The executive functions in primary insomniacs: literature review

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Abstract

Primary insomnia can cause a great impact on the individuals' cognitive functioning, especially related to the called executive functions. Therefore, this work aimed to review studies in literature that addressed the relationship between primary insomnia and executive functions in young adults. For this purpose, it was conducted a bibliographical survey regarding publications of the last twenty years (1993-2013), in electronic databases: PubMed, PsycInfo and Scielo. Eleven scientific articles were selected by inclusion and exclusion criteria set. Most part of the studies did not identify deficits in executive function in adults with primary insomnia. However, it was observed that there was a mismatch from the methodological perspective between studies, related to the variability of the methods used, the types of tests and diagnostics criteria for primary insomnia.

Keywords: Primary Insomnia - Executive Functions – Neuropsychology - Adults.

Las funciones ejecutivas en pacientes con insomnio primario: revisión de la literatura

Resumen

El insomnio primario puede causar un gran impacto en el funcionamiento cognitivo de las personas, sobre todo en lo que respecta a las funciones ejecutivas. Por lo tanto, este estudio tuvo como objetivo revisar la literatura sobre estudios que abordan la relación entre el insomnio primario y funciones ejecutivas en adultos jóvenes. Se realizó una revisión de la literatura en relación con las publicaciones de los últimos veinte años (1993-2013), en bases de datos electrónicas: PubMed, PsycInfo y SciELO. Once artículos fueron seleccionados por un conjunto de criterios de inclusión y exclusión. La mayoría de los estudios no han identificado deficiencias las funciones ejecutivas en adultos con insomnio primario. Sin embargo, se observó que había una falta de coincidencia desde el punto de vista metodológico entre los estudios con respecto a los métodos utilizados, los tipos de pruebas y criterios de diagnóstico para el insomnio primario.

Palabras clave: Insomnio primário - Funciones ejecutivas – Neuropsicología - Adultos.

Introduction

Insomnia is currently considered a serious public health problem, being a frequent complaint in primary care. Some epidemiological studies show that approximately 43 to 48% of the general population present insomnia complaints, but only about 6-10% of these meet the disorder diagnostic criteria (Morphy, Dunn, Lewis Boardman, & Croft, 2007; Ohayon & Reynolds, 2009). In Brazil, a study carried out by Marchi (2004) with a representative sample of 1,105 individuals from the city of São José do Rio Preto, found the prevalence of insomnia in 32% of the investigated sample. These epidemiological data, in turn, will vary according to the diagnostic criteria used, as there is no consensus for the classification used in the insomnia definition in terms of its symptoms, frequency and gravity (Edinger et al., 2004).

The incidence of insomnia has been shown to be higher in women, especially after menopause, in the elderly people, in patients with medical diseases and / or psychiatric disorders, in shift workers, among the unemployed and people with low income and limited schooling (Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008).

Studies have shown that insomnia may bring several damages to the individual´s life, especially as regards the increased risk of developing heart diseases, hypertension, lung problems, diabetes, and the increase in consumption of alcohol, tobacco, caffeine, illicit drugs and the use of medication. The raise of fatigue, irritability and the decline in cognitive performance are also constant complaints (Carey, Moul, Pilkonis, Germain, & Buysse, 2005).

Because of these losses, it has been observed an increase in spending on public health services, number of work absenteeism, risk of accidents and decreased productivity (Suh et al., 2012). In the United States, an estimate about adults with chronic primary insomnia

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showed that the total cost of insomnia due to reduced performance at work was 860 dollars, but the total costs, which included lost productivity and missed work, were 1,100 dollars per person over six months (Wade, 2011).

Insomnia has been defined as a difficulty in initiating or maintaining sleep, or even to wake up earlier than expected and not get back to sleep, followed by a feeling of non-restorative and poor quality sleep. It results in a series of damages in the daytime functioning, causing a strong impact on people´s social life and cognitive performance (Benca & Morin, 2012; Pinto Jr. et al., 2011). To make the diagnosis, these symptoms must be constant and cause clinically significant distress (American Psychiatric Association, 2013).

In this sense, two nosological categories are known in establishing criteria for the diagnosis of insomnia. They are the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM V) (APA, 2013) and the International Classification of Sleep Disorders, 2nd edition (ICSD-2) (American Academy of Sleep Medicine, 2005).

The DSM V requires sleep complaint (difficulty to initiating or maintaining sleep) to be present for at least three months, with clinically significant distress and damage in important areas of daytime functioning (APA, 2013). On the other hand, ICSD-2 considers that the complaint about the difficulty in initiating or maintaining sleep, or even waking up too early, being a poor quality sleep, should occur, despite adequate opportunity to sleep, along with the complaints of daytime impairment, for a period longer than three months. Although both categories use the same criteria to define insomnia, the DSM V does not subdivide it into categories and establishes a broad diagnosis that includes insomnia in a single dimension, named Insomnia Disorder. Whereas ICSD-2 delineates numerous subtypes of insomnia, that, according to experts make the diagnosis confusing (AASM, 2005). Additionally, empirical researches have not found validity evidences for all subtypes of insomnia (Edinger et al., 2011). Therefore, up to now, there is no consensus on which of these two categories have greater validity and reliability in the diagnosis.

Taking ICSD-2 as basis, since it delineates more clearly the types of insomnia, when insomnia presents itself independently without any evident causative factor, it is called primary. But when it appears as comorbidity to other medical conditions, such as mental disorders (depression, anxiety), substance abuse, physical diseases and other sleep disorders, it is called secondary or comorbid insomnia. The prevalence of primary insomnia is from 1% to 2%, and secondary insomnia is present in about 80% of the cases (Brazilian Society of Sleep, 2003; Morin, LeBlanc, Daley, Gregoire, & Merette, 2006).

Primary insomnia, specifically, has been widely investigated in the literature, due to its biopsychosocial nature. One of the perspectives that have been highlighted to explain the physiopathology of primary insomnia is the hyperstimulation/ hyperexcitation. This model postulates that people who have insomnia experience a cognitive, somatic and cortical hyperstimulation and, because of this, they have difficulties in falling or maintaining asleep during the night (Riemann et al., 2010).

Additionally, many studies have shown that chronic insomnia causes a series of damages on cognitive abilities, particularly regarding the attentional control, memory and concentration (Leger, Guilleminault, Bader, & Levy Paillard, 2002). Consequently, individuals become more likely to make mistakes and to exhibit difficulties in making decisions, solving complex problems and organizing ideas (Bastien, 2011). Thus, one can infer that people with insomnia have difficulty engaging in behaviors oriented to a specific goal or purpose, in other words, chronic primary insomnia can affect executive functioning.

Executive functions (EF) is a relatively new term in the neurosciences and neuropsychology literature, and, probably for this reason, there is no single definition that characterizes them. Luria (1981) considers EF as higher mental functions that control the most complex forms of human activity oriented to goals. As for Lezak, Howieson, and Loring (2004), EF are conceptualized as capabilities that allow someone to keep a behavior of autoregulation in an independent and intentional manner.

Lezak et al. (2004) suggest that EF involve four serial components that together enable an individual to behave and respond adaptively to situations such as: volition, planning, deliberate action, and effective performance. Volition is related to intentional behavior and requires the formulation of a goal or intention. Planning is an essential component in adaptive behavior, involves the identification and organization of elements and steps towards the achievement of a goal, covering a variety of capacities, such as memory, flexibility, impulse control and sustained attention. Deliberate action is involved in the transition from intention and plan to the behavior itself. The individual, then, performs the actual performance from these deliberate actions, through self-regulation and behavior monitoring, being able to evaluate, keep or modify it (Lezak et al., 2004).

Another model proposes dividing the executive components in "hot" and "cold" (Diamond, 2013). The hot ones are related to social behavior regulation, conflict resolution involving emotional and interpersonal factors and situations where punishment and reinforcement are connected. As for the cold ones, they are more based on logic and abstraction, not depending on emotional content to perform, such as the planning and cognitive flexibility (Chan, Shum, Toulopoulou, & Chen, 2007).

According to Malloy-Diniz et al. (2010), these multiple existing conceptualizations, somehow, complement each other, with EF constantly being considered as those responsible for willful and independent behaviors and behaviors related to the individual itself.

Therefore, most authors consider that EF do not correspond only to a single cognitive ability, but to a number of distinct cognitive components related to each other around three core functions: inhibition (inhibitory control, behavioral inhibition, selective attention); working memory (updates and manipulate information relevant to the execution of a task) and cognitive flexibility (ability to change the course of action or thought). From these components, complex EF are constructed, such as planning, problem solving, decision making and reasoning (Diamond, 2013).

This set of cognitive processes is responsible for controlling responses to new or difficult situations, and are generally associated with the prefrontal cortex (PFC), portion that is anterior to the premotor area of the frontal lobe (Best & Miller, 2010).

In the literature, some theoretical revisions as the one performed by Fortier-Brochu, Beaulieu-Bonneau, Ivers and Morin (2011) and Shekleton, Rogers and Rajaratnam (2010) have been finding that chronic insomnia bring damages for a number of cognitive processes. However, these studies have not directly addressed the relationship between executive functioning and primary insomnia. Because of this, the present study aimed to review scientific articles that investigated the relationship between executive functions and primary insomnia in young adults, since EF correspond to a set of cognitive processes that are critical to daytime functioning of people with insomnia.

Method

Scientific articles selected through the electronic sources Pubmed, PsycInfo and SciELO were consulted. For this, was used the intersection of the following keywords in English: "insomnia"; "executive functions"; "working memory"; "cognitive flexibility"; "inhibitory control"; "selective attention"; "problem solving" "decision making" and "cognitive functioning"; and in Portuguese: "insonia"; "funções executivas"; "memória de trabalho"; "flexibilidade cognitiva"; "controle inibitório", "atenção seletiva"; "resolução de problemas"; "tomada de decisões" and "funcionamento cognitivo".

The inclusion criteria for the studies found were: (a) have been published within the last 20 years (1993-2013), (b) evaluate EF domain in people with primary insomnia, (c) use adults sample (18 to 50 years old) with any type of primary insomnia, (d) to be empirical research and (e) full texts published in English or Spanish or Portuguese. While the exclusion criteria were: (a) researches involving case studies and (b) works with animal models.

For articles selection, a descriptive analysis was primarily done by using the bibliometric indicators present in the index fields provided by the cited research bases, with the following items discriminated: *authorship and publication year*. Next, each article was analyzed in order to evaluate: the demographics data of the sample, the diagnostic procedures (which criteria were used), the methodological characteristics, the neuropsychological tests, the criteria used to identify participants with and without insomnia and the exclusion criteria.

Results

In Pubmed database there were 516 studies cataloged. However, according to the established criteria, only 11 articles met the objectives of this study. In PsycInfo database, 374 articles were found, but only seven of them were selected in accordance to the criteria, considering that these studies were the same as those found in Pubmed database. In respect to Scielo database, only one article was found, and it did not fit in this study (see *Figure 1*). Thus, since most of the articles did not address the primary insomnia or involved other cognitive processes that were not part of EF, only ten studies met all criteria previously established. Below, there is a summary and analysis of the major studies found (see Table 1).

Figure 1: Steps of the search for scientific articles relating primary insomnia and executive functions in three databases: PubMed, PsycInfo and SciELO.

Pubmed	516 articles	Inclusion criteria exclusão	11 articles Critérios
PsycInfo	374 articles	Inclusion criteria	07 articles
Scielo	01 article	Inclusion criteria	00 articles

Table 1: *Methodological characteristics addressed in the scientific articles relating primary insomnia to executive functions.*

Studies	Objectives	Diagnostic criteria	Domains of EF assessed	Tests used	Results	Limitations
Bonnet & Arand (1995)	Assess sleep patterns, cognitive performance and metabolic measures of people with and without chronic insomnia in an laboratory environment for 36 consecutive hours.	Other criteria.	Working memory.	Symbol replacement task and WAIS digit subtest.	Insomniacs underperformed the control group in the working memory task.	The diagnostic criteria for the group of insomniacs was not based on any classification and the fact that participants spent 36 hours in a laboratory environment may have influenced the results.
Lundh, Froding, Gyllenhammar, Broman, & Hetta (1997)	Evaluate the cognitive performance of patients with and without chronic insomnia.	Other criteria.	Cognitive flexibility.	Emotional Stroop Test.	In the emotional Stroop insomniacs and the control group had similar results.	The criteria used to diagnose the insomniac group were not specified, which may have allowed a great heterogeneity in the sample.
Rosa & Bonnet (2000)	Assess behavioral, physiological and subjective variables on volunteers with and without chronic insomnia for 36 consecutive hours.	Other criteria.	Working memory.	Williams Test of working memory.	Insomniacs underperformed the control group in the working memory task.	The diagnostic criteria for the group of insomniacs were not based on any classification and the fact that participants spent 36 consecutive hours in assessment may have influenced the results.
Szelenberger & Niemcewicz (2001)	Assess the brain current density of patients with and without primary insomnia, submitted to an attention test.	DSM-IV.	Selective attention.	Continuous attention test.	The Continuous Attention Test revealed no differences between the group of insomniacs and the control group, but the insomniacs had lower brain current density in the prefrontal cortex.	The test used was not sensitive enough to assess selective attention.
Varkevisser, Van Dongen, Van Amsterdam, & Kerkhof (2007)	Investigate the relationship between daytime functioning and chronic insomnia in outpatient situation.	ICSD-2.	Working memory.	2-back.	There were no significant differences between insomniacs and control group in the working memory task.	Experimental or statistical factors.
Orff , Drummond, Nowakowsk, & Perils (2007)	Evaluate daytime functioning of individuals with and without primary insomnia.	Other criteria.	Cognitive flexibility and verbal fluency.	COWAT and Trail Making Test.	There were no deficits in any of the neuropsychological measures used when comparing participants with and without insomnia.	Impact of laboratory environment in the sleep routine of insomniacs and also the tests used may not have been sensitive enough to detect cognitive impairment.
Sagaspe, Philip, & Schwartz (2007)	Investigate the inhibitory motor control in patients with the sleep obstructive apnea syndrome and ffpsychophysiological insomnia.	ICSD-2.	Inhibitory control.	Go/No-go Paradigm.	Reaction time to signal “stop” was slower in subjects with sleep apnea. The participants with insomnia and apnea did not differ from control group in their reaction time to the signal “go”.	The sample of insomniacs was relatively small, and measures of sleep may also have suffered the impact of the laboratory environment, damaging the accurate diagnosis of primary insomnia.

Boyle, Trick, Johnsen, Roach, & Rubens (2008)	Evaluate the ability to drive on the next day, the cognitive and psychomotor skills of people with and without primary insomnia, after the administration of eszopiclone during the night.	DSM IV.	Working memory.	Processing of quick visual information; digits and symbols replacement test.	The driving ability and measures of cognitive and psychomotor function were not impaired.	The use of hypnotics may have influenced the cognitive performance positively.
Fang, Huang, Yang, & Tsai (2008)	Examine the daytime functioning of individuals with primary insomnia and without insomnia.	DSM-IV.	Problem solving.	Wisconsin Card Sorting Test	The results showed that insomniacs showed no impairment in solving problems when compared to individuals without insomnia.	Large age differences between the two groups may have provided a possible impact of age on cognitive functioning.
Fernandez-Mendoza et al. (2010)	Investigate the effects of chronic insomnia in some cognitive abilities. The groups of people with and without chronic insomnia were divided according to sleep duration in two categories: ≥ 6h and <6h.	Other criteria.	Cognitive flexibility and verbal fluency.	Thurstone's Word Fluency Test (TWFT) and Trail Making Test (A and B).	There was no significant difference between people with and without chronic insomnia, in none of the cognitive processes investigated. But the group of insomniacs with short sleep showed lower performance in cognitive flexibility.	Big difference between the number of individuals that composed the control group and the group of insomniacs, and the criteria for the diagnosis of insomnia were not specified.
Drummond, Walker, Almklov, Campos, Anderson, & Straus (2013)	Examine the neural correlates of working memory performance in patients with and without primary insomnia.	ICSD-2.	Working memory.	N-back.	There was no difference between the group with primary insomnia and control group in the working memory test, but there was a reduction in the right dorsolateral prefrontal cortex.	The neuropsychological test may not have been sensitive enough to detect possible neural deficits.

It can be observed in Table 1 that the studies assessed mainly the domains of working memory, cognitive flexibility, selective attention, problem solving and inhibitory control. However, most of them focused on working memory.

Regarding the methodology, all studies used comparisons between an experimental group (people with chronic insomnia) and a control group (people without insomnia). Szelenberger and Niemcewicz (2001), Varkevisser, Van Dongen,Van Amsterdam, and Kerkhof (2007), Sagaspe, Philip, and Schwartz (2007), Boyle, Trick, Johnsen, Roach, and Rubens (2008) and Fang, Huang, Yang, and Tsai (2008) used DSM or ICSD insomnia diagnostic criteria, while other studies attempted to use other types of diagnostic criteria, which were determined by the researchers themselves.

In regard to the working memory, the studies of Bonnet and Arand (1995) and Bonnet and Rose (2000) were found, which, through a similar methodology, sought to investigate, among other variables, working memory in people with and without insomnia. Participants in both studies underwent a battery of neuropsychological and physiological tests, performed for 36 consecutive hours in laboratory. It was observed that the group of insomniacs in both studies achieved a lower performance on working memory tests, compared to those without insomnia. However, the results found in these studies may have suffered influences from the artificial environment of the laboratory and testing routine itself, established over 36 hours.

On the other hand, Varkevisser et al. (2007) sought to assess, in an outpatient setting, working memory of 30 people with chronic insomnia and 20 without insomnia, through a test called 2-back. However, no significant differences between the groups with and without insomnia were observed. Boyle et al. (2008) also investigated working memory of 32 people with chronic insomnia and 32 without insomnia. For this, participants were submitted to two different experimental situations. In the first one, 3 mg of eszopiclone (hypnotic used to treat insomnia) was administered in a group, and in the second one, placebo substance was administered. The next day, the driving ability, working memory and psychomotor activities were measured. It was observed that participants reported improved sleep with the administration of ezopiclone, but there were no significant differences in working memory between the groups in both conditions.

Another study, by Drummond, Walker, Almklov, Campos, and Anderson (2013), assessed the brain activity of 25 participants with insomnia and 25 without insomnia, who underwent a test called N-back, that also measured the cognitive domain of working memory. The results showed no significant differences in cognitive performance between insomniacs and the control group, but it showed that, with increasing complexity in the task of working memory, there was a reduction in the activation of the right dorsolateral prefrontal cortex (region related to working memory). Emphasizing thereby that insomniacs have a hypoactivation of brain areas related to EF.

Regarding the evaluation of the field of cognitive flexibility was found, among others, the study by Lundh, Froding, Gyllenhammar, Broman, and Hetta (1997). In this research, the performance in cognitive flexibility, measured by the Emotional Stroop Test was similar between the groups with and without insomnia. In this study, however, it is necessary to consider that the test used to assess cognitive flexibility was based on the Stroop effect (Emotional Stroop Test), which is mostly used to assess aspects of inhibitory control and selective attention. In their study, Orff, Drummond, Nowakowsk, and Perils (2007) evaluated the diurnal impairment of 37 individuals with primary insomnia and 17 without insomnia. The participants underwent a neuropsychological battery that measured, among other processes, cognitive flexibility, through the Trail Making Test. The results showed no significant differences between groups. However, both studies showed a major limitation regarding the lack of more discriminating diagnostic criteria for the composition of the group with primary insomnia.

The study by Mendoza-Fernandez et al. (2010) also assessed cognitive flexibility. The study included 117 people with chronic insomnia and 572 without insomnia, divided according to sleep duration (measured by polysomnography) in two categories: ≥ 6 h of sleep (normal sleep) and < 6 h of sleep (short sleep). Attention and verbal fluency of the participants were measured through the Trail Making Test A and B, and the Thurstone Word Fluency Test (TWFT), respectively. No significant difference between people with and without chronic insomnia was found, however, the group of people with insomnia who had short sleep showed a lower performance in Part B of the Trail Making Test, which is associated with cognitive flexibility.

Other found studies sought to assess selective attention, inhibitory control and problem solving. Szelenberger and Niemcewicz (2001), for example, evaluated, by Low Resolution Electromagnetic Tomography, the cerebral current density in 14 patients with and without primary insomnia, subjected to a test of continuous attention (that evaluates selective attention). The continuous attention test revealed no differences between the group of insomniacs and the control group, but the insomniacs had lower cerebral current density in the prefrontal cortex, area associated with executive functioning.

In the evaluation of inhibitory control, the study of Sagaspe et al. (2007) sought to investigate inhibitory control motor important component of executive functions) of 22 patients with the obstructive sleep apnea syndrome and 13 with psychophysiological insomnia. The participants underwent a test ruled by the Go / No go paradigm, which assess the inhibitory control facing the presentation of two commands: “Go” and “No go”. Reaction time to “No go” signal (time to internally suppress the response) was slower in individuals with apnea. In contrast, both the participants with apnea and insomnia did not differ from their control groups in their reaction time to “Go” signal. Thus, individuals with sleep apnea showed deficits in inhibitory control motor, unlike insomniacs. Perhaps, these results are reflections of constant drowsiness presented by apneic and hyperstimulation in insomniacs. However, it appears that the sample in this study was relatively small for insomniacs, and sleep measures may also have suffered from a laboratory environment.

Regarding problem solving, Fang et al. (2008) sought to assess it through the Wisconsin Card Sorting Test (WCST). The study included 18 individuals with insomnia and 21 individuals without insomnia. The results showed that insomniacs presented no impairment on problem solving, when compared to those without insomnia. The authors noted that although the neuropsychological measures have not pointed any cognitive impairment, there was a series of subjective complaints of impairment by insomniacs. In addition, the WCST is a complex test that seizes more general aspects and is not always associated with a specific indicator of executive functioning, such as problem solving.

Discussion

Through this review of the literature, it was possible to observe that there is a shortage of studies evaluating primary insomnia and executive functions in adults. Most studies have sought to make a broad assessment of cognitive performance of individuals with insomnia, addressing only some executive functions.

Also, it was noticed that the insomniacs reported numerous complaints of impaired cognitive performance, whereas there was little evidence of damage in the neuropsychological tests (Bastien, 2011). This fact, however, can be largely explained by methodological differences between studies. There was, for example, variability in methods, testing and diagnostic criteria for insomnia employed in each study (Edinger et al., 2010).

Many studies presented here also used a relatively small sample, which may have limited the statistical power to detect subtle differences between insomniacs and good sleepers. Moreover, it is necessary to use strict criteria for sample selection, both for the control group as for the insomniacs, given that many medical and psychiatric diseases or even age can influence sleep and cognitive functioning. In many of these studies, people with insomnia were under treatment based on hypnotics, and such drugs tend to minimize symptoms of insomnia and lead to good cognitive performance.

Shekleton et al. (2010) point out that one of the difficulties in making comparisons between studies that assess cognitive performance in individuals with primary insomnia refers to the insensibility of neuropsychological tests to assess cognitive deficits considered subtle, since most of the neuropsychological tests were developed to assess the damage caused by a brain injury or a disease that affects neurocognitive functioning (Lezak et al., 2004).

Furthermore, those tests were compiled to provide consistent results over time, regardless of the organism rhythmic aspects, such as the temperature variation, sleep/wake cycle and the feeding cycle. Some studies have shown that the temporal variation can influence behavior, due to the action of a system of multiple oscillators and the influence of temporal cues in the environment, such as the light/dark cycle and social factors, such as school, feeding and labor schedules (Dijk, & Von Schantz, 2005). In this sense, it can be hypothesized that the neuropsychological tests are characterized as insensitive to adequately capture the temporal oscillations of the organism (Altena et al., 2008).

The batteries of neuropsychological tests used to assess the domains of executive functions also can not access each domain separately, reflecting the theoretical inconsistency about the definition of executive functions (Miyake et al., 2000). Therefore, it can be inferred that these are aspects that can also serve as explanation for the shortage of studies and the range of tests used throughout the studies evaluated in this work.

It was also observed that most of the articles use the hyperstimulation model to explain successful cognitive performance of insomniacs on neuropsychological tests. According to the explanatory model for primary insomnia of hyperstimulation / hyperarousal, people with insomnia are constantly hyperalert both cognitively and physiologically (Turcotte et al., 2011). Thus, the cognitive performance of insomniacs may have been influenced by their constant overstimulation, causing their performance to be similar or even higher than people without insomnia. Moreover, these results may reflect the so-called compensatory effect. The phenomenon of compensation involves excessive effort made by insomniacs to counteract the effects of the sleepless night. Because of that, their cognitive performance becomes similar or even superior to those of individuals who do not complain of insomnia (Bastien, 2011).

Another fact to be considered is that, in many of these studies, for the diagnosis of insomnia, polysomnographic examination done in a laboratory setting was used. Polysomnography is an exam that is usually done at night and records the broad biophysiological variations that occur during sleep. The individual needs to sleep in a lab with some electrodes implanted in the brain and usually it is recommended that the test is performed for three nights in a row, although many laboratories only perform it for one night. According to Edinger, Means, Carney, and Krystal (2008), the first few nights in the lab may have a masking effect on the sleep, since the new situation may be causing a different behavior than usual, leading to a precipitate diagnosis.

Therefore, there are several variables that may be influencing or limiting the surveys that sought to assess the direct or indirect relationship between primary insomnia and executive functions. However, it is noticed that insomniacs tend to constantly overestimate their diurnal damages, while most studies seem to support the hyperstimulation / hyperarousal model of primary insomnia.

Final considerations

The current review aimed to do an updated scan of the relation between primary insomnia and EF in adults. It was found that such studies are scarce and have diverse methodological issues to be considered. Despite of this, it can be concluded that most studies do not report deficits in EF of individuals with primary insomnia. It becomes clear that further studies investigating this relation should take into account: strict diagnostic criteria for the selection of the insomniacs and the control groups; that the use of medication that interferes in sleep is controlled; that more sensitive testes are used to detect subtle impairments, involving complex tasks and covering a considerable number of EF processes. The testing conditions should also be controlled, once it is necessary to pay attention to the administration of the tests and the instructions given to the participant, the test environment and the application time of the tests, since attention fluctuates according to homeostatic and circadian factors (Varkevisser & Kerkhof, 2005).

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