

Reflexology and polysomnography: Changes in cerebral wave activity induced by reflexology promote N1 and N2 sleep stages



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ABSTRACT

Background: Several studies have shown the effectiveness of reflexology in different health problems as well as obtaining a high degree of relaxation during its application. A previous study suggested a possible relation between the relaxation obtained during the reflexology session and the sleep. However, the design of the study did not provide evidence for this hypothesis. In this study, we use a polysomnogram to investigate the effects during its application.

Method: Prospective experimental study conducted in a sleep laboratory. Twelve healthy adults were enrolled. Two groups were created based on whether or not they had knowledge of reflexology. Reflexology was applied for 35 min and their sleep effects were measured by means of polysomnography. A descriptive and bivariate analysis was performed. A bivariate analysis conducted through chi-square test or ANOVA was considered appropriate.

Results: After controlling for baseline data, nine of the participants did move toward N1 ($p = 0.833$) and N2 ($p = 0.227$) stages, remaining in these states between 4 min and 25.5 min. No significant differences were found between the two groups.

Conclusions: The application of reflexology induces changes in the activity of brain waves in correspondence with the appearance of a high degree of sleepiness and sleep (N1 and N2 NREM sleep). There is a gradual transition and an orderly progression from wakefulness to sleep, which could explain the effects of relaxation and well being obtained with this method, as well as many other benefits.

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1. Introduction

In recent years there has been a growing demand by the population for complementary medicines (CAM), which has generated an important success of these therapies. An estimated 38% of the adult American population uses some kind of CAM [1] while in other industrialised countries it oscillates from 36% to 62%, the majority being women [2–4]. Reflexology, as one of many therapeutic modalities, has experienced important changes in recent years [5] from being “an option”, to being an “alternative” and recently has been considered a CAM [6], reaching high levels of popularity [7].

The beginnings of reflexology in the West started with the first research and publications by Dr. Fitzgerald [8], “Zone Therapy”, considered the father of modern reflexology [3,9–12].

Fitzgerald describes his discovery of reflexology in the following way: “Six years ago I accidentally discovered that pressure with a cotton-tipped probe on the muco-cutaneous margin (where the skin joins the mucus membrane) of the nose gave an anaesthetic result as though a cocaine solution had been applied”.

The author, from his experiences, drew the first sketches of the human body that he divided by means of ten vertical lines from the head to the feet, establishing the existence of connections and therapeutic relationships between them as well as the manner in which to apply the treatment. Eunice Ingham delved in his legacy, drawing new zone maps and discovering their therapeutic possibilities. Subsequently and during years, Marquardt, Bayly, Norman and Carters have delved into her theories [12], endowing modern reflexology with its own identity as a therapeutic modality.

Recent studies show positive effects as a result of the application of reflexology in different health problems [13–19], which can be the result of a relaxation response associated with its application [18,20,21]. Other studies show reflexology as a useful procedure to alleviate fatigue and promote sleep [22] even though other authors question a placebo effect of this procedure [23]. On the other hand, its application promotes evident biochemical changes [24–26]. Also, somato-topic relations have been identified in magnetic resonance imaging (MRI) records [27,28], as well as changes in sympathetic and vagal activity measured by nonlinear parameters [29] and changes in the cerebral functions [30]. All this suggests that the benefits obtained from its application are the result of responses that possibly go much further than a placebo effect.

Nakamuru et al. [28], have investigated, by means of MRI, the existing relationship between cortical activity of somatosensory zones and stimulation of the reflex areas of the eyes, the upper area of the back and the small intestine. His results conclude that the

areas activated during stimulation of each reflex zone are associated with the corresponding somatotopic representation of a part of the body or areas near the somatosensory area. Most recently, Miura et al. [27], confirmed the results of this investigation ruling out the placebo effect that derives from the instructions given to the participants. These authors investigated the effect of stimulation of the reflex areas in the primary sensorial cortex. Among other results, they found that stimulation of the visual reflex area on each foot induces activity in the left part of the post-central circumvolution, and that false information does not affect this activity.

Holey et al. [31], studied the effects of massage of the connective tissue in the autonomous nervous system by means of thermography and measurements of physiological parameters such as blood pressure, heart rate and dorsal temperature of the foot. His results show that this type of massage has effects on the autonomous nervous system.

Ryotokuji et al. [32], obtained positive results in his study on stress reduction and the improvement of the homeostatic balance on the body functions with the application of infrared lamps on points of the plantar area of the feet.

In our clinical experience, we have observed, in the users of this modality, a general relaxing effect and, in some cases, sleepiness after a short application period. Taking into account these observations, as well as ocular and spontaneous movements described in a previous study [33], they suggest that during the application of reflexology a process of sleep is established.

The following paragraphs of the introduction are a brief overview of sleep and its phases:

Sleep is a very complex process, difficult to understand and determine [34]. It occupies more than one third of our life and it is basic in its proper development. Sleep deprivation entails important physiological and cognitive consequences [35–37,52]. Sleep can be defined as a conscious physiological and reversible state with associated characteristics such as a partial and temporary disconnection of the environment with an increase of the threshold of response to external stimuli, a decrease in activity, motor capacity and reaction to external stimuli, which are accompanied by a state of relaxation and decrease of muscular tone. Indicators appear in this process such as a state of quiescence with closed eyes, as well as, a stereotypical posture and changes in sensorial perception [35,38–42]. Furthermore, it may also be accompanied by other abnormal and bothersome behaviours or activities called parasomnias, such as somnambulism or bruxism among others [43].

The changes that define the different stages of sleep and wakefulness reflect that diverse and extremely important physiological processes are closely related, or even determined by sleep or

the frequency thereof [41]. In this respect, we can note the establishment or conservation of energy, the elimination of free radicals accumulated during the day, the regulation or recovery of cortical electrical activity, thermal regulation, metabolic or endocrine regulation, synaptic homeostasis, immunological activation or consolidation of memory among others [44,45].

The latest research defines sleep by means of their behavioural and electrical cerebral changes, distinguishing between different phases from well-defined criteria [40–42,44]. *“It can be viewed as behaviour, a brain state, and a process, which are intricately interrelated, and manifest themselves at many distinct spatiotemporal scales”* [34].

Thus, in normal sleep, two basic stages alternate: non-REM (NREM) sleep, associated with some patterns of synchronized electroencephalography (EEG), and REM sleep, similar to wakefulness manifested as desynchronized EEG, therefore requiring the registration of other parameters that need to be recorded in unison, such as the electrooculography (EEO) and electromyogram (EMG) in order to bio-electrically distinguish it from wakefulness [46]. In wakefulness, there exists a cortical activation that is identified by waves of high frequency and low amplitude, while NREM sleep appears as a synchronized activity in the EEG, with waves of low frequency and high amplitude. These changes manifest the homeostatic regulation of sleep [34], including sleep spindles and K-complex associated with low muscle tone and minimal psychological activity [38,39,47]. REM sleep, on the other hand, is characterised by an activated EEG, muscle weakness and the presence of rapid eye movement [39].

The brain activity in the period of night sleep was studied by Dement, who observed the existence of a cyclical pattern, which he called “architecture of sleep” and whose graphic representation is called hypnogram. Initially, sleep was classified in NREM sleep (phases, 1,2, 3,4) and REM sleep [44]. This nomenclature has recently been modified by the American Academy of Sleep Medicine [48].

Currently the nomenclature is N1 (formerly NREM1), N2 (formerly NREM2), N3 (phases 3 and 4 of slow NREM sleep are grouped together) and R (formerly REM) (Fig. 1).

The process of the sleep-wake cycles (CV-S) is regulated by a complex neural network, whose structure is anatomically connected by neurotransmitters allowing the succession of the phases of the cycle. A time giver located in the suprachiasmatic nucleus in the hypothalamus establishes the circadian rhythm which is adapted to the 24 h of the day by external regulators, being the retina the most important one due to its connections with the nucleus [49].

Sleep is a physiological process of which we still have much to study and there are many questions without answers. An event with which we have incurred a significant debt in recent years by reducing our hours of sleep, despite the evidence of the numerous benefits it provides for our mental and physical health or the

negative effects associated with its different disorders [37,40].

Polysomnography (PSG) is a multichannel recording technique, which allows the simultaneous exploration of physiological parameters while we sleep. These parameters are recorded through electrodes and sensors. These sensors are placed on specific locations of the body and they transform biological activity into a bioelectrical signal that is subsequently analysed [50].

The objective of this study was to record by means of (PSG) changes that emerged in cerebral waves during the implementation of reflexology.

2. Methods

2.1. Study design

Experimental and prospective study performed at the Sleep Centre of Tarragona during 2015.

2.2. Participants

Twelve healthy adults participated in the study. They had no history of psychiatric or neurologic problems, sleep disorders, abuse or addiction to alcohol or other drugs, medication or hormone treatment, epilepsy or any important pathology. Seven participants practiced some sort of regular physical activity twice a week. The participants were selected among those attending the presentation of the project at the Therapy Centre, and by the information sent by e-mail to clients of the centre. For the study, we accepted people that had some knowledge about reflexology and had received treatment at some point in time, as well as people that had no knowledge or had not received any treatment.

From a sample of 20 volunteers, 12 participants were selected and divided into two groups of six people. Those that had knowledge about reflexology and frequently used it were assigned to group A. To Group B, we assigned participants who had no knowledge of it.

All participants were briefed on all aspects of the study and asked to sign a consent form in order to participate. The experimental protocol was approved by the Nursing Faculty of the Rovira i Virgili University (IN-0711159). This protocol was assessed and approved by the Centre of Sleep Management. The study complied with the ethical requirements for biomedical research of the Declaration of Helsinki. All sensors were applied non-invasively, using adhesive percutaneous electrodes.

2.3. Questionnaires

Questionnaires were administered at baseline.

The Epworth Sleepiness Scale (ESS) measured daytime sleep. Developed by Johns, M., it consists of 8 items that score from 0 to 3 the degree of sleepiness in different daily situations, distinguishing sleepiness from fatigue. Scores vary from 0 to 3 and the range of the scores oscillates from 0 to 24. In general, a score superior to 10 is accepted as a cut-off point for sleepiness. Some authors propose different cut-off points by the degree of severity of subjective sleepiness, with scores of mild sleepiness being between 9 and 12, moderate from 13 to 16 and suggestive severe sleepiness those superior to 16 [51].

The Beck Depression Inventory (BDI-II). Jesus Sanz and Carmelo Vazquez [52] used the Spanish adaptation of the original version of Beek, Steer and Brown [53]. It is one of the most used self-applied instruments in clinical practice and in research that evaluates depression. It has good psychometric properties, few difficulties in its application, and is easy to use. In general, between 5 and 10 min are required for the process to be completed. This inventory

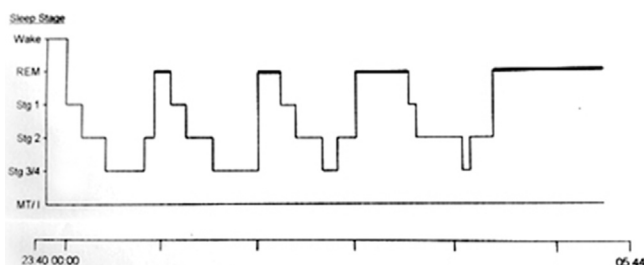


Fig. 1. Hypnogram in which we can observe the different phases of sleep.

identifies depressive symptoms and quantifies their intensity. It consists of 21 items that correspond to the majority of the diagnostic criteria of the major depressive episode DSM-IV. It covers the day of evaluation and the previous two weeks. Each item is answered on a scale of 4-points that varies from 0 to 3. It is scored by adding the responses to all 21 items. The cut-off score suggested by Sanz and Vázquez is: 0–13: minimal, 14–19 mild 20–28 moderate, and 29–63 severe.

The criteria utilized to participate in the study was an Epworth test score be < 12 and the Beck II inventory score <13-.

The interview gathered the following data: address, city, studies, profession, sex, age, weight, height, body mass index (BMI) and level of knowledge of reflexology.

2.4. Procedure

Participants were summoned a week before in order to supply them with information about the study and request their collaboration assuring them of the confidentiality of the data. Participation was voluntary, and the informed consent and image rights were obtained. Additionally, participants completed a health survey, declaring no knowledge of an existing medical condition or consumption of any medication. They completed the Beck II Depression Inventory and afterwards they were assigned to an intervention group and they were summoned to perform the study in the sleep centre.

2.5. Sleep centre and polysomnography (PSG)

The collection of data was performed at the Sleep Centre of Tarragona. The centre has a room prepared for sleep exploration where the polysomnograph is located. In an adjoining room, the electrodes were placed. Reflexology was applied in a separate room without external noise. During the activity, a natural tenuous ambient light and a temperature of 25° C were maintained. A registered nurse specialized in reflexology with over 10 years experience applied the treatment, while a sleep technician placed the electrodes and recorded the data. Both professionals worked independently.

A polysomnograph model GRASS M 78 with 17 channels was used. The physiological parameters recorded were the following: 3 channels for electroencephalogram (EEG) were used to mark the standard electrode sites, which were the following: F3-A2, C3-A2, O1-O2, 1 channel for electromyography (EMG); submental (triangle), and right and left electrooculography (EOG), 1 channel for electrocardiogram (EKG), as well as, one for nasal ventilation, one for thoracic movement, one for abdominal movements and one for snoring detection. A continuous pulseoximetric recording and a noise intensity measurement were also performed. The paper speed was 10 mm/second. For the placement of the electrodes, the standard international registration system 10/20 was applied.

The data was stored and a later review was performed offline by two doctors certified in sleep medicine that did not know the participants or had any prior information about them.

The review criteria utilised was based on the Manual for Review of Sleep and Associated Events of the American Association of Sleep Medicine (AASM).

2.6. Experimental intervention

Each participant came to the sleep centre on a specific day and time, where he/she performed a semi structured interview and the ESS.

The intervention consisted in applying reflexology and recording the bioelectric behaviours during the activity by means of

polysomnography. The cartographic map of the reflex areas of the feet, and the treatment technique used in this study were based on the methodology of Hanne Marquardt [9]. The application was initiated with a regulating procedure of palms with soles on both feet, and a slow and meticulous stretching of all the toes, followed by the application of the treatment in the reflex areas of the head (toes) in which we dedicated the first 15 min. The remaining intervention time (20 min) was used on the other reflex areas, therefore completing the foot. The treatment technique integrated the basic movement with the thumb, characterised by an ascending and descending rhythmic movement on the sole. On the toes, a sustained sedative movement was combined on the reflex areas of the visual cortex and the temporal mandibular joint (TMJ). On the dorsal area of the foot the basic treatment (Caterpillar) was applied with the index finger and the thumb. The same protocol was applied to all the participants, even though the uniqueness of each participant singularity was taken into account, by adapting the treatment to the particular characteristics of each one. The intervention ended with the initial regulatory procedure. Reflexology was applied during 35 min. The data was recorded 10 min before applying reflexology until 10 min after the end of the application. Six studies were performed between 11.00 h and 14.00 h and six between 16.00 h and 19.00 h.

2.7. Variables and measures

The sleep measures were defined as minutes of total sleep time (TST), total recorded time (TRT), sleep efficiency (SE; %, total sleep time/total recording time), sleep onset latency (SOL), wake after sleep onset (WASO), number of awakenings in stages (ESTW), and percentages of time in stages 1.2 (ESTN1; ESTN1 (%) ESTN2 and ESTN2 (%)).

2.8. Statistical analysis

Variables were measured in both control groups, which were expected to be equivalent: sex, age, weight, height, BMI, session initiation time.

The dependent variables measured, all quantitative, in which we explore the existence of significant differences between the averages of both groups were: TTR; TST; SOL; SE; ESTW; ESTN1; ESTN1 (%); ESTN2 and ESTN2 (%).

An ANOVA was used between subjects in order to compare the different averages between both groups of each of the quantitative variables. The assumptions of homoscedasticity (Levenne test) were tested and in case of non-compliance we used a robust test to measure its infringement (Brown-Forsythe test). To check the homogeneity of gender between both groups we applied the Fisher's Exact Test. The level of significance was $p < 0.05$.

For the analysis of results, we used the statistical analysis SPSS v.15.0 software.

3. Results

3.1. Description of participants

Both groups were homogeneous in all their variables. However, the exploratory data analysis shows much more homogeneity in group A, who already had knowledge and/or experience with reflexology in the majority of variables related to sleepiness, especially in the SOL. The Scores of the subjects in these variables are much similar between them than those participants belonging to group B that have no experience or knowledge of reflexology (Table 1).

The age of the participants was between 23 and 54 years of age,

Table 1
Sociodemographic characteristics.

Variables		Total (N = 12)	Group A (n = 6)	Group B (n = 6)	p
Gender	Male	4	1	3	
	Female	8	5	3	
Marital status	Married	3	1	2	
	Single ^a	9	5	4	
Level of education	High school	2	2	0	
	Associate degree	3	1	2	
	Bachelor degree	4	2	2	
	Master degree	3	1	2	
Employment	Unemployed	3	1	2	
	Employed	9	5	4	
Age (years) [mean (SD)]			43.0 (9.5)	32.0 (7.3)	0.545
Weight (kg)			59.5 (2.1)	63.2 (8.8)	0.078
Height (m)			1.7 (0.1)	1.7 (0.1)	0.233
Body Mass Index			21.2 (1.1)	23.1 (2.4)	0.378

^a Also included widow or divorced. [mean (SD)].**Table 2**
Sleep parameters during reflexology intervention by group. The outcome of one of the male participants was dismissed by interferences.

Sleep parameters	Total (N = 11)				t	p
	GA (n = 6)		GB (n = 5)			
	Mean	SD	Mean	SD		
<i>PSG sleep</i>						
TST (min)	28.58	6.793	23.40	16.806	0.485	0.504
SOL (min)	3.50	1.817	9.13	8.760	2.463	0.155
SE (%)	66.52	20.426	48.78	33.050	1.196	0.302
WASO (min)	12.33	8.085	25.600	19.427	2.352	0.159
N1, % of TST	62.75	25.966	52.94	32.187	0.315	0.589
N2, % of TST	44.70	20.653	27.06	19.729	1.96	0.205

Note: TST, minutes of total sleep time; SOL, sleep onset latency; SE, sleep efficiency (% total sleep time/total recording time); WASO, wake time after sleep onset.

4 males and 8 females (see Table 1). The results of the questionnaires were similar. Scores on the Beck-II inventory remained under 9 in all the participants. The EES oscillated between 4 and 10 points.

3.2. PSG sleep data

Table 2 shows the characteristics of sleep parameters during reflexology. Nine of the participants did move toward stage 1 and 2 sleep, remaining in these states between 4 min and 25.5 min. The time of latency, from the beginning of the application of reflexology, oscillated between 0.5min and 21.5min. The total sleep time (TST) oscillated between 21min and 37min. Sleep efficiency (SE) was located between 42% and 90.5%. The average cardiac frequency oscillated between 48 ppm and 72 ppm and the average O2 saturation oscillated between 96% and 98%.

Only one of the participants in group A did not move toward N2 stage, nevertheless, the participant did move to the N1 stage remaining there for 21 min. One of the participants in group B did not enter into the sleep stage.

There were no cortical arousals at any moment.

In Fig. 2, we can observe Stage W.

In Fig. 3, we can observe stage N1 of sleep.

In Fig. 4, we can observe K complex and sleep spindle, and in Fig. 5, N2 stage.

There were no significant differences in the parameters of the PSG between group A and B. The mean of TST, SE and the percentage of the N1 and N2 stages were similar independently of its experimental condition. (Fig. 6).

3.3. Subjective perception

Six of the participants that entered the two stages of sleep assured that they had not slept. Three felt that they had slept and two of them said they had dreamed. One of them was not sure that sleep was achieved. The participant who did not enter the sleep phase commented she had almost fallen asleep but resisted it. Despite not having slept, she mentioned having felt a high degree of relaxation.

Upon awakening, all reported having felt a high degree of relaxation and furthermore, three of them expressed having felt a great inner peace.

There were no differences regarding the intervention between the morning or afternoon schedule. The results were similar regardless of the circadian rhythm.

4. Discussion

As far as we know this is the first experimental study using polysomnography in order to investigate whether the application of reflexology induces some degree of sleepiness using objective and subjective measures. The polysomnographic analysis during application of reflexology has not been performed previously, for this reason there are no studies that can establish a direct discussion.

Some authors have investigated the effectiveness of music therapy on the quality of sleep and insomnia using polysomnography. In the Lazic and Ogilvie [54] study, music was not effective in inducing sleep. However, Jespersen et al. [55], performed a review that included six studies showing that music can be effective in improving the subjective quality of sleep in adults with symptoms of insomnia. Another study by Chang et al. [56], evaluated the influence of music on the quality of sleep in adults with chronic insomnia. The results show that even though Phase N2 was shortened and REM sleep prolonged, it had little effect on the quality of sleep.

Bel et al. [57] investigated the modulatory effect of a homeopathic remedy in the slow wave sleep, finding that the parameters of slow wave sleep were modified.

Desai, Tailor and Bhatt [58], explored the effects of yoga on brain waves showing that they increase following the practice of breathing, meditation and yoga postures.

NREM 1 sleep is characterised by the progressive decrease of alpha occipital rhythm, the appearance of waves or vertex points, the appearance of slow eye movements and the permanence of tone [44]. Functionally, the alpha waves inhibit areas of the cortex

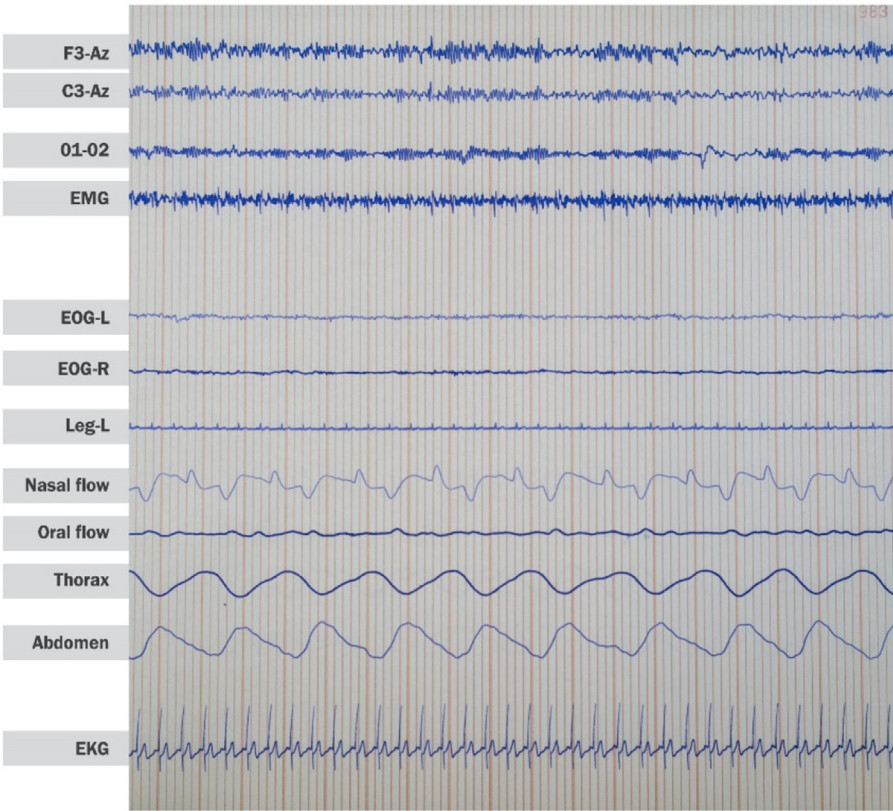


Fig. 2. Stage W.

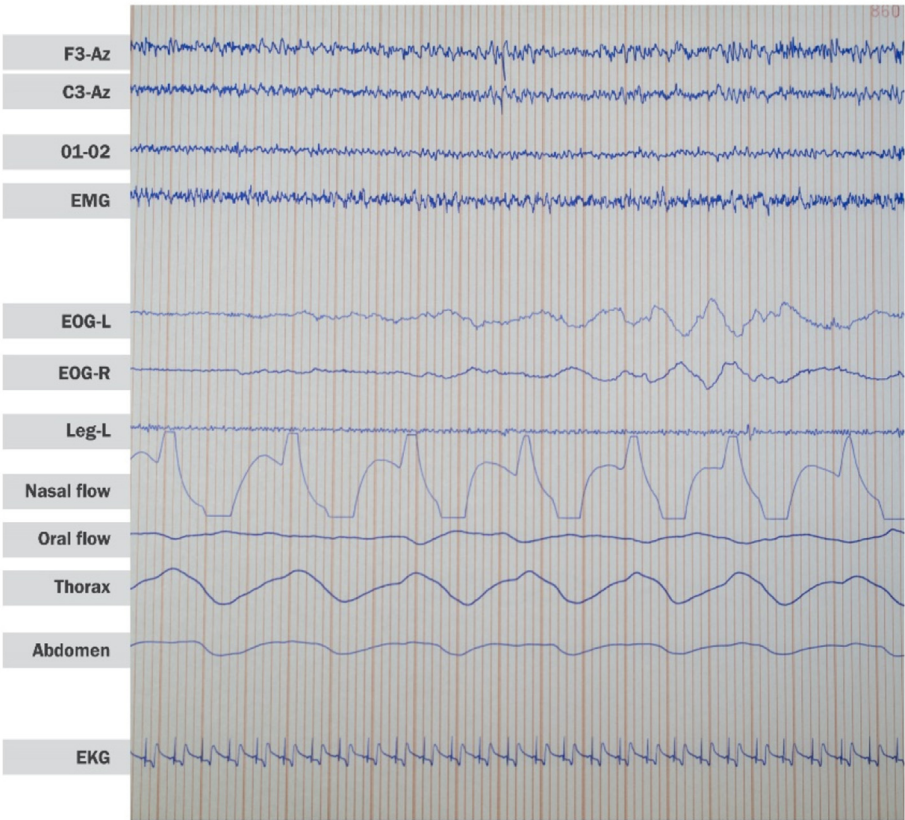


Fig. 3. Stage N1.

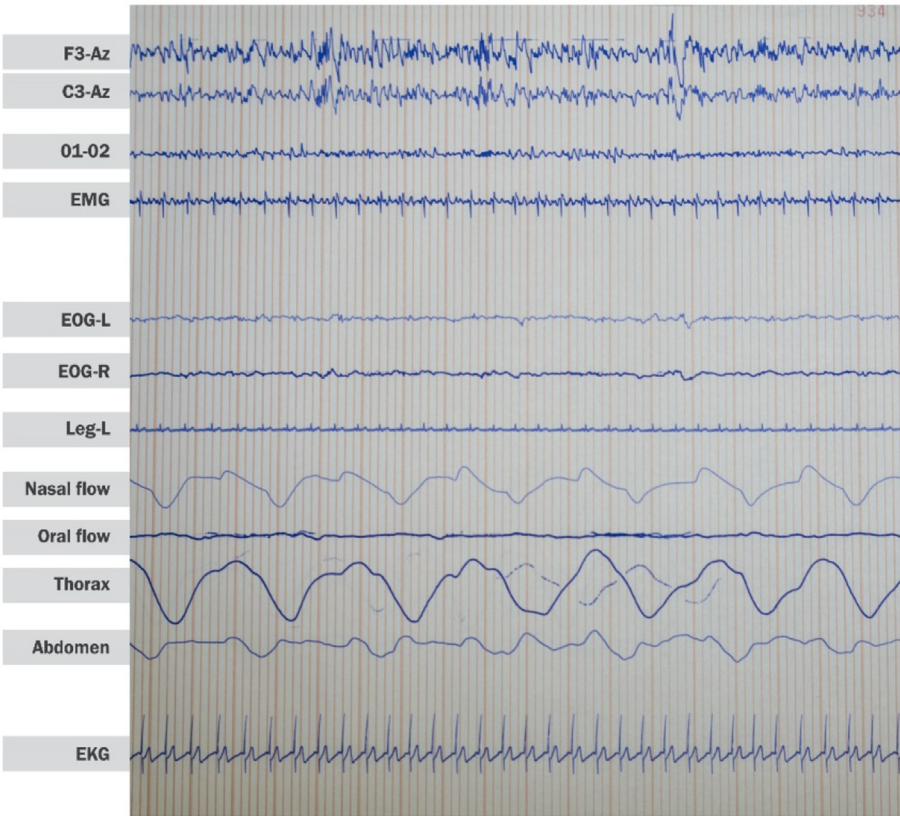


Fig. 4. K complex ans sleep spindle.

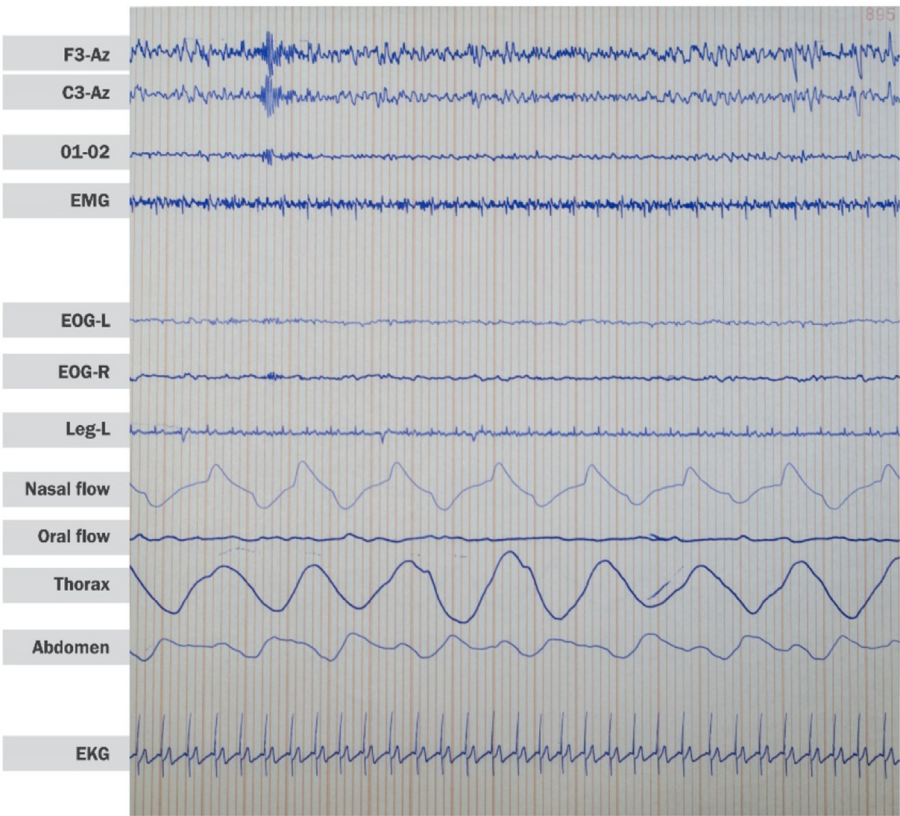


Fig. 5. Stage N2.

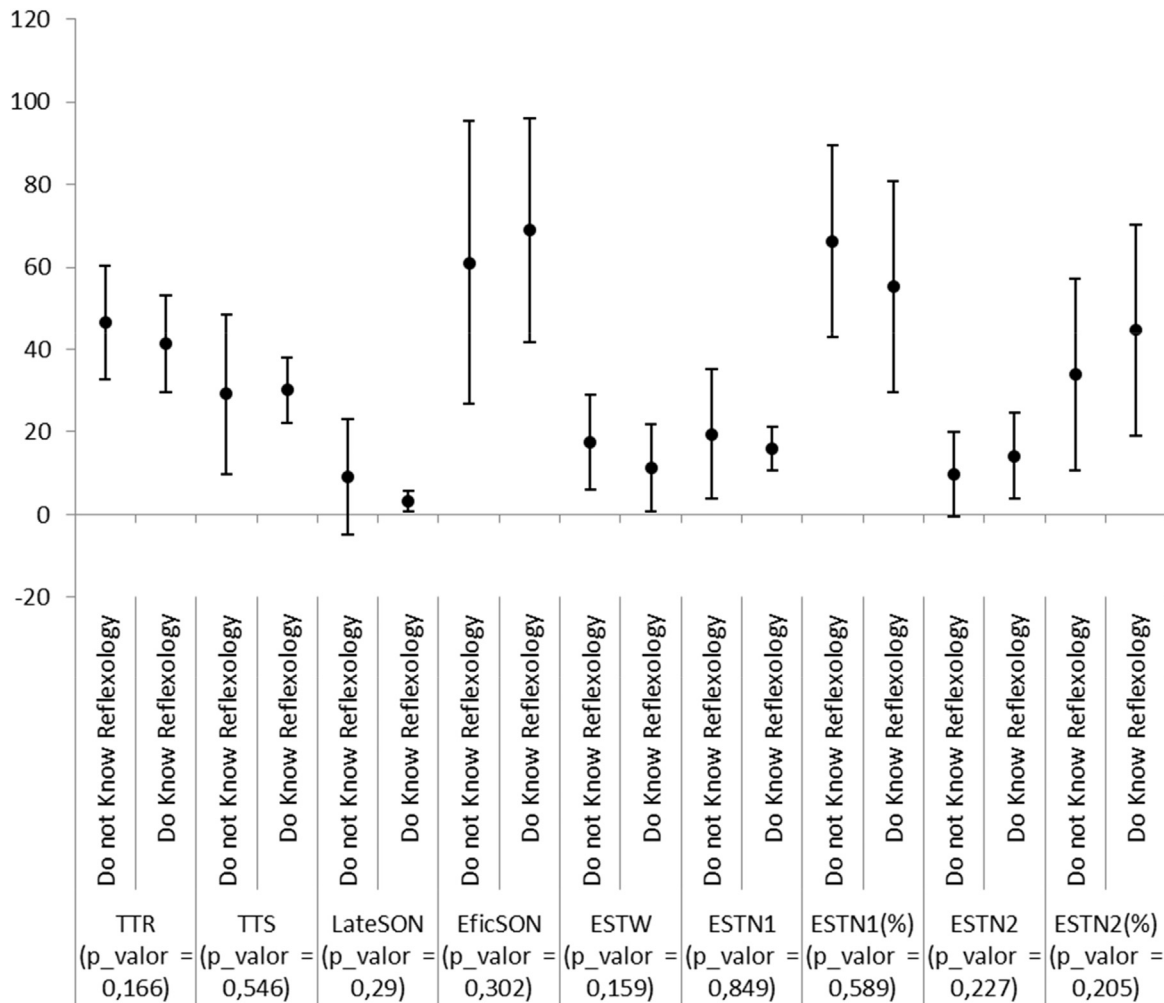


Fig. 6. Polysomnographic data. There were no significant differences between experimental conditions on the PSG variables in both groups.

and play a vital role in the creation of neural networks. The activity of alpha waves is associated with periods of calm and relaxation. Physiologically, they correlate with the decrease in the degree of pain and discomfort. These findings could explain some of the benefits obtained with the implementation of reflexology, such as reducing pain, stress and anxiety among others.

The findings, in conjunction with Desai, Tailor and Bhatt [58], show that during the application of reflexology the activity of the brain waves are modified. However, in our study, the changes appeared within minutes of the reflexological application with a degree of sleepiness and sleep in correspondence with N1 and N2 stages of NREM sleep. These effects occurred regardless of the schedule in which it was applied. The results suggest the existence of a strong relationship between the application of reflexology and the onset of sleep. Similarly, the statistical analysis showed no difference between those who had knowledge of reflexology and those who did not have any knowledge.

Under normal circumstances, sleep initiates through NREM with the first phase of N1 stage. Generally, it lasts between 1 and 7 min [39], and corresponds with a state of sleepiness where the alpha EEG rhythm disappears [59]. In this study, 10 participants (90.90%) rapidly move toward the N1 stage, remaining in it a period of time oscillating between 11 min and 28 min, 9 of them (81.81%) move toward the N2 stage, remaining in it between 4 min and 25.5 min. Considering the sleep latency, sleep appeared shortly after initiating the application of reflexology. During this time, the work on

reflex areas focused on the toes, especially the large toes that correspond to the reflex areas of the head, which permit locating all the structures of the brain stem. We must take into account that the information perceived by our senses is channelled through the thalamus which, along with the cerebral cortex, are the some of the main structures implicated in the generation of bioelectric changes of NREM sleep [45].

It could be considered that the work in these reflex areas, during the first 15 min, had some relationship with the results obtained. In correlation with this observation, one of the important areas of application during this period of time was the reflex area of the visual cortex, which, according to our practical experience, we identified as an area of high therapeutic content. It is possible that all the reflex areas related to the ocular system, both for its anatomy as well as its physiology, can be potential areas of great therapeutic content, which can be due to its informational relations with the somato-sensory cortex [27,28].

Sleep spindles define one of the bioelectric characteristics of the N2 phase. Recent studies [60] have identified the presence of a close functional connectivity between the hippocampus and the neo cortex during periods of sleep of this phase, which suggests an increase in the capacity of transference of information during the N2 stage of sleep, giving credibility to the hypothesis that links sleep with cognitive processes [45]. This could explain the improvements obtained in respect to the cognitive deterioration in the study of reflexology applied to persons with Parkinson's disease

[61].

Regarding the immune system, we know that the quality and quantity of sleep are effective in the protection against colds in healthy adults [62]. In addition, relations between sleep and the immune system may favour a restorative function that has a positive impact on improving immunity [63]. In relation to this data, in our therapeutic experience, many people that regularly use reflexology have reported that they suffer less cold and less cold syndromes, which they relate to the use of reflexology.

Heart rate is another physiological parameter that decreases during N2 phase. In correlation with these characteristics, some studies have shown changes in heart rate during its application [64,65]. In the present study, the cardiac frequency showed no significant changes, maintaining a steady beat throughout the application.

Some participants despite having fallen asleep, manifested that they believed that they had not slept, this could relate to the beginning of somnolence that appears at the onset of sleep, even before reaching stage 1 of NREM sleep.

Some jaw movements were recorded during sleep in participants in both groups (Fig. 3). Le Huquet [66], did some research in healthy patients during sleep and developed a method for recording the jaw position in three-dimensions. The results of his studies show that the position of the jaw was significantly influenced by the different phases of sleep. Significant movements, such as closing and protruding of the jaw, were recorded in the transition from being awake to phase 1 sleep ($p < 0.05$). This, according to the author, suggests a simultaneous modulation of the muscle tone in the upper airway. This could relate to the improvement they have experienced in problems of the jaw and bruxism in some of our clients with the application of reflexology.

Different epidemiological studies have established the contributions of sleep to physical and mental health [40]. We propose that the entry into the N1 and N2 stages, as well as the sleep efficiency obtained, can relate to the development of a process of internal self-regulation induced by reflexology. Thereby obtaining benefits associated with sleep, such as relaxation, decreased stress, and increased immunity or recovering vitality among others. We agree with Jacobs and Friedman [67] that as it happens with relaxation, reflexology can exert similar therapeutic effects that occur during sleep, promoting a disconnection which facilitates the conservation and/or renovation of cerebral energy.

Finally, data from PSG supports the proposal of establishing as a hypothesis the Theory of Reflexology and Sleep Stages, in relation to one of the possible mechanisms of action.

On the other hand, there is little evidence of the effects of reflexology as sleep inducing. The findings suggest that reflexology could be applied as a non-pharmacological treatment to induce sleep.

In this study, no adverse effects were observed.

This study shows that reflexology is much more than just a foot massage and more research is needed on the effects and benefits.

4.1. Limitations

The results of this study provide evidence of the effectiveness of reflexology to induce sleep; however, the results should be interpreted carefully. One limitation is the number of participants of the sample. Moreover, participants in this study had scores of depression and sleepiness in the normal range. Another limitation is that the reflexology was applied by only one professional. The aforementioned does not allow us to generalize the results.

4.2. Recommendations

We need to replicate the study with a larger sample that could provide more information. Future studies should use polysomnographic measures of sleep parameters to gather evidence on the effectiveness of the application of reflexology in this field.

4.3. Conclusion

The application of reflexology induces changes in the activity of brain waves in correspondence with the appearance of a high degree of sleepiness and sleep that is identified with the N1 and N2 NREM sleep.

During the application of reflexology, there is a gradual transition and an orderly progression from wakefulness to sleep, which could explain the effects of relaxation and well being obtained.

There is little evidence about the benefits of reflexology in sleep disorders. Future research should investigate, by means of PSG, if the application of reflexology can be effective in people with chronic insomnia, sleep disorders or other health problems related to it.

Author disclosure statement

There are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.ctcp.2017.05.003>.

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