S., Herrera, F., Kohl-Bareis, M., Zange, J., Bloch, W., Rittweger, J. 2015. Microcirculation of skeletal muscle adapts differently to a resistive exercise intervention with

and without superimposed whole-body vibrations. *Clin Physiol FunctImaging*, 35, 425–435.

Bennett, D.J., Gorassini, K., Fouad, L., Han, S.Y., Cheng, J. 1999. Spasticity in rats with sacral spinal cord injury. *Journal Neurotrauma*, 16, 69–84.

Bennett, D.J., Sanelli, L., Cooke, C.L., Harvey, P.J., Gorassini, M.A. 2004. Spastic long lasting reflexes in the awake rat after sacral spinal cord injury. *Journal Neurophysiol*, 91, 2247–2258.

Bezerra, M.A., Leal-Cardoso, J.H., Coelho-De-Souza, A.N., Criddle, D.N., Fonteles, M.C. 2000. Myorelaxant and antispasmodic effects of the essential oil of *Alpinia Speciosa Schum on rat ileum. Phytother Res.,* 7, 549-551.

Bohannon, R.W, Smith, M.B. 1987. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther*., 67, 206-7.

Cal, K. 2006. How does the type of vehicle influence the in vitro skin absorption and elimination kinetics of terpenes? *Archives of Dermatological Research,* 297, 311–315.

Cândido, E.A.F., Xavier-Filho, L. 2012. Viabilidade do uso do óleo essencial da *Alpinia zerumbet*, Zingiberaceae, na otimização do tratamento fisioterapêutico em paralisia cerebral espástica, *Arq Bras Neurocír*, 31, 110-115.

Cerqueira, F.L., Albuquerque-Junior, R.L.C., Zini, C.A., Caramao E.B., Cândido, E.A.F. 2015. Efeitos da cinesioterapia associada ao bioproduto à base do óleo essencial da *Alpinia zerumbet* sobre o colágeno dos tecidos musculares espásticos de ratos pós-lesão medular. *Inter Science Place - Rev Cient Intern.,* 10(4):127-206.

Gao, F., Grant, T.H., Roth, E.J., Zhang, Li-Qun 2009. Changes in Passive Mechanical Properties of the Gastrocnemius Muscle at the Muscle Fascicle and Joint Levels in Stroke Survivors. *Arch Phys Med Rehabil.,* 2009, 90, 819-826.

Gao, F., Zhang, L.Q. 2008. Altered contractile properties of the gastrocnemius muscle post stroke. *J Appl Physiol*, 105, 1802–1808.

Ghotbi, N., Nakhostin Ansari, N., Naghdi, S., Hasson, S. 2011. Measurement of lower-limb muscle spasticity: Intrarater reliability of Modified Modified Ashworth Scale. *Journal Rehabil Res Dev.,* 48, 83-88.

Gila, L., Malanda, A., Carreno, I.R., Falces, J.R., Navallas, J. 2009. Electromyographic signal processing and analysis methods. *An Sist Sanit Navar,* 32, 27–43.

Hermens, H.J., Freriks, B., Disselhorst-Klug, C., Rau, G. 2000. Development of recommendations for sEMG sensors and sensor placement procedures. *Journal Electromyogr Kinesiol,* 10, 361–74.

Jorquera, G., Altamirano, F., Contreras-Ferrat, A., Almarza, G., Buvinic, S., Jacquemond, V., Jaimovich, E., Casas, M. 2013. Cav1.1 controls frequency-dependent events regulating adult skeletal muscle plasticity. *Journal Cell Sci,* 126: 1189-1198.

Joumaa, V., Rassier, D.E., Leonard, T.R., Herzog, W. 2007. Passive force enhancement in single myofibrils. European *Journal of Physiology,* 455, 367-371.

Kallenberg, L.A., Hermens, H.J. 2008. Behaviour of a surface EMG based measure for motor control: motor unit action potential rate in relation to force and muscle fatigue. *Journal Electromyogr Kinesiol,* 18, 780–78.

Khalil, Z., Pearce, A.L., Satkunanathan, N., Storer, E., Finlay-Jones, J.J., Hart, P.H. 2004. Regulation of Wheal and Flare by Tea Tree Oil: Complementary Human and Rodent Studies. *Journal of Investigative Dermatology,* 123, 683-690.

Koh, K.J., Pearce, A.L., Marshman, G., Finlay-Jones, J.J., Hart, P.H. 2002. Tea tree oil reduces histamine-induced skin inflammation. *British Journal of Dermatology*, 147, 1212-

Kronbauer, G.A., Castro, F.A. de S. 2013. Estruturas elásticas e fadiga muscular. Rev. Bras. Ciênc. Esporte, 35, 503-520.

Labeit, S., Kolmerer, 1995. Titin: giant protein in charge of muscle ultratructure and elasticity. *Science*, 270, 293-96.

Lahlou, S., Figueiredo, A.F., Leal-Cardoso, J.H., Magalhães, P.J.C. 2002. Cardiovascular effects of 1,8-cineole, a terpenoid oxide present in many plant essential oils, in normotensive rats. *Canadian Journal Physiology Pharmacology,* 80, 1125–1131.

Laranja, S.M., Bergamaschi, C.M., Schor, N. 1991. Evaluation of acute administration of natural products with potential diuretic effects, in humans. *Memórias do Instituto Oswaldo Cruz,* 86, 237-40.

Laranja, S.M.R., Bergamaschi, C.M., SD N 1992. Avaliação de três plantas com potencial efeito diurético. *Revista Associação Médica Brasileira*, 38, 13-6.

Lee, S.S.M., Spear, S., Rymer, W.S. 2015. Quantifying changes in material properties of stroke-impaired muscle. *Clinical Biomechanics,* 30, 269-275.

Li, S., Francisco, G.E. 2015 New insights into the pathophysiology of post-stroke spasticity. *Front. Hum. Neurosci.* 9:192.

Li, Y., Gorassini, M.A., Bennett, D.J. 2004. Role of persistent sodium and calcium currents in rat motoneuron firing and spasticity in chronic spinal rats. *Journal Neurophysiol*., 91, 767–783.

Li, S. 2017. Spasticity, Motor Recovery, and Neural Plasticity after Stroke. *Front. Neurol.* 8:120.

Maciel, M.A.M., Pinto, A.C., Veiga, Jr, V.F., Grynberg, N.F. 2002. Plantas medicinais: a necessidade de estudos multidisciplinares. Quim Nova, 25, 429-438.

Maia, M.O.N., Dantas, C.G., Xaxier-Filho, L., Cândido, E.A.F., Gomes, M.Z. 2016. The Effect of *Alpinia zerumbet* Essential Oil on Post-Stroke Muscle Spasticity. *Basic and Clinical Pharmacology and Toxicology*, 118, 58-62.

Mendonça, V.L.M., Oliveira, C.L.A., Craveiro, A.A., Rao, V.S., Fonteles, M.C. 1991. Pharmacological and toxicological evaluation of *Alpinia speciosa*. Memorias do Instituto Oswaldo Cruz, 86, 93-7.

Moraru, E., Onose, G. 2014. Data condensed synthesis regarding kinesiotherapeutic procedures used in spasticity therapy. *Journal of Medicine and Life* 7, Issue 3, July-September, 7, 317-321.

Mpalantinos, M.A., Soares, M.R., Parente, J.P., Kuster, R.M. 1998. Biologically active flavonoids and kava pyrones from the aqueous extract of *Alpinia zerumbet.* Short Communication, 12, 442-444.

Nascimento, N.R.F., Cardoso, J.H.L., Lessa, L.M.A., Roriz-filho, J.S., Cunha, K.M.A., Fonteles, M.C. 2005.Terpinen-4-ol: mechanisms of relation on rabbit duodenum. *Journal Pharmacol*, 57, 467-474.

Ottenheijm, C.A.C., Witt, C.C., Stienen, G.J., Labeit, S., Beggs, A.H., Granzier, H. 2012. Thin filament length dysregulation contributes to muscle weakness in nemaline myopathy patients with nebulin deficiency. *Hum Molec Genet*., 18, 2359-2369.

Picelli, A., Tamburin, S., Cavazza, S., Scampoli, C., Manca, M., Cosma, M., Berto, G., Vallies, G., Roncari, L., Melotti, C., Santilli, V., Smania, N. 2014. Relationship between ultrasonographic, electromyographic, and clinical parameters in adult stroke patients with spastic equinus: an

observational study. *Arch Phys Med Rehabil*, 95, 1564–1570.

Pingel, J., Bartels, E.M., Nielsen, J.B. 1993. New perspectives on the development of muscle contracture following central motor lesions. *The J Physiol.* 595(15):1027-1038.

Prudent, D., Perineau, F., Bessiere, J.M., Michel, G., Bravo, R. 1993. Chemical analysis, bacteriostatic and fungistatic, properties of the essential oil of the atoumau from Martinique (*Alpinia speciosa* K. Schum.) *Journal essential oil research*, 5, 255-264.

Ranatunga, K.W. 2011. Skeletal muscle stiffness and contracture in children with spastic cerebral palsy. *Journal Physiol,* 598, 2665.

Robinson, K.G., Mendonca, J.L., Militar, J.L., Theroux, M.C., Dabney, K.W., Shah, S.A., Miller, F., Akins, R.E. 2013. Disruption of Basal Lamina Components in Neuromotor Synapses of Children with Spastic Quadriplegic Cerebral Palsy. *Plos one*., 8(8).

Roy, A., Krebs, H.I., Bever, C.T., Forrester, L.W., Macko, R.F., Hogan, N. 2011. Measurement of passive ankle stiffness in subjects with chronic hemiparesis using a novel ankle robot. *Journal Neurophysiol*., 105, 2132–2149.

Santos, B.A., Roman-Campos, D., Carvalho, M.S., Miranda, F.M.F., Carneiro, D.C., Cavalcante, P.H., Cândido, E.A.F.,

Xavier-Filho, L., Cruz, J.S., Gondim, A.N.S. 2011. Cardiodepressive effect elicited by the essential oil of *Alpinia speciosa* is related to L-type Ca2+ current blockade. *Phytomedicine*, 18, 539–543.

Sapra, B, Jain S, Tiwary AK. 2008. Percutaneous Permeation Enhancement by Terpenes: Mechanistic View. *Am Assoc Pharmaceutical Sci J,* 10, 120-132.

Smith, L.R., Chambers, H.G., Subramaniam, S., Lieber, R.L. 2012. Transcriptional abnormalities of hamstring muscle contractures in children with cerebral palsy. *PLoS One.* 2012; 7(8):e40686.

Smith, L.R., Póten, E., Hedstrom, Y., Ward, S.R., Chambers, H.G., Subramaniam, S., Lieber, R. 2009. Novel transcriptional profile in wrist muscles from cerebral palsy patients. Medical Genomics, 2, 44.

Victório, C.P. 2011. Therapeutic value of the genus Alpinia, Zingiberaceae. Revista Brasileira de Farmacognosia *Bazilian Journal of Pharmacognosy,* 21, 194-201.

****