Master's Thesis of Physical Education

The effects of 6 weeks Zumba Fitness Program on oscillatory brain activity and cognition in women between 57 – 90 years old

줌바 피트니스 프로그램이 57 – 90 세

여성들의 인지 기능과 두뇌 활동에 미치는 영향

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Graduate School of Physical Education
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Abstract

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Electrical activity of the brain has been studied throughout time and measured using the electroencephalogram (EEG). Studies reveal that exercise has been related to changes in cortical activity, however, the number of researches related with dance and fitness dance-based programs effects on brain activity are very few. The aim of the present study was to examine the effects of 6 weeks Zumba fitness program on oscillatory brain activity and on cognition in women between 57 – 90 years old. Thirty voluntary healthy women, between 57 – 90 years old, members of the adult group "Taller del maestro" of Villa Delia neighborhood located in the city of Bogota - Colombia participated in this study. Participants were randomly assigned, in two groups, Zumba group (n=15) and Control group (n=15). Zumba group women participated during six consecutive weeks, two times per week in a Zumba class, Participants EEG activity was measured before 6 weeks Zumba workout, during activity and immediately after last Zumba class. Also, cognitive test for working memory and attention were performed before and after 6 weeks. Results demonstrates increases in beta absolute power during the stages during and after compared to before measurement. However, no significant results were found in absolute alpha band power during the stages after 6 weeks Zumba program and during session in the Zumba group, these findings suggest increases in EEG beta band power reflect grater cortical activations during and after Zumba, while alpha increases can be due to fatigue or decreased anxiety. This study also showed that 6 weeks of Zumba Fitness program generate positive effects in working memory. On the other hand, taking into account that control group did not underwent any type of treatment, results of brain activity and cognition did not show significant differences before VS after 6 weeks for this group. Additionally, in order to verify data and compare beta wave activity during a Zumba session with control group participants, Motor imagery (MI) test was performed for both groups after 6 weeks. Results showed greater brain activity in beta brain wave in the Zumba group, related to a greater cognitive capacity of attention and working memory while the control group presented low values which can be associated with a lower cognitive capacity.

Key words: Zumba Program, Brain waves, working memory, attention, Motor imagery

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Chapter 1. Introduction

1.1 Current context

Advances in technology and the implementation of new techniques have allowed us to increase our knowledge about brain function over time. "One of the oldest methods for assessing the relationship between brain and behavior is the Electroencephalography (EEG) that provides a direct real-time measure of neural activity" (Park, Fairweather, & Donaldson, 2015, p. 118). The EEG measures the electrical activity of the brain at different sites of the head, typically using electrodes placed on the scalp (Freeman & Quiroga, 2013). Due to the importance of the study of brain activity, neuroscientists and psychologists have used this method to study brain activity and its relationship to the cognitive process. According to Gevins et al. (2012): "A test combining EEG measures with working memory task performance measures offers promise in the ability to track changes in an individual's cognitive status over time" (p. 1297).

Cognition plays and important role on learning process and daily life activities. Due to these, there are a lot of cognitive stimulation techniques and methods to enhance learning process at an early age. Furthermore, considering the importance of brain health in humans and the knowledge about its functioning, the sport medicine field, in order to improve brain functioning, prevent and ameliorate the symptoms of some brain diseases, has been carried out several investigations, especially, on patients with diseases associated with cognitive decline. Investigations show that physical activity (PA) has a positive effect on brain health and cognition, especially those related with aerobic exercise. These studies suggest that “Physical activity improves executive functions, attention, cognitive speed and episodic memory” (Gligoroska & Manchevska, 2012, p. 200). Also, “New evidence indicates that exercise exerts its effects on cognition by affecting molecular events related to the management of energy metabolism and synaptic plasticity” (Gómez-Pinilla & Hillman, 2013, p. 403). However, there are not only researches related to cognitive activity, other brain related studies have been performed. “Exercise has been widely related to changes in cortical activation and enhanced brain functioning” (Moraes et al., 2007, p. 637) Studies revealed that physical activity has been related to changes in brain functioning and the affective state of an individual (Aminul & Samiran, 2015). Also, there are studies related to the effects of exercise on brain electrocortical activity measured by EEG, Crabbe and Dishman (2004) concluded that “compared to before exercise, alpha activity was greater immediately after and during exercise when expressed as absolute power” (p. 563).

Over time, it has been talked about aerobic dance, as a mean to improve primary physical fitness, body composition parameters, self-concept and mood changes. Even thought, there are studies related with brain activity and cognition, this area has been understudied, Kosmat and Vranic (2017) have mentioned that the reason behind this relatively neglect might be related to the struggle found to define dancing activities in terms of intensity. Owing to these, the number of research projects are very few specially, those related with brain activity. Bläsing et al. (2012) concluded that "performing and perceiving dance epitomize embodied cognitive processes including those based on somatosensation, learning, memory, multimodal imagery, visual and motor perception, and motor simulation" (p. 306). Also, Kimura and Hozumi (2012) revealed, there is an acute effect of a complex aerobic dance program on executive cognitive function immediately after dance workout. It is important to consider that some researches on the dynamics and brain activity have been also performed. A study that compared patterns of alpha synchronization between professional dancers and novices during performance of tasks involving different creative demands concluded that; "professional dancers show stronger alpha synchronization in posterior parietal brain regions than novice dancers" (Fink, Graif, & Neubauer, 2009, p.854). Also, during improvisation dance, professional dancers exhibited more right-hemispheric alpha synchronization (Fink, Graif, & Neubauer, 2009). Gruzelier, Thompson, Redding, Brandt and Steffert (2014) demonstrated the effect of alpha/theta neurofeedback in enhancing cognitive creativity on contemporary dancers, in which the impact of hypnogogic training on creativity alfa and theta neurofeedback training increased cognitive creativity.

Unfortunately, although there are some researches related with dance effects on brain activity these are very few, especially those related to oscillatory brain activity. Since most of these studies are generally related to physical improvements. Furthermore, this has been performed mainly on young and old population taking into account that "the assumption that young adults are at the peak of their cognitive ability means that exercise will not cause cognitive abilities to be higher or lower compared to other young adults with more or less exercise" (Rezab, 2015, p. 2). Consequently, most of the researches involve old population or patients with cognitive decline. Schultz et al. (2015) concluded that in a late-middle-aged, at-risk cohort, higher Cardio Respiratory Fitness CRF is associated with a diminution of Aβ-related effects on cognition. Kimura and Hozumi (2012) in a study performed to Thirty-four elderly participants, showed that a dance program under the Combination style work out, condition could significantly influence higher cognitive processes, particularly executive cognitive function. However, these studies have been focusing mainly on traditional exercises and dances such as cycling, running and ballet, contemporary dance among others leaving aside other types of dance-based programs like Zumba.

> Zumba® program is a Latin-inspired, dance-fitness class that incorporates Latin and international music and dance movements, creating a dynamic, exciting, exhilarating, and effective fitness program. A Zumba class combines fast and slow rhythms that tone and sculpt the body using an aerobic/fitness approach to achieve a unique blended balance of cardio and muscle-toning benefits. (Zumba, 2013, par. 1)

In view of the characteristics of Zumba, this program could be considered as an option to improve brain functioning, stimulate and prevent cognition lost in adult women. Moreover, because of the lack of researches related with new fitness trends, is important to study the effects of Zumba fitness program on brain activity in order to observe brain wave pattern changes caused by its performance. The previous will allow us to design and implement new training programs focus on brain health and cognitive improvement through physical activity, not only for adult women, also general population and people with cognitive problems. Thus, the purpose of this study is to analyze the effects of 6 weeks Zumba fitness program on oscillatory brain activity and on cognition in women between 57 – 90 years old. Since different studies suggest that "in various situations and conditions, beta waves significantly correlate with stimulatory and cognitive responses to external environments and mental states when awake, which vary among people according to individual differences and environmental factors” (Güntekin, Emek-Savaş, Kurt, Yener, & Başar, 2013; Hsu, Cheng, & Chiu, 2017; Van Ede, De Lange, Jensen, & Maris, 2011). In addition, “activating music is often directly related to voluntary coordinated movements, such as dancing, it may also influence motor regions of the brain, which can result in beta wave activity” (Höller et al., 2012 cited by Hurless et al., 2013, p. 3). Other studies suggest “a significant absolute power increase in beta after exercise at frontal areas, which might be related to increased cortical activation” (Moraes et al., 2007, p. 637) and also compared to before exercise, alpha activity was greater immediately after (Crabbe & Dishman, 2004). I hypothesized that during and after a Zumba fitness program session participant are going to exhibit an increase in beta and alpha oscillatory brain activity during EEG recordings, as an increase in cognition after 6 weeks Zumba program.

1.2 Statement of the Problem

Dance is a field or art that has not been found in many research projects in relation to brain activity. Even though, there are some researches, these are very few. Especially those that talk about oscillatory brain activity, in comparison with other areas, like sports field. This may be because of the difficulty of defining dancing activities in term of intensity (Kosmat & Vranic, 2017). “Investigations on the influence of dance expertise on EEG activity are sparse, as most expert studies assess either proficiency in task performance, various types of athletes or the influence of aerobic exercise on EEG activity among non-experts" (Nota, Chartrand, Levkov, Montefusco-Siegmund, & DeSouza, 2017, p. 82). Not only most of the researches about dance are more focused on technique and performance, mood changes, anthropometrical measures and physical improvements but also leave aside brain activity. These studies have also had the tendency to mainly make use of traditional dances such as ballet, contemporary dance, among others, leaving aside new dance styles and dance-based programs like Zumba.

Although, currently the number of Physical Activity (PA) and fitness programs is increasing, the knowledge about these new programs is not clear, as is the study of these programs in relation to brain activity and exercise prescription. Furthermore, adherence to conventional methods of exercise is decreasing, increasing the need to carry out research on new training trends. Bethancourt, Rosenberg, Beatty and Arterburn (2014) concluded that: "Prominent barriers to PA and PA program participation were physical limitations due to health conditions or aging, lack of professional guidance, and inadequate distribution of information on available and appropriate PA options and programs" (p. 10). The lack of knowledge added to other factors as conflicting data, lack of researches, leaves a space in which it is important to work if we want to increase the PA participation, adherence, and the knowledge about new training methods on brain activity like Zumba, being a fitness dance program that has been well received in the population worldwide. According to Domene, Moir, Pummell and Easton (2014) “in many countries around the world both salsa dance and Zumba fitness are popular leisure pursuits fostered by members of both the Latin and non-Latin communities” (p. 2). Nonetheless, there are not studies that investigated the effects of Zumba Fitness on brain activity. Even though, there are researches about aerobic exercise these are also very few “one reason for this may be that many measures of brain activity require subject immobility” (Kubitz & Mott, 1996, p. 91) and due to difficulties of utilizing modern brain-imaging techniques while exercising (Ludyga, Gronwald, & Hottenrott, 2016). On top of that, there is a lack of information about dance base fitness programs and new trends, there is a need to focus on the programs that are attracting the attention of the population and involves the participation of a large number of people in order to see the benefits at a general level. Additionally, it is necessary to work with adults as a preventive measure of early cognitive decline and to enhance their brain health.

Most of the studies related with brain activity and exercise, talk about cognitive process and have been performed on young and very old population, due the assumption that young adults are at the peak of their cognitive ability and exercise will not cause any cognitive effect (Rezab, 2015). Hence, the number of studies performed in young and middle adults is limited and even though there are some researches the results tend to be conflicting as stated by Åberg, et al. (2009) "the relationship between physical exercise and neurocognitive function in young adults remains unknown because of conflicting data" (p. 20906). Despite of these researches on cognitive function, most of the population do not know the benefits of aerobic exercise on brain activity, hence, neither the effects on cognition and brain functioning. Allowing the common thinking that only through other techniques, such as; learning new languages, memory games and tests and others that provide benefits are the single way to improve concentration and memory. The population, in particularly, sedentary people, or novice don't know about aerobic exercise and have questions like, 'what should I do?' Start exercising! We don't know exactly which exercise is best, how much exercise is required to improve memory? (Godman, 2014). This lack of knowledge discourages people to engage physical activity programs which generates problems associated with physical inactivity.

1.3 Research Significance

Since there is a lack of information about the effects of dance base fitness programs on brain activity, indeed there are no investigations related to Zumba. This new knowledge about Zumba Program will allow us to have a greater knowledge about brain activity patterns associated with aerobic dance, that unlike a normal aerobic exercise "comprise a number of dance elements including different patterns, steps, and movements” (Kimura & Hozumi, 2012, p. 623). Also, it involves other elements such as music and tempo which are not included in all aerobic exercises, that also can affect brain activity. Additionally, findings of this research will be very useful for the medicine sports and neuropsychology field, since it could be used for the improvement or implementation of brain stimulation techniques through physical activity, associated with areas stimulated by Zumba. Likewise, it will allow Zumba to be known as a method of cognitive stimulation, scientifically proven, which will provide more options for people with related problems as cognitive decline, mild cognitive impairment or as an option for motor imaginary training for rehabilitation for those who are trying to regain motor skill lost or impaired among others.

1.4 Objective

Examine the effects of a 6 weeks Zumba fitness program on oscillatory brain activity and on cognition in women between 57 – 90 years old.

1.4.1 Specific objectives

- Observe absolute band power alterations in beta and alpha brain waves before 6 weeks, during a session and immediately after a Zumba class.

- Determine the effects of 6 weeks Zumba fitness program on cognition (working memory and attention).
- Determine the effects of 6 weeks Zumba fitness program on beta wave activity during Zumba Motor imagery.

Chapter 2. Literature review

2.1 Dance and Brain Activity (EEG)

In order to understand and analyze the electrical activity in the brain, the electroencephalography or EEG is the most used device to measure it. “EEG is one of the oldest methods for assessing the relationship between brain and behavior and provides a direct real-time measure of neural activity” (Park, Fairweather, & Donaldson, 2015, p. 118). Unfortunately, even though there are studies about brain activity, those who talk about brain activity in dance, are very few. A study that investigated EEG alpha activity between professional dancers and novices during performance of tasks involving different creative demands, concluded. “That professional dancers show stronger alpha synchronization in posterior parietal brain regions than novice dancers. Also, during improvisation dance, professional dancers exhibited more right-hemispheric alpha synchronization” (Fink, Graif, & Neubauer, 2009, p. 854). Additionally, Park, Yagyu, Saito, Kinoshita, & Hirai (2002) in a study that observed “the brain wave activity of a professional Salpuri Dancer while she recalled her performance, showed an increase in alpha brain activity together with marked frontal midline theta activity” (p. 955). Nevertheless, other researches that study brain activity have been focused on the effects of different methods as audio feedback, video feedback, meditation or cognitive training programs in order to improve performance or enhance concentration. Gruzelier, Thompson, Redding, Brandt and Steffert (2014) demonstrated the effect of alpha/theta neurofeedback in enhancing cognitive creativity on contemporary dancers, in which the impact of hypnogogic training on creativity alfa and theta neurofeedback training increased cognitive creativity.

2.2 Exercise and brain activity measured by EEG

"Physical activity has been related to changes in brain functioning and the affective state of an individual" (Moraes et al., 2007, p. 637). In consequence, these different studies so as to evaluate the changes in cortical activity during and after exercise have been performed. to measure those changes or combinations of electrical activity of the brain commonly known as brain wave pattern (Aminul & Samiran, 2015). The electroencephalogram has been one of the most used tool to measure it. "Electroencephalography (EEG) is a mobile brain imaging technique with more-than-sufficient time resolution to capture cortical dynamics during human locomotion" (Enders et al., 2016, p. 379). According to Moraes et al. (2007) study that investigated the effects of a maximal effort exercise in the brain electrocortical activity, results indicated a significant absolute power increase in beta after exercise at frontal and central areas, which might be related to increased cortical activation. Furthermore, Crabbe and Dishman (2004) concluded: "Compared to before exercise, alpha activity was greater immediately after and during exercise, when expressed as absolute power but not as relative power in other frequency bands; delta, theta, and beta activity also increased" (p. 563). Enders et al. (2016) in a study that investigated the effects of a high-intensity cycling exercise on changes in spectral and temporal aspects of electroencephalography (EEG) measured from 10 experienced cyclists, observed significant changes in electrocortical activity in frontal, supplementary motor and parietal areas of the cortex and a small ERD in $\alpha - \beta$ band during the phases of the right and left down stroke followed by ERS toward the end of the crank cycle being stronger in β compared with the α band. Aminul and Samiran (2015):

> Indicated an increase in beta absolute power in various subareas after exercise in the participants. Whereas, pre exercise EEG recordings reported no such differences concluding that acute aerobic exercise may lead to higher cortical activation which influences changes in beta absolute power in brain regions. (p. 54)

An other research that examined the effects of aerobic exercise on spontaneous electroencephalographic (EEG) activity indicated "that brain activation increased (alpha activity decreased and beta activity increased) during the exercise condition and returned to baseline following exercise" (Kubitz & Mott, 1996, p. 91). Furthermore, previous research suggest "that cortical activation patterns depend on exercise mode and intensity"

(Brümmer, Schneider, Abel, Vogt, & Strüder, 2011, p. 1863). Brümmer, Schneider, Abel, Vogt, & Strüder (2011) found:

> [That] moderate-intensity exercise was followed by an increase in α activity in either somatosensory brain areas after "familiar exercise" or in emotional areas after "unfamiliar exercise" modes. After high-intensity exercise, changes in α and β frequencies were observed, which also seem to be specific to individual exercise familiarization/preference. (p. 1863)

2.3 EEG during Motor Imagery

Movement execution and its relation to brain activity have been study over the time. However, the study of brain activity of complex movements such as those performed in dance or other sports has been difficult to carry out. For this reason, other strategies or methods such as motor imagination, action observation among others have arisen. Motor representations for complex movements that cannot physically be performed during neuroimaging have utilized tasks involving AO (Action Observation) and/or KMI (kinesthetic motor imagery) from an internal first-person perspective (Di Nota, Chartrand, Levkov, Montefusco-Siegmund, & Desouza, 2017). Motor imagery (MI) is a term introduced by cognitive neuroscientists to describe the mental rehearsal of voluntary movement without accompanying body movement (Formaggio, Storti, Cerini, Fiaschi,

& Manganotti, 2010). This has been used as a strategy for rehabilitation in some movement impairments or skill improvements. "In normal subjects, for instance, motor imagery is used by athletes and professional musicians, where it is called 'mental rehearsal', to improve performance" (Solodkin, Hlustik, Chen, & Small, 2004). MI is related to the mirror neuron system "a group of specialized neurons that "mirrors" the actions and behavior of others" (Rajmohan & Mohandas, 2007, p. 66). The brain regions associated with this system in humans are the premotor cortex, the supplementary motor area, the primary somatosensory cortex and the inferior parietal cortex (Molenberghs, Cunnington, & Mattingley, 2009) and there is evidence of "the existence of a cortical network with the properties of mirror neurons (mirror system) in humans" which is important and is related to motor learning specially in dance since "Imitation also plays a central role in learning to dance and the acquisition of the long sequences of choreographed movements are dependent on social learning" (Laland, Wilkins, & Clayton, 2016, p. 5). Thus, motor imagery can modulate sensorimotor rhythms (Cheyne, 2013) there are EEG studies that evaluate the brain activity during MI performance. Di Nota, Chartrand, Levkov, Montefusco-Siegmund, & Desouza (2017) concluded that "ballet dancers highly familiar with the genre of the experimental stimulus demonstrated higher individual alpha peak frequency (iAPF), greater alpha desynchronization, and greater task-related beta power during AO, as well as faster iAPF during KMI of non-dance movements" (par. 2). An EEG associated with actual hand movement study to those associated with imagined hand movement performed by (McFarland, Miner, Vaughan, & Wolpaw, 2000) showed that both movement and imagery are accompanied by desynchronization over sensorimotor cortical areas in both mu and beta bands. Also studies demostrated, that brain oscillations in the α- and β-range become suppressed during motor processing and motor imagery (Schaller, Weiss, & Müller, 2017)

2.4 Dance on Cognition

Dance is a term that is complex to define due to its components and also because it is considered by many as an art, term that itself involves different emotions and knowledge. because of these there are different definitions. "dance is defined as any patterned, rhythmic movement in space and time" (Copeland & Cohen, 1983 p. 2). According to Kealinohomoku (2001), "dance is a transient mode of expression performed in a given form and style by the human body moving in space" (p. 33).

Traditionally dance has been played a significant role in all societies culture of each country around the world. therefore, it is important for the human being. Considering it "an integral part of human cultural scheme as it performs social, spiritual, artistic, and emotional as well as amusement related functions" (Sultana, Chaudhry, & Mushtaq, 2013) . Considering the importance of dance for the human being life, different studies related to dance have been carried out, especially those related with dance benefits on physical and emotional level. What is more, there are some studies related with cognition, because of its nature, “dancing as a neurocognitive experience activates multiple cognitive functions such as perception, emotion, executive function (decision-making), memory, and motor skills” (Foster, 2013, p. 2). Aerobic dance exercises comprise a number of dance elements including different patterns, steps, and movements. Participants are required to pay attention and follow the instructor's lead to learn new dance elements and smoothly switch between these elements throughout the exercise (Kimura & Hozumi, 2012). In a recent study, Kosmat and Vranic (2017) found beneficial effects of a dance intervention of moderate length (10 weeks, 45 min/week) in short-term memory and executive functioning on a sample of elders with no cognitive impairments, living in a residential care setting. Another study about Recalling dance movement from long-term memory in female dancers, (Stevens, Ginsborg, & Lester, 2011) found that recall rates were similar across immediate and delayed conditions and qualitative data indicating that music and dancing movement were important for Long term memory (LTM) development. A previous study that compared the effects of acute aerobic dance exercise on cognitive performance demonstrated that the executive cognitive network was facilitated in a Combination style (CB) (long choreography routine) dance workout that has a dual-task nature and induces movement (task) interference with unexpected movement changes (Kimura & Hozumi, 2012). It is known, there are few numbers of studies on cognitively healthy individuals and young population, but despite the limited number of researches of dance on cognition, these have been focused more on the elderly population or patients with diseases such as Mild Cognitive Impairment, Parkinson’s and Alzheimer's disease. In a study that determined whether executive function improves in individuals with Parkinson Disease (PD) following an 8-week dance program Prewitt, Charpentier, Brosky, & Urbscheit (2017) suggested that therapeutic dance may specifically improve the executive function domain of cognition, particularly when connected to physical movement. Also, suggested “if this effect is consistent, dance programs could improve short-term executive function in individuals with PD” (Prewitt, Charpentier, & Brosky, 2017, p. 2). After an intervention study that evaluates whether dance and movement therapy (DMT) would improve dementia patients' cognitive level or behavior. Hokkanen et al. (2008) demostrates that DMT seems to offer one option in treating dementia, having effects on cognition and self-care abilities.

Chapter 3. Methodology

3.1 Research Method

Thirty voluntary women, between 57 – 90 years old, right-handed, healthy subjects were included in this study after informed consent. Participants were evaluated before and after 6 weeks Zumba workout. Measurements included: EEG activity before, during and immediately after Zumba class (last class), EEG recording during Zumba choreography mental rehearsal (Motor Imagery (MI)), Height, weight and Body Mass Index (BMI) and two cognitive tests. Zumba routines consisted of 50 minutes session that included a 5 min warm-up, 35 min central part and 10 min cool-down period. The classes were performed two times per week (Monday - Friday) for six consecutive weeks.

3.2 Study Location

The study was conducted in Bogota – Colombia, on the first floor of the community center of the Villa Delia neighborhood.

3.3 Subjects

Thirty voluntary healthy women, between 57 – 90 years old, members of the adult group "Taller del maestro" of Villa Delia neighborhood participated in this study after informed consent.

As inclusion criteria, Healthy women were included in the study, who confirmed, through their annual medical check-up, to be free of chronic conditions that might limit their ability to engage in the dance program, those who had no engaged in any specific physical activity program during the previous two years and have not had experience in dance or aerobics group class during that time. Subjects that had previous cardiovascular events, had psychological conditions that could affect cognitive function, muscle skeletal problems, hypertension, osteoarthritis, cardiovascular disease or any other health problem that limit their physical activity performance were excluded. Additionally, subjects, who were under the treatment of some medication that affects cognitive process and normal brain activity, like sleeping pills and those participants who did not pass the mini mental examination test, which was carried out to the participants before starting the Zumba treatment, in order to evaluate their cognitive state were also excluded. All details of this study were explained before the research began and an informed written consent was obtained from all participants.

Participants were randomly assigned, in two groups, Zumba group (n=15) and Control group (n=15) using a random number generated with computer software Microsoft® Excel for Mac, version:16,22, 2019).

3.4 Assessments

3.4.1 EEG Recording pre-during -post and device

To carry out the measurements, participants were asked, beforehand, to refrain from smoking, drinking alcohol or caffeine and eating within 2 h before data collection. Recordings were obtained at three different times; before, during and after Zumba treatment for 3 minutes. EEG data were recorded using InteraXon's four-channel dry electrode headset sensing head band MUSE (Muse, 2018) (Figure 1) and recording with Muse Monitor Data Acquisition for Real Time EEG brainwave data graph and recording mobile app (Release Date: 2015) (Musemonitor, 2015) (Figure 2).

Muse EEG system has four electrodes located at standard 10-20 coordinates (TP9, AF7, AF8, TP10) with electrode Fpz used as the reference electrode (Figure 3).

Figure 1. Muse: the brain sensing headband

Source: (Choosemuse, 2019)

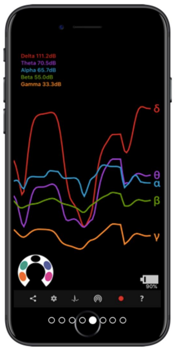

Figure 2. Muse Monitor Mobile App

Source: (Musemonitor, 2018)

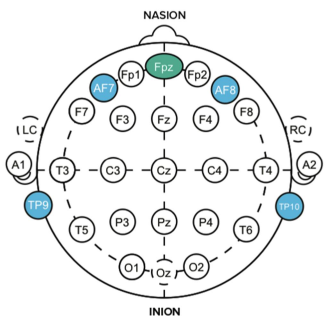

Figure 3. Muse electrode locations by 10-20 International Standards

Source: (Choosemuse, 2018)

3.4.1.1 EEG Recording Baseline (Before Zumba)

Baseline (resting) EEG data was collected one week before Zumba classes started, it was recorded for 3 minutes, closed-eyes, to observe electrical activity without external stimuli, thus minimizing visual artifacts (Aminul & Samiran, 2015). Before the recording participants were asked to wear the Muse headband, adjusting and fitting instructions as help were provided to each participant. Women were seated in a comfortable chair to reduce muscular tension and had eight minutes to relax, recording starting at minute five (without notice to participants, in order to avoid alterations in brain activity) for the remaining three minutes. During the task, all lights, besides the video monitor, remain turn off to minimized visual stimuli interferences (Moraes, et al., 2007). After 6 weeks of Zumba, immediately after last session (approx. 2- 5min) participants underwent identical EEG recording procedure.

3.4.1.2 EEG Recording during Zumba Session

In order to observe brain activity during the Zumba session in the participants, it was recorded in the third week, during one of the Zumba sessions. Participants were asked to wear Muse headband during one of the choreographies. Recording lasted 3 minutes.

3.4.1.3 EEG Recording After Zumba Session

Immediately after last Zumba session (approx. 2-5 min after) participants underwent similar EEG recording procedure as baseline (resting) recording (without the five minutes of relaxation).

Once the last session was finished, women were seated in a comfortable chair and were asked to wear the Muse sensing headband. Brain activity was measured during three minutes with closed-eyes.

3.4.2 EEG Motor Imagery (MI)

To verify data obtained during Zumba session and considering that, movement imagination partly activates same motor network that is responsible for motor execution (Jeannerod, 2001), an additional measurement was made to know the brain activity of the participants during Zumba mental rehearsal.

EEG Motor imagery recordings were conducted after 6 weeks of the Zumba program (after the last session in the afternoon hours). As in other EEG recordings participants were asked to wear the EEG device Muse and were seated in a comfortable chair, in front of a computer screen. During MI recordings participants were asked to visualize themselves performing a Zumba choreography (following the choreography) without accompanying body movement, with eyes closed, while the recording of brain waves was carried out for one minute.

Before recordings participants had the opportunity to watch a 1-minute Zumba dance choreography video and tried to follow the choreography mentally or with body movement. To become familiar with the task (participants were able to watch the video as many times as they wish before recording). During the task participants were asked to imagine themselves performing the choreography, they watched on the video, without accompanying body movement, eyes closed, just listening to the music, while the recording of brain waves was performed for one minute.

3.4.3 Anthropometric parameters and height

Height was calculated using a stadiometer and weight was measured using a weight scale. Participants were asked to wear comfortable clothes and remove shoes. Once the results were obtained, Body Mass Index (BMI) was calculated using the formula: body mass divided by the square of the body height, expressed in units of kg/m2 (Alba, 2012) .

3.4.4 Cognitive test

Working memory and attention were measured through two tests: N back test and attention (find the difference of images) using a tablet app.

N back test: The subject was presented with a sequence of stimuli, and the task consisted on indicating when the current stimulus matches the one from certain number of (n) steps earlier in the sequence. The load n factor could be adjusted to increase or decrease the level of difficulty.

For this test the stimulus were numbers and the load factor 1. The participant had to press the red button that appears on the screen each time the number that appears was similar to the number that appeared earlier. This test was carried out for 1 minute using the tablet (Figure 4).

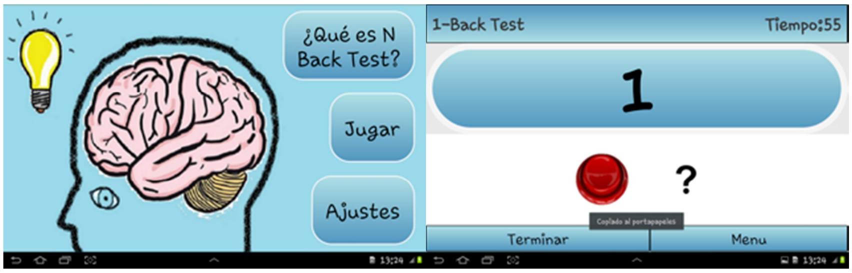

Figure 4. N back test: screenshot from the tablet application

Source: own elaboration

Spot the Differences in Pictures: is a test in which participants had to find 7 differences and spot it, hidden differences between two pictures, during 2 minutes the score was set from zero to 100 (Figure 5).

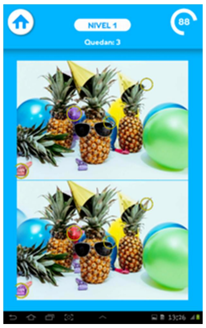

Figure 5. Spot the differences: screenshot from the tablet application

Source: own elaboration

3.5 Zumba Session

Participants were instructed under the supervision of a trained Zumba instructor for 50 minutes (standard dance class) two times per week for six consecutive weeks. Each session followed the same structure (Table 1) that include a 5-min warm-up, 35 min central part and 10 min cool-down period where participants learnt different choreographies. The music selection for each session was one of the four styles of dance (Merengue, Salsa, Reggaeton or Cumbia).

Table 1. Timing and Activity Schedule within One Zumba Session

Duration	Activity
5 min	Greeting and warm up
35 min	Zumba Step sequence learning and repetition (central part)
10 min	Cool – down slow choreography combines with stretching exercise (cool - down)

Source: own elaboration

3.6 Type of research and Design

Type: Experimental Research

Design: Pretest - posttest with control group

3.7 Data Analysis

3.7.1 EEG Analyses

The EEG data was recorded by Muse Monitor Data Acquisition for Real Time EEG brainwave data graph and recording mobile app (Release Date: 2015). Brain wave values are absolute band powers, based on the logarithm of the Power Spectral Density (PSD) of the EEG data for each channel: (Gamma (30 - 44 Hz) Beta (13-30Hz), Alpha (7.5-13Hz), Theta (4-8 Hz), and Delta (1- 4 Hz)). The EEG PSD values as read from the sensors are commonly in the {-1:+1} range (Musemonitor, 2015) (Figure 6).

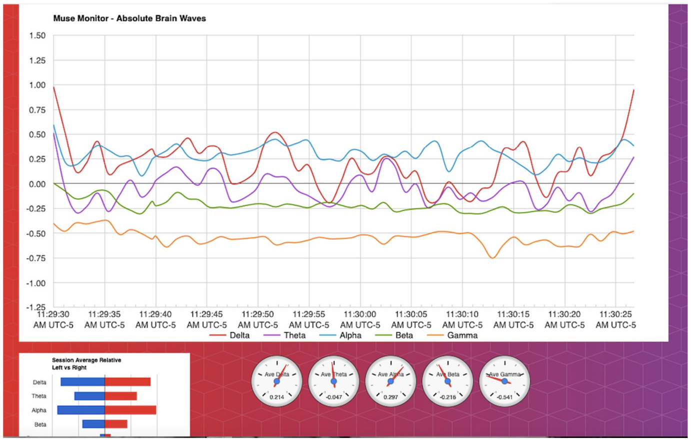

Figure 6. Muse monitor graph: graphing online

Source: (Musemonitor, 2019)

3.7.2 Statistical Analysis

Statistical analysis was performed with the SPSS V 25.0. Statistical significance was set at $p<0.05$ level

3.8 Ethics

All the procedures of this study were carried out under ethical processes, as well as an informed consent signed by the participants. This study was approved by the Institutional Review Board of Seoul National University.

Chapter 4. Results

4.1 Validity test of the instrument.

To estimate internal reliability in this study, the Cronbach's alpha statistical method was used.

The Cronbach's alpha allows estimating the internal reliability of an instrument through a set of items that are expected to measure the same construct or theoretical dimension (Hernández, Fernández, & Baptista, 2014).

According to George and Mallery (2003) it is suggested to consider the magnitudes of the coefficients and be classified as follows

- Alpha coefficient> .9 is excellent.
- Coefficient alpha> .8 is good.
- Alpha coefficient> .7 is acceptable.
- Alpha coefficient> .6 is questionable.
- Alpha coefficient> .5 is poor.
- Alpha coefficient <.5 is unacceptable.

4.1.1 Results reliability analysis

Table 2. Results reliability analysis

	STAGE	
CPSS	**Pre**	**Post**
BMI	0,745	0,811
MMSE	0,724	0,746
Motor Imagery	0,832	0,793
Working Memory NBACK test	0,742	0,841
Brain Activity	0,714	0,703

According to the above, it can be concluded that the results of the tests are reliable with an internal consistency equal to or greater than 72.4% for all the dimensions and stages analyzed.

4.2 Descriptive analysis (Univariate)

4.2.1 Demographic characteristics

Table 3. Demographic characteristics

Status	Frequency	Percentage
Married	19	63.3
Widowed	6	20.0
Divorced	5	16.6

Education	Frequency	Percentage
Primary	15	50.0
Secondary	10	33.3
Bachelor's	5	16.7
# Hours / Week	**Frequency**	**Percentage**
0	8	26.6
1	8	26.6
2	14	46.7
Age (Years)	**Frequency**	**Percentage**
50 – 60	6	20.0
60 – 70	15	50.0
70 – 80	7	23.3
80 – 90	2	6.7
Socioeconomic Level	**Frequency**	**Percentage**
3	14	46.7
4	16	53.3

Source: own elaboration

Table 3 shows the demographic characteristics data, showing that in the selected group; 63.33% of the women were married followed by 20% who were widows and a 16.6% were divorced.

The 83.3 % of the participants had an education level equal to or lower than the secondary, being 50% with a basic elementary level and 16.7% had an undergraduate degree. (none of the participants, despite their studies, have practiced their profession for more than 6 years).

Regarding the hours of physical activity, none of the participants reported practice any regular physical activity or sport. The hours of activity mentioned in table 3, correspond to walking. Almost 50% said that they used two hours a week to walk (46.7%), while 26.6% indicated that they used only one hour. The same number of women indicated that they did not practice activities related to physical exercise weekly.

All the participants were over 50 years old, being the modal range of 60-70 years, where 50% of the participants were in that range and 30% of them were aged 70 or older.

Regarding socioeconomic level, all participants were from strata 3-4. Level 4 being slightly more representative, with 53.3% of the total sample and level 3 with 46.7%.

4.2.2 Demographic Information

Table 4. Demographic Information

	Zumba Group (n=15)		Control group (n=15)			
	Mean	Standard Deviation	Mean	Standard Deviation	t	p
AGE (Years)	67.47	8.1	67.87	6.67	-0.148	0.884
EDUCATION	1.67	0.82	1.67	0.72	0.00	1.00
N° Hours /Week	1.27	0.8	1.13	0.92	0.43	0.67
SOCIOECONOMIC LEVEL	3.47	0.13	3.6	0.51	-0.71	0.48
HEIGHT (cm)	158.06	0.06	158.06	0.05	0.00	1.00
WEIGHT (Kgs)	60.89	7.48	60.63	6.70	0.98	9.23
BMI	24.33	2.35	24.25	2.3	0.1	0.92
MMSE	27.87	1.68	27.73	1.58	0.22	0.82

Source: own elaboration

Table 4 shows the demographic information, Body Mass index (BMI) and the results of Mini -Mental State examinations (MMSE) for the participants. Body Mass Index of the participants were at normal levels (=24.33) for this age range (World Health Organization). Which suggest no increased risk of chronic diseases. However, the number of hours of physical activity reported by participants was less than that recommended by the World Health Organization, therefore the physical activity of the participants was insufficient. According to World Health Organization (2011):

> Older adults should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75

minutes of vigorous- intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. (p. 2)

The MMSE showed that none of the participants were currently at risk of dementia, considering them eligible for the study. Table 4 also shows the results of statistical analyses of comparisons characteristics of the Zumba group and Control group. p values show homogeneity in both groups because there were no significant differences ($p > 0.05$) for the demographic variables, indicating that both groups showed similar characteristics.

4.3 Inferential Statistics

4.3.1 Hypothesis testing

Considering that one of the objectives of the research, besides characterizing the results of the instrument, is to know the effectiveness of the 6 weeks Zumba fitness program on brain activity and cognition, through statistical tests. For the validation of these tests, hypothesis tests linked to the an a priori hypotheses defined in the investigation were used.

For hypotheses validation, the contrast test (Decision Rule) defined as:

** If the P value > 0.05. There is not enough statistical evidence to reject the null hypothesis (We accept the null hypothesis (Ho)) (The alternative hypothesis (Ha) is rejected).

** If the P value <0.05 There is not enough statistical evidence to accept the null hypothesis (Ho)) (The alternative hypothesis (Ha) is accepted).

* All statistical tests were tested based on the decision rule.

* The value of the significance was 0.05. Ad hoc value.

4.3.2 Normality test

For the correct selection of statistical methods and the tests necessary to validate the hypotheses, a normality test was performed. For this study, a Shapiro-Wilk test was used, which according to Oztuna, Elhan, & Tuccar(2006) works adequately for sample sizes that are less than or equal to 30. Results are shown in the Table 5.

Table 5. Normality test

Variable	Stage	Shapiro-Wilk		
		Statistic	gl	p
BMI	Pre- Experimentation	0,810	14	0,009
	Post - Experimentation	0,786	14	0,005
MMSE	Pre- Experimentation	0,866	14	0,046
	Post - Experimentation	0,894	14	0,010
MOTOR IMAGERY	Pre- Experimentation	0,901	14	0,014
	Post - Experimentation	0,841	14	0,022
WORKING MEMORY N Test	Pre- Experimentation	0,785	13	0,005
	Post - Experimentation	0,875	13	0,032

ATTENTION	Pre- Experimentation	0,835	13	0,018
	Post - Experimentation	0,901	13	0,006

Source: own elaboration

According to the results, it can be affirmed that, with a 95% reliability, there is not enough statistical evidence to indicate that the variables follow a normal distribution ($p<0.05$); this implied that the statistical tests were performed from a non-parametric approach.

4.3.3 Brain Activity (Zumba group)

To analyze whether the brain activity had significant changes or not during the stages: before (resting condition), during and after the Zumba program, the F Friedman test, that fits properly to this study, was the one that was used to make the comparisons of alpha and beta brain activity results of the Zumba group.

4.3.3.1 ALFA

The hypothesis test associated with the brain activity of the alpha wave was defined as:

$\boldsymbol{H_o}$**:** There are no significant differences in the Alpha activity before, during and after 6 weeks Zumba fitness program ($Me_1 = Me_2 = Me_3$)

$\boldsymbol{H_1}$**:** There are significant differences in the Alpha activity before, during and after the 6 weeks Zumba fitness program ($Me_1 \neq Me_2 \neq Me_3$, At least there is a median different from the others)

Table 6. Friedman Test, Alpha Scores Zumba Group

	ALFA
x^2	6.533
DF	14
Sig. Asymptotic	0,381

Source: own elaboration

The test had a statistic x ^ 2 = 6.533 and an associated p value of (p = 0.381, p <0.05); According to the results there is not enough statistical evidence to reject Ho and therefore it can be inferred that there were no significant differences of the alpha before, during and after the Zumba program, although, there is an increase in each stage. This can be verified in Figure 3 where it can be seen that the medians of stages did not overlap.

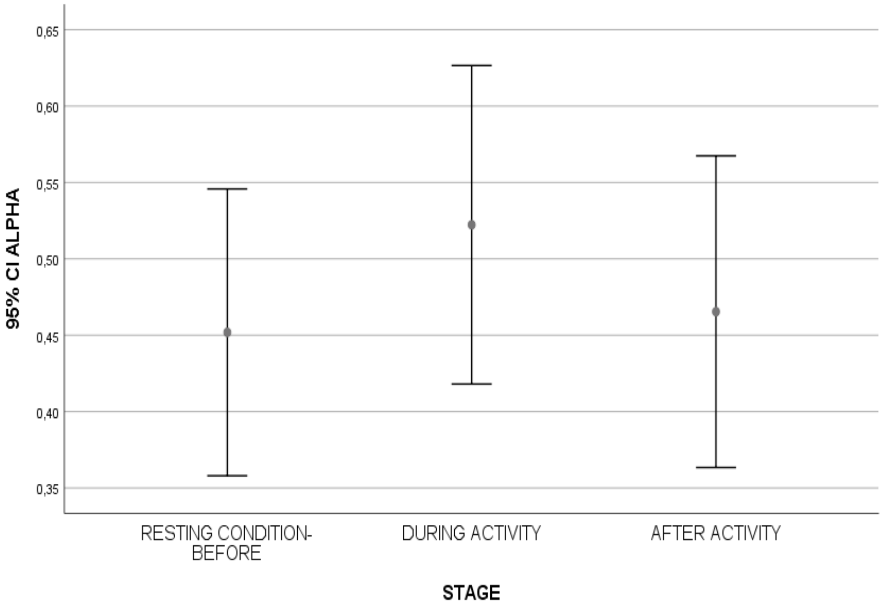

Figure 7. Alpha vs. Stage

Source: own elaboration

4.3.3.2 BETA

The hypothesis test associated with Beta was defined as:

$\boldsymbol{H_o}$**:** There are no significant differences in Beta activity before, during and after the implementation of Zumba fitness program ($Me_1 = Me_2 = Me_3$)

$\boldsymbol{H_1}$**:** There are significant differences in beta activity before, during and after the implementation of Zumba fitness program ($Me_1 \neq Me_2 \neq Me_3$, At least there is a median different from the others).

Table 7. Friedman Test, Beta Scores Zumba Group

	BETA SCORE
x^2	16.533
DF	14
Sig. Asymptotic	0,002

Source: own elaboration

The Friedman test had a statistic (Chi square) x ^ 2 = 16.53 and an associated p value of (p = 0.002, p <0.05); with which it can be inferred that there is not enough statistical evidence to accept Ho and therefore, it can be inferred that there were significant differences of the beta in at least one stage of the process. To establish which stages there were significant differences in, a post hoc test was run (in this case Bonferroni post hoc test) obtaining:

Table 8. Post Hoc Test

(I) STAGE		Mean Difference (I-J)	Std. Error	Sig.
RESTING CONDITION-BEFORE	DURING ACTIVITY	-315.00000*	65.23463	0.000
	AFTER ACTIVITY	-187.06667*	65.23463	0.019
DURING ACTIVITY	RESTING CONDITION-BEFORE	315.00000*	65.23463	0.000
	AFTER ACTIVITY	127.93333	65.23463	0.170
AFTER ACTIVITY	RESTING CONDITION-	187.06667*	65.23463	0.019

BEFORE DURING ACTIVITY	-127.93333	65.23463	0.170

Source: own elaboration

Table 8 shows that there were significant differences between the initial stage (Resting - Before activity) and during and final stages. Instead, between the stages during and after there were no significant differences.

This can be confirmed on Figure 8 where the stages with significant differences did not overlap.

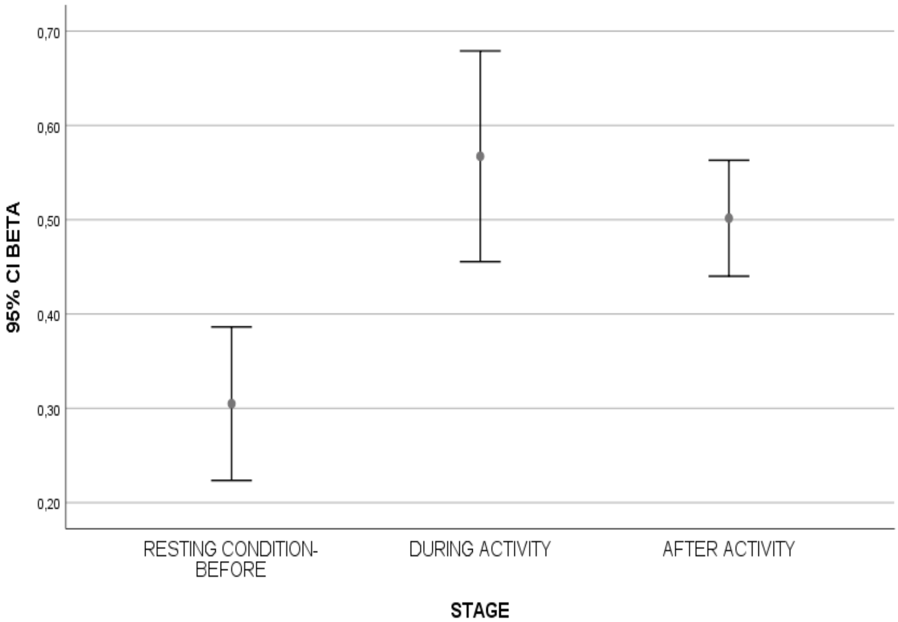

Figure 8. Beta vs. Stage

Source: own elaboration

4.3.4 Brain Activity (Control group)

On the other hand, since the control group had no measurement during the test (During Activity), The stages before and after the activity were contrasted.

According to Whitley and Ball (2002) the Wilcoxom signed rank test is defined, as a rank test that is used in non-parametric statistics. they say that this can be considered as a copy of the test t, where the independent variable is binary but the dependent variable is not normally distributed.

The Wilcoxon rank test was carried out for statistical analysis of brain activity of alpha and beta waves, for control group.

4.3.4.1 ALPHA

$\boldsymbol{H_0}$There are no significant differences in Alpha activity before and after 6 weeks Zumba Fitness Program *(*$Me_1 = Me_2$)

$\boldsymbol{H_1}$There are significant differences in Alpha activity before and after 6 weeks Zumba Fitness Program ($Me_1 \neq Me_2$)

Table 9. Alpha - Wilcoxon Test

	ALPHA SCORES
z	-0.332
DF	14
Sig. Asymptotic	0,754

Source: own elaboration

The test had a statistic z = -0.0332 and an associated p value of ($p = 0.381$, $p > 0.05$); according to the results there is not enough statistical evidence to reject Ho, therefore, it can be inferred that there were no significant differences on alpha during the stages before and after in the control group.

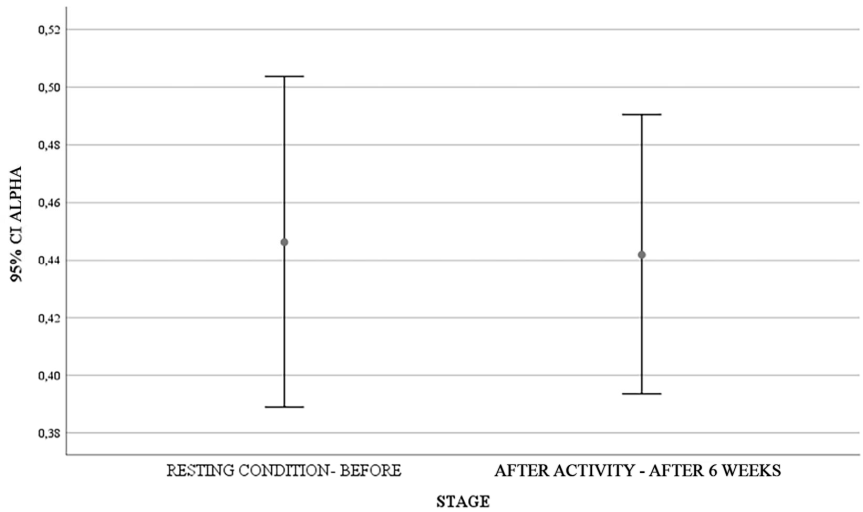

Figure 9. Alpha vs. Stage

Source: own elaboration

4.3.4.2 BETA

$\boldsymbol{H_o}$There are no significant differences in Beta activity before and after in the control group ($Me_1 = Me_2$)

$\boldsymbol{H_1}$: There are significant differences in Beta activity before and after in the control group

$(Me_1 \neq Me_2)$

Table 10. Beta - Wilcoxon Test

	BETA SCORES
z	-1.237
DF	14
Sig. Asymptotic	0,109

Source: own elaboration

The test had a statistic z = -1,237 and an associated p value of (p = 0.109; p> 0.05); according to the results there is not enough statistical evidence to reject Ho and therefore it can be inferred that there were no significant differences of the Beta brain wave activity before, and after six weeks for the control group.

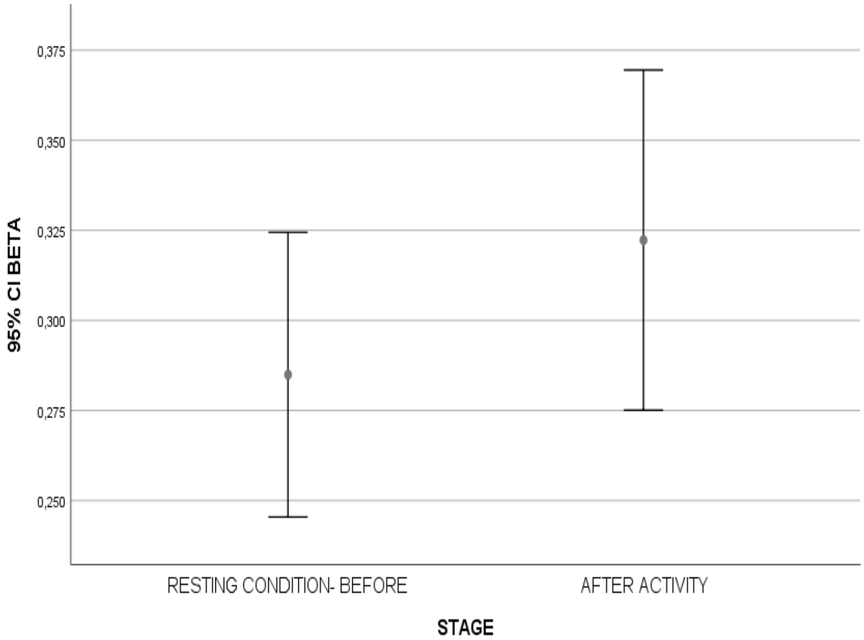

Figure 10. Beta vs stage

Source: own elaboration

4.3.5 Motor Imagery

It seeks to establish if during Motor Imagery (MI) test, brain activity of beta wave was greater in the Zumba group than in the control group. To identify this, a Mann Whitney test was performed, an analogous test to t-test of independent samples from the nonparametric approach (Rivas, Moreno, & Talavera, 2013).

Hypothesis:

$\boldsymbol{H_o}$:There are no significant differences in Beta activity of the Zumba group with the control group ($Me_1 = Me_2$)

H_1There are significant differences in Beta activity of the Zumba group with the control group $(Me_1 \neq Me_2)$

Table 11. Mann Whitney test - Motor Imagery

	MOTOR IMAGERY
Mann-Whitney U	45,000
P	0,005

Source: own elaboration

The test had a statistic U = 79.0 and an associated p value of (p = 0.005); According to the results there is not enough statistical evidence to accept Ho and therefore, it can be inferred that there were significant differences in the Beta brain wave activity between the Zumba group and the control group.

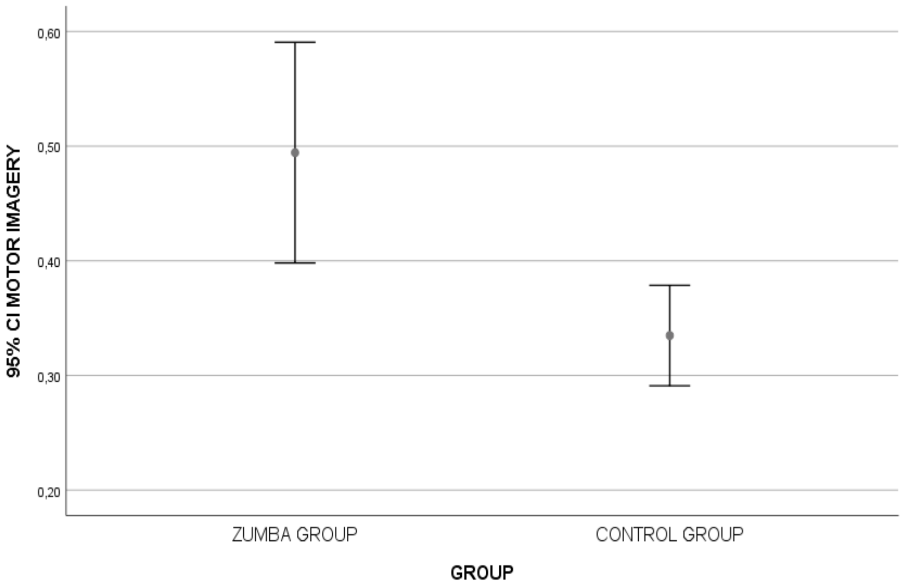

Figure 11. MI Beta Zumba vs. Control group

Source: own elaboration

4.4 Cognitive tests

For the research it is of interest to know the effects of Zumba fitness program on cognition. it was measured if there was an effect of the Zumba program on working memory and attention, specifically.

To analyze the behavior of the variables, Wilcoxon tests were performed for both groups (Zumba and Control) in working memory and in attention.

4.4.1 Working Memory test (Zumba Group)

$\boldsymbol{H_o}$There were no significant differences in working memory after the implementation of 6 weeks Zumba fitness program (($Me_1 = Me_2$)

$\boldsymbol{H_1}$**:** There were significant differences in working memory after the implementation of 6 weeks Zumba fitness program ($Me_1 \neq Me_2$).

Table 12. Working memory test- Zumba Group

	Working Memory
Z	-2.356
P	0.018

Source: own elaboration

The Wilcoxon test had a statistic z = 2.356 and an associated p value of ($p = 0.018$, $p < 0.05$); According to the results there is not enough statistical evidence to accept Ho and therefore it can be inferred that there were significant differences in the Working Memory test before and after Zumba.

Figure x shows that the scores after 6 weeks Zumba program, were higher than those obtained before; this allows to infer that 6 weeks Zumba fitness program had a positive effect on working memory of the participants.

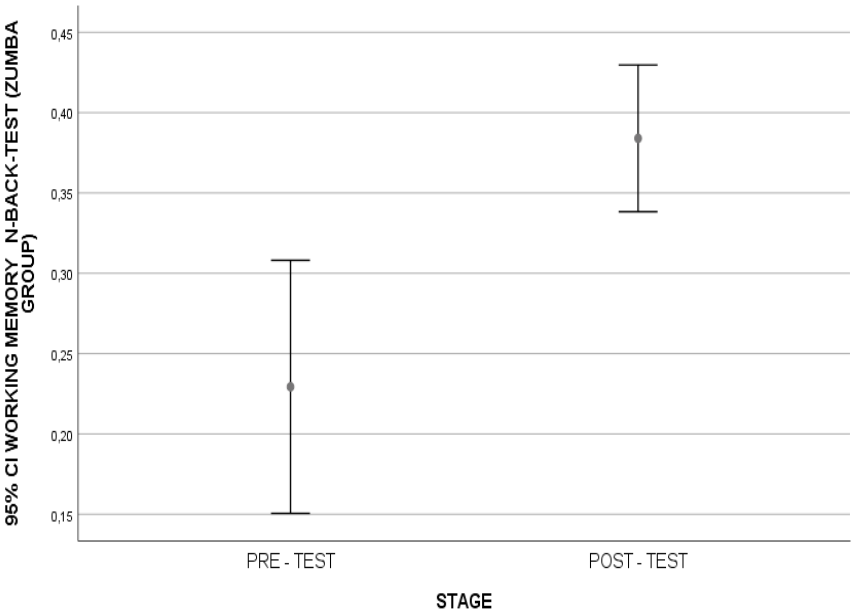

Figure 12. Working Memory - N- back test Zumba Group

Source: own elaboration

4.4.2 Working Memory test (Control Group)

$\boldsymbol{H_o}$There were no significant differences on working memory after 6 weeks (($Me_1 = Me_2$)

$\boldsymbol{H_1}$**:** There were significant differences on working memory after 6 weeks ($Me_1 \neq Me_2$).

Table 13. Working memory test- Control Group

	Working Memory (N back test)
Z	-1.070
P	0,284

Source: own elaboration

The test had a statistic z = -1,070 and an associated p value of (p = 0.284, p> 0.05); according to the results there is not enough statistical evidence to reject Ho and therefore it can be inferred that there were no significant differences in the Working Memory test between before and after six weeks in the control group.

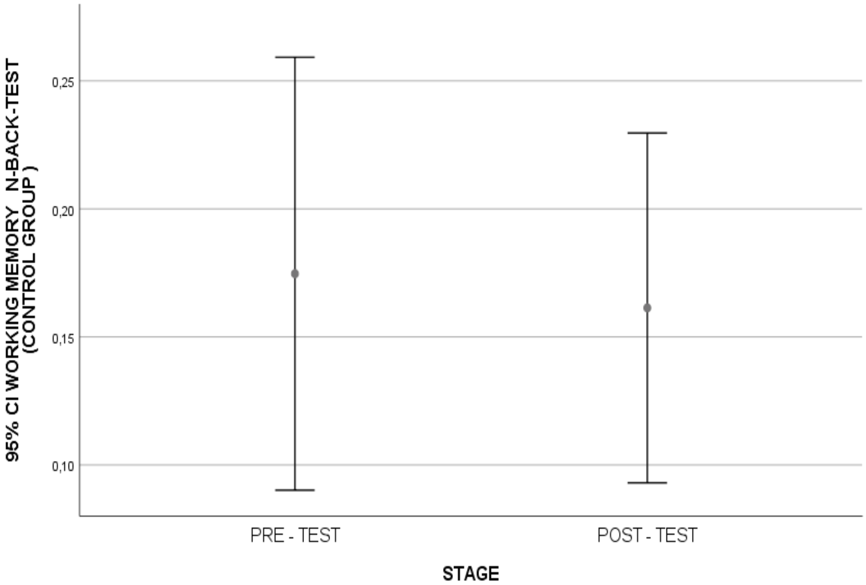

Figure 13. Working Memory - N- back test Control Group

Source: own elaboration

4.4.3 Attention test (Zumba Group)

$\boldsymbol{H_o}$**:** There were no significant differences on attention after the implementation of 6 weeks Zumba fitness program *(*$Me_1 = Me_2$).

$\boldsymbol{H_1}$ **:** There were significant differences on attention after the implementation of 6 weeks Zumba fitness program *(*$Me_1 \neq Me_2$).

Table 14. Attention - Zumba Group

	Attention
Z	1.368
p	0,171

Source: own elaboration

The test had a statistic z = 1.368 and an associated p value of ($p = 0.171$, $p > 0.05$); According to the results there is not enough statistical evidence to reject Ho and therefore, it can be inferred that there were no significant differences on attention between, pre-test and post-test in the Zumba group. however, there is a slight increase after 6 weeks.

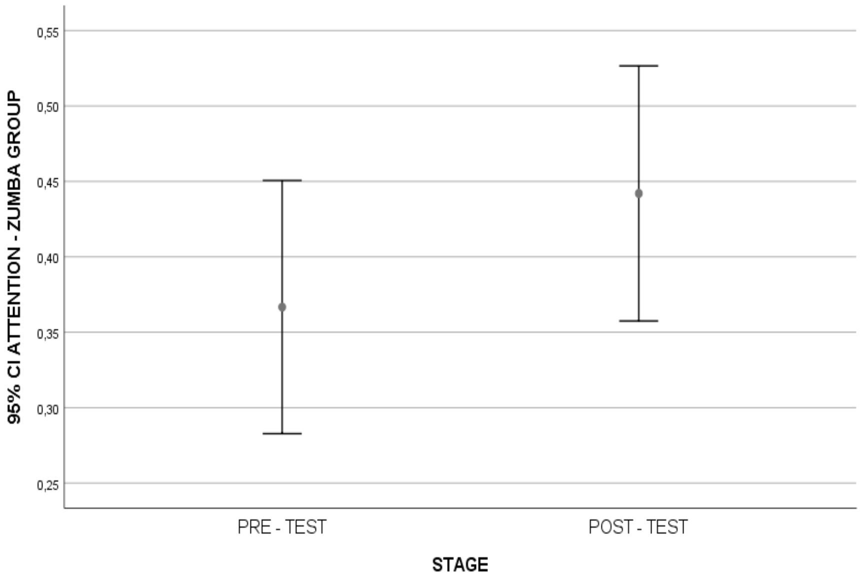

Figure 14. Attention - Zumba Group

Source: own elaboration

4.4.4 Attention test (Control Group)

$\boldsymbol{H_o}$**:** There were no significant differences on attention after 6 weeks Zumba fitness program *(*$Me_1 = Me_2$).

$\boldsymbol{H_1}$**:** There were significant differences on attention after 6 weeks Zumba fitness program *(*$Me_1 \neq Me_2$).

Table 15. Attention Control Group

	Attention
Z	-0.738
p	0,458

Source: own elaboration

The test had a statistic z = -0.738 and an associated p value of (p = 0.458, p> 0.05); according to the results there is not enough statistical evidence to reject *Ho* and therefore it can be inferred that there were no significant differences on attention in the control group after 6 weeks.

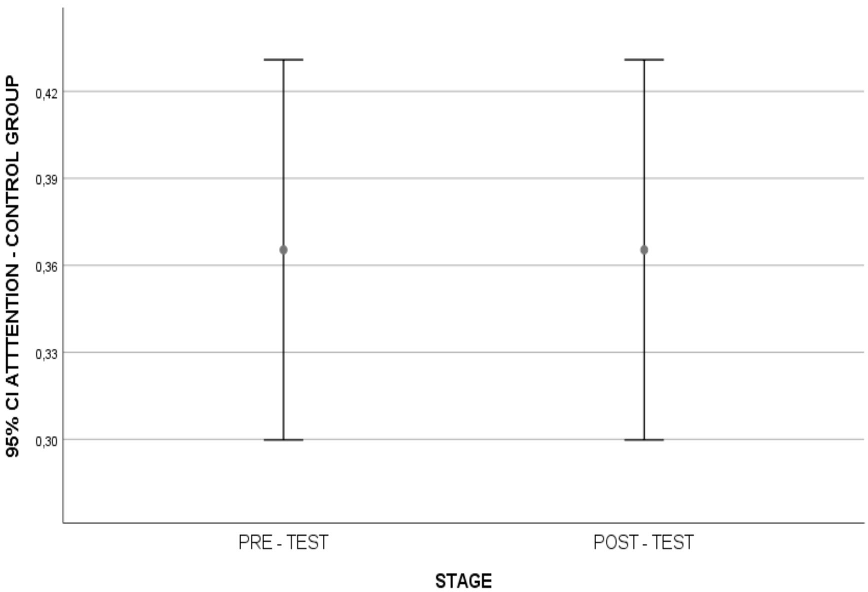

Figure 15. Attention - Control group

Source: own elaboration

4.5 Cognitive test differences between groups

To test if there were significant differences in working memory and attention between groups, a Mann Whitney test was performed:

4.5.1 Working Memory Test vs. Groups

$\boldsymbol{H_o}$**:** There were no significant differences on working memory between Zumba and control group *(*$Me_1 = Me_2$).

$\boldsymbol{H_1}$**:** There were significant differences in the working memory between Zumba and control group *(*$Me_1 \neq Me_2$).

Table 16. Working memory differences between groups

	Working Memory
Z	-1.995
p	0,023

Source: own elaboration

The test had a statistic z = -1,995 and an associated p value of ($p = 0.023$, $p < 0.05$); According to the results, there is not enough statistical evidence to reject *Ho* and therefore it can be inferred that there were significant differences on working memory between Zumba and control group.

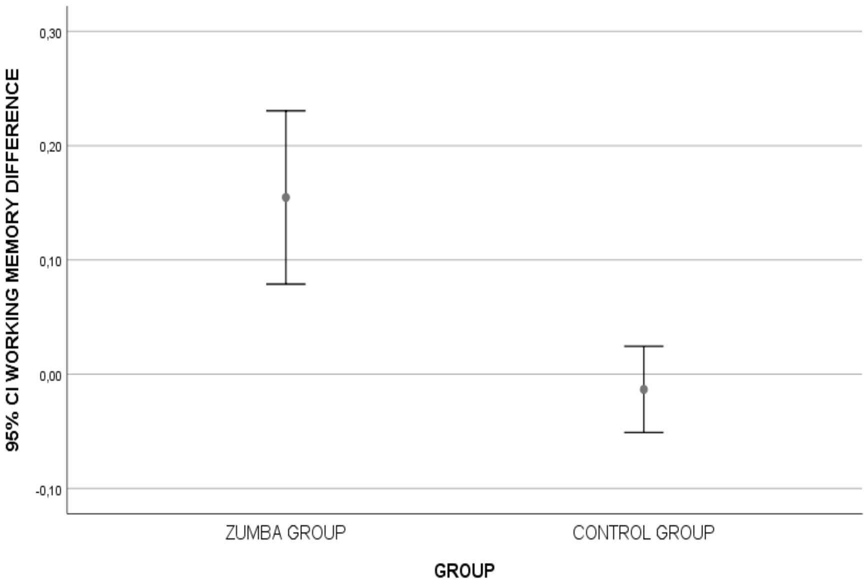

Figure 16. Working memory differences between groups

Source: own elaboration

4.5.2 Attention Test difference between groups.

$\boldsymbol{H_o}$**:** There were no significant differences on attention between Zumba and Control group *(*$Me_1 = Me_2$).

$\boldsymbol{H_1}$**:** There were significant differences on attention between Zumba group and control group ($Me_1 \neq Me_2$)

Table 17. Attention differences between groups

	Attention
Z	-1.995
p	0,000

Source: own elaboration

The test had a statistic z = -1.995 and an associated p value of (p = 0.000, p <0.05); According to the results there is not enough statistical evidence to reject *Ho* and therefore it can be inferred that there were significant differences on attention between Zumba and control group.

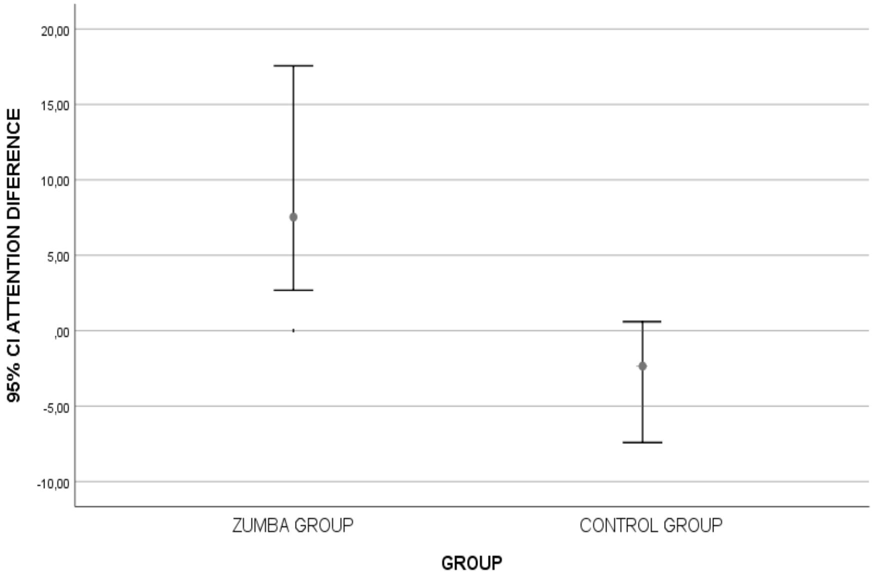

Figure 17. Attention differences between groups

Source: own elaboration

4.6 Weight and Body Mass Index

After six weeks, the weight and Body Mass Index (BMI) of the groups were analyzed to determine if there were significant changes. The Zumba group had a weight mean of 60.88 pretest and 60.68 post-test. the control group shown 60.63 pre -test and 60.80 post-test.

There is evidence of slight decrease and increase, which were not statistically significant variations. It is concluded that both weight and BMI for Zumba and Control group were not significant. To analyze, t tests were performed for independent samples.

Table 18. Weight & BMI

	t	gl	p
WEIGHT ZUMBA GROUP	0.076	28	940
IBM ZUMBA GROUP	0.099	28	922
WEIGHT CONTROL GROUP	-0.067	28	947
IBM CONTROL GROUP	-0.098	28	923

Source: own elaboration

The p values show homogeneity in both groups, since there were no significant differences ($p > 0.05$) for weight and the respective BMI associated with the weights of the participants.

4.7 Analysis of the results (general view)

The statistical analysis showed homogeneity, in both groups, for demographic characteristics (table 4), such as age, weight, height, BMI, socioeconomic level and MMSE. As brain activity measurements are sensitive to changes, due to several factors, the homogeneity in the demographic information in both groups, guaranteed a better analysis.

The analysis of results of the effects of 6 weeks Zumba fitness program on brain activity in the experimental group (Zumba group), revealed that, alpha brain wave activity (table 6), did not show significant differences in the stages before, during and after. (x ^ 2 = p = 0.381 p <0.05). On the other hand, beta brain wave activity (table 7, 8), shown significant differences in the stages (x ^ 2 = 16.53 = 16.533 p = 0.03 p <005) with a significant increase between the initial stage and during and final stages (post hoc 0.000 -0.019). However, between the stages during and after there were no significant differences (post hoc 0.170). Also considering, due to the fact that for the control group there was no measurement during the session (during activity), the stages before and after the activity were contrasted. it was observed that alpha activity wave after 6 weeks (Table 9) did not show significant differences ($z = -0.0332$ $p = 0.381$, $p > 0.05$), likewise, beta wave (table 10), which also did not show significant differences ($z = -1.237$ $p = 0.109$, $p > 0.05$).

Motor Imagery results (Table 11) indicate that brain activity of the beta wave was greater in the Zumba group than in the control group (man Whitney U = 45,000 $p = 0.005$ $p < 0.05$).

This study also measured the cognition of the participants, specifically, on working memory and attention. Results showed (Table 12) that after 6 weeks Zumba fitness program, working memory improved in relation to the initial stage (resting - before activity) for the women who participated in the program (Z = 2,356 p = 0,018 p <0, 05). However, attention test results (Table 14) showed, although the differences improved, they were not statistically significant ($Z = 1.368$ $p = 0.171$ $p > 0.05$). In contrast, both working memory and attention (Tables 13, 15) showed no significant differences before and after 6 weeks for the control group (Z = -1,707 $p = 0.284$ $p > 0.05$, $Z = -0.738$ $p = 0.458$ $p > 0.05$ respectively).

Chapter 5. Discussion

Alpha and Beta brain activity. The present study investigated the effects of 6 weeks of Zumba fitness program, on oscillatory brain activity of alpha and beta brain waves and on cognition (working memory and attention) in women between 57 – 90 years old. No significant results were found in absolute alpha band power during the stages after 6 weeks Zumba program and during the Zumba session in the Zumba group, although, there was a power increase during activity in frontal sites compared to baseline measurements. On the other hand, findings showed increase in the absolute power of beta in the frontal area during and after the session.

These results agree with other investigations in which no significant differences were found on alpha activity, despite presenting increase. Electrocortical brain activity in alpha and other frequencies increased when measured during or after exercise, though absolute alpha activity was increased after exercise when compared to resting levels, cumulative evidence showed no evidence of an effect of exercise that was specific to alpha activity (Crabbe & Dishman, 2004). In an elderly group after exercise, alpha absolute power analysis showed a more pronounced increase in the left frontal area when compared with the right frontal area after exercise, but with no significant differences (Moraes, et al., 2011). Increase in alpha has been associated as indicative of relaxation, fatigue or a change in affect.

Moreover, most of the studies and literature reviews of the effects of exercise on electrocortical activity agree that increased alpha activity reflects a state of decreased cortical activation as an indicative of fatigue, relaxation, or decreased anxiety (Boutcher & Landers, 1998; Ensari, Greenlee, Motl, & Petruzzello, 2015). Also, Enders et al. (2016) demonstrated a significant increase in alpha EEG power as fatigue developed throughout the exercise, the strongest increase was found in the frontal area of the cortex. This increases in alpha activity can be in consequence of the alteration in cortical communication. Hilty, Langer, Pascual□Marqui, Boutellier and Lutz (2011) suggested that (muscle) fatigue alters interaction between cortical structures. However, other studies suggested, that alpha increases depend on whether the person is trained or not. Boutcher and Landers (1998) mentioned that alpha activity is an indicative of relaxation among trained runners but fatigue among untrained runners. Also, Fink, Graif and Neubauer (2009) mentioned, that alpha synchronization (power increase) may reflect inhibition of cognitive process. like during cool down after Zumba session in which cognitive load decreases, and relaxation process begins.

On the other hand, in this study a significant increase in beta absolute power was observed during the stages during and after 6 weeks Zumba session when compared to resting levels, which may be directly related to an increase in cortical activation. “Different authors agree that exercises enhances cortical activation, represented by beta activity increases” (Moraes, et al., 2007, p. 640) (Kubitz & Mott, 1996; Hyodo et al., 2012) this cortical activation during and following exercise is related to alterations in EEG frequency bands, such as alpha (8-13 hz) and beta (14-30 hz) (Niedermeyer & Da Silva, 2005). Especially in frontal areas, "power increase in beta after exercise at frontal (Fp1, F3 and F4) and central (C4) areas” (Moraes, et al., 2007, p. 637). Moreover, Fink, Graif and Neubauer (2009) also mentioned that beta power increases, are usually observed post movement in a wider distributed premotor and sensorimotor area and occurs immediately following real or imagined movement as a resetting of motor representation in these networks. Increases during Zumba session may be the result of increases in cognitive loads during its perform, increases in body temperature and other physiological and metabolic responses during exercise. Doyle, Yarrow and Brown (2005) agree with the above, mentioning that beta frequency band is related to movement, specifically in the frontal and central areas, which are associated with planning and execution of voluntary movements, and, therefore, might be altered by exercise. Tomporowski and Ellis (1986) suggest that brain cortical systems are altered in response to the increased metabolic arousal that accompanies physical activity. And hypothalamic modulation of increased temperature and metabolism can also influence the cortical activity (Nybo & Nielsen, 2001; Nielsen & Nybo, 2003).

Although exercise causes an increase in beta activity, this result can be also related to other factors. Since Zumba fitness program involves not only aerobic exercise, also music (Latin), tempo can also affect brain activity of the brain waves during the performance (Gentry, et al., 2013). Previous work demonstrating that movement and auditory rhythms show strong multisensory interactions and, more specifically, that beat, and rhythm perception interact with motor cortex activity (Bauer, Kreutz, & Herrmann, 2015). Because, tempo of relaxing music is generally slower, and tempo of stimulating music is generally faster, tempo differences can cause changes in brain activity. Beta wave activity occurred especially when listening to activating music (Gentry, et al., 2013). Also, Höller et al. (2012) observed, increases in beta activity while subjects listening to activating music. "Since activating music is often directly related to voluntary coordinated movements, such as dancing, activating music may influence motor regions of the brain, which can result in beta wave activity" (Hurless et al., 2013, p. 3). This results agree with this investigation since latin music involves mostly medium-to-fast tempo beats which may be associated with increases in power in beta especially during the session.

Even though alpha and beta power increase during and after exercise other researches show that variations in brain activity especially in alpha vary depending on the type of exercise, intensity and duration of the exercise, and measurement time after exercise. Increases also are presented in different areas according to the type of exercise. Bonnet and Arand (2001) observed changes within the β frequency range 15- and 30-min post exercise which shows a reduction of activity in frontal brain areas after treadmill and bike but not arm crank exercise. Also, Schneider, Brümmer, Abel, Askew and Strüder (2009) revealed an increase in frontal α activity immediately post exercise whereas increases after bike exercise were found to be localized in parietal regions. Enders et al. (2016) indicates that alpha activity was most elevated when measured immediately and up to about 6 min after the exercise ends. The above shows that these changes in brain patterns vary depending on the type of exercise.

The control group did not present significant differences neither for alpha nor for beta after 6 weeks since this group did not undergo any treatment. Alpha values are associated with cortical inhibition due to their state of relaxation during baseline measurement. Plus, alpha synchronization may reflect inhibition of cognitive process (Fink, Graif, & Neubauer, 2009). However, beta values, even though they were not significant, might arise due to stress of the test, or other factors as any other distractors that did not allow them to relax completely during the test.

Motor imagery (MI): Brain activity measure during movement can generate data errors, due different factors like movement, sweating and artifacts (Enders, et al., 2016). Considering the previous statement; in order to verify data and compare beta wave activity during a Zumba session with control group participants, MI was performed. Results showed significant differences in Beta brain wave activity between the Zumba group and the control group, being greater in the Zumba group. Demonstrating that 6 weeks Zumba fitness program have positive effects on brain activity. This result may associate to increases in cognition specially attention and working memory. Since beta power increases have been related to cognitive task and cortical activation (Moraes, et al., 2011) also, beta power has been related to cognitive aspects of movement, including cue anticipation, visuomotor integration and preparation (Di Nota, Chartrand, Levkov, Montefusco-Siegmund, & Desouza, 2017). Those are present at the perform of a Zumba session. Also, Di Nota, Chartrand, Levkov, Montefusco-Siegmund and Desouza (2017) mentioned that kinesthetic motor imagery (KMI) “of a complex dance sequence relative to everyday, non□dance movements recruits greater cognitive resources suggests it may be a more powerful tool in driving neural plasticity of action networks, especially among the elderly and those with movement disorders" (Di Nota, Chartrand, Levkov, Montefusco-Siegmund, & Desouza, 2017, p. 1). The above agree with this investigation results.

Cognitive test. A significant increase in the working memory tests was evidenced after 6 weeks of the Zumba program, nevertheless, despite increases in the attention tests, these were not statistically significant in the Zumba group, which may be associated with intervention duration and participants age, since older population is, on the average, characterized by a progressive decline in sensorimotor and cognitive functions (Kosmat & Vranic, 2017). "The most noticeable changes in attention that occur with age are declines in performance on complex attentional tasks such as selective or divided attention" (Murman, 2015, p. 114). Murman (2015) also mentioned that "learning is further compromised in older adults if the test requires mental manipulation of the material to be learned (working memory) or if subjects must perform more than one activity while learning (divided attention)" (p. 114). Also, Different studies have proposed dance-based exercises to improve attention, however these have had a longer duration. Muller et al. (2017) "showed significant improvements in attention after 6 months and in verbal memory after 18 months in a twenty-two healthy seniors' group" (p. 1). Another study suggested that "dance interventions, lasting between 10 weeks and 18 months, were related to either the maintenance or improvement of cognitive performance" (Predovan, Julien, Esmail, & Bherer, 2019, p. 161). However, despite these investigations, some have shown significant effects on cognition in less time but not specifically on attention. "Performing and perceiving dance epitomize embodied cognitive processes including those based on somatosensation, learning, memory, multimodal imagery, visual and motor perception, and motor simulation" (Bläsing et al., 2011, p. 25)

Regarding working memory measurements, it is defined as the ability to actively maintain and manipulate information (Baddeley, 2003). Bonny, Lindberg and Pacampara (2017) suggested, that dance experience may be connected to mental processes, in regard of working memory, when learning or developing choreography for a routine, dancers have to not only coordinate multisensory information (e.g., music, kinesthetic, visual) but also have to maintain their spatial position on a dance floor according to a predetermined sequence of movements. Furthermore, in a recent study, Kosmat and Vranic (2017) found beneficial effects of a dance intervention of moderate length (10 weeks, 45 min/week) in short-term memory and executive functioning on a sample of old-old adults with no cognitive impairments.

On the other hand, the control group did not present an increase in any of the cognitive tests, this, allows to determine that 6 weeks of Zumba are enough to improve cognition, mainly working memory, considering the nature of the program. the above, coincides with other investigations about the effects of aerobic dance exercise on cognition.

Chapter 6. Conclusion

The present study is the first one that evaluated the effects of 6 weeks Zumba Fitness program on brain activity, specifically, on alpha and beta brain waves and on cognition. This study demonstrates increases in beta absolute power through the stages during and after compared to before - baseline measurement. These findings suggest that the observed patterns on brain activity and particularly increases in EEG beta band power reflect greater cortical activations. In consequence of the increases in cognitive load, attentional demand, planning and execution of voluntary movement; physiological, biochemical and metabolic mechanisms activated during the performance of physical exercise. such as, hypothalamic modulations that causes increase in temperature and increases in blood flow among others. Likewise, and due to the nature of this program it is assumed that increases in beta wave can also be caused due to the tempo of activating music, which agrees with previous investigations.

However, no significant results were found in absolute alpha band power during the stages after 6 weeks Zumba program and during session in the Zumba group, although there was a power increase during activity in frontal sites compared to baseline measurements. Increases in alpha wave during the Zumba session may be due to fatigue or decreased anxiety. Although, increases of this brain wave after the session are indicative of a decrease in cortical activity, associated with decreased cognitive demand during the calm down and metabolic and physiological changes during relaxation process after exercise or can also be due fatigue caused by the practice of Zumba.

This study also showed that 6 weeks of Zumba Fitness program generate positive effects in working memory and increases in attention, which, despite not being statistically significant, showed increases in the cognitive tests of the Zumba group with respect to the control group, which did not present changes at the cognitive level. These positive effects were corroborated with Motor Imagery (MI) measurements for both groups after 6 weeks. Results showed greater brain activity in beta brain wave in the Zumba group, related to a greater cognitive capacity of attention and working memory while the control group presented low values which can be associated with a lower cognitive capacity.

6.1 Implications for theory and practice

These research findings are very useful for the sports medicine and neuropsychology field, since these contribute to complement past researches in the field and as a support for the efficiency of aerobic dance exercise on cognition of women between 57 and 90 years old. It also demonstrates and proves the benefits that Zumba Fitness program has on cognition and discloses brain activity of alpha and beta brain bands during their practice.

Which will allow to be used for the improvement or implementation of brain stimulation techniques through physical activity. Moreover, this study allows Zumba Fitness program to be known as a method of cognitive stimulation, scientifically proven, which provide more options for people, especially for those with related problems as cognitive decline, mild cognitive impairment or as an option for motor imaginary training. Further investigations on the effects of Zumba on brain cortical activity to specific regions and with different population as patients with cognitive disorders should be performed. As well as, more research projects about Zumba fitness program on Motor Imagery for rehabilitation purposes for those who are trying to regain motor skill lost or impaired among others and on cognition. Taking into account that exercise has a connection with mood, this have to be taken into consideration for further researches related with cortical activity.

6.2 Limitations of the research

Due to the nature of this study, it is important to mention that, despite of having a portable EEG (wireless) for recordings in the field, it is well known that "Movement-related and specifically gait-related artifacts have been a central issue to the debate about the interpretation of EEG data recorded during locomotor activities" (Enders et al., 2016, p. 386). which should be considered for any study.

Since Zumba fitness program involves not only a large number of movements during its execution and aerobic exercise, we had to address the issue of perspiration, this did not directly affect the recordings but caused delays when making the measurements as we had to repeat some, especially during the sessions. This, since sweating and movement sometimes affected the adhesion of the electrodes to the scalp, which should be kept in mind for further investigations.

Because of the costs, we had two sensing headband MUSE, however the number of electrodes of these did not cover all regions of the brain, it would be interesting to carry out a research on the effects of Zumba Fitness program on brain cortical activity to specific brain regions.

Another limitation was the duration of the study because of the following three factors: time, economical resources and the difficulty for participants' recruitment, since it is difficult to get cooperation for a long period of time. Further research should be carried out with a larger number of participants and during a longer period of time. Since this study is the first that investigates effects of Zumba dance program on oscillatory brain activity and on cognition in women between 57 – 90 years old, results need to be replicated by other studies and on larger samples as the implementation of this study in different population groups.

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