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Improvement of executive functions after the application of a neuropsychological intervention program (PEFEN) in pre-term children

Abbreviated title: EF intervention in preterm children

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Abstract

Prematurity is one of the most prevalent health problems in developed countries. It is associated with important clinical and educational consequences, problems in activities of daily life, as well as alterations in different domains of executive functions (EF).The objective of the present study was to evaluate the effectiveness of a stimulation program for the EF (PEFEN Program) in a group of premature children and compare the effects with a control group, who worked with routine curricular skills. The participants were children aged 4 and 5 years, born preterm between 32 and 37 weeks of gestation with a weight between 1500-2499 grams, without severe chronic pathology, or disability equal to or greater than 33% (mental, sensorial and/or motor).The participants were evaluated individually using the BENCI, CUMANIN, and BRIEF-P neuropsychological tests, before and after both interventions. The results showed that the preterm-children who received the PEFEN program significantly improved in the domains of verbal understanding, phonic fluency, verbal fluency, working memory, visual memory, verbal memory, rhythm, and attention, in comparison with the control group. It is recommended to implement programs such as PEFEN to improve the development of EF in the school environment and prevent the deficit in populations at risk.

Key words: prematurity, children, neuropsychology, executive functions, early-stimulation, mindfulness

Highlights

- The application of EF stimulation programs improves neuropsychological performance in preterm children.
- Neuropsychological domains such as memory, attention and EF improve after the application of the program.
- The PEFEN program has shown its usefulness in premature children.

1. Introduction

The executive functions (EF) are fundamental cognitive skills for achieving good performance in life, as well as in the school and social environment, allowing people to face new and complex situations (Lezak, 2004). At the age of 5 years the three key components of EF have already been partially developed, these being working memory, inhibition, and cognitive flexibility (Matthew, Davidson, Amso, Anderson & Diamond, 2006). Working memory involves the monitoring, manipulation, and updating of information; whilst inhibition refers to the ability to deliberately and precisely inhibit the production of automatic responses when the situation requires it; whilst cognitive flexibility allows for switching effectively between different mental operations (Miyake et al., 2000, Sastre-Rivas, 2009).

Intervention programs that have focused on EF in school children have revealed that training programs in creativity, flexibility, self-control and discipline bring about improvements in both their academic results and their daily lives (Diamond, 2013). In addition, the poorer the initial performance of the children, the greater the benefit they receive after training (Diamond, 2013, Diamond, Barnett, Thomas & Munro, 2007, Diamond & Lee, 2011). The literature also reports that in order to protect children from the negative effects of certain adverse experiences (toxic stress), it is fundamental, among other things, to encourage training in specific skills with special emphasis on EF, along with emotional and behavioral self-regulation (Shonkoff, 2010; Shonkoff et al., 2011; Shonkoff, Richter, Van der Gaag & Zulfiqar, 2012).

In developed countries, prematurity is one of the most prevalent health problems during childhood and is considered to be one of the factors underlying the high risk of dependence and disability, with important consequences at both the family and social level (García-Bermúdez et al., 2012). The increase of premature births in developed societies is associated with an increase in fertility treatments, the existence of better obstetric and neonatal care (which promotes a greater survival of even the most premature children), along with the advanced age and high stress levels of the mother (Davidoff, et al., 2006, Liu, et al., 2016, Nogueira-Cruz, Laynez-Rubio, Cruz-Quintana & Pérez-García, 2012). The immaturity of the biological systems and morphological and functional characteristics of the premature child makes it more likely that they will present complications in their short, medium, and long term cognitive development (Narberhaus et al., 2007, Sastre Rivas, 2009).

According to the World Health Organization (2016), a baby that is born alive before 37 weeks of gestation is considered premature. Premature children are divided into three categories according to gestational age and birth weight: extreme preterm (<28 weeks and weighing less than 1000 g), very premature (28 to <32 weeks and weighing less than 1500 g) and moderate-late preterm (32 to <37 weeks and weighing less than 2.500 g).

The majority of studies on the consequences of prematurity have focused on the so-called very premature and extreme children, comparing them with full-term children. The literature reports that these two groups show greater delays in their neurocognitive development including: lower IQ, an increased risk of disability such as moderate mental retardation or cerebral palsy, greater respiratory problems, apnea, intraventricular hemorrhages, anemia, motor retardation, and visual problems (Bayless, Pit-ten Cate & Stevenson, 2008; Begega et al., 2010). In addition, school problems associated with neuromotor, cognitive, language and behavioral delays are frequently reported (Bhutta, Cleves, Casey, Cradock &Anand, 2002, Böhm, Smedler & Forssberg, 2004, Ortiz-Mantilla, Choudhury, Leevers & Benasich, 2008, Wocadlo & Rieger, 2007). EF and memory can also be affected by prematurity (Bayless & Stevenson, 2007), with these problems remaining in adolescence (Lhaugen et al., 2010; Loe, Lee, Luna & Feldman, 2011), and even in adulthood (Mathiasen, Hansen, Forman, Kessing & Greisen, 2011, Narberhaus et al., 2007, Saavalainen et al., 2006, Tideman, 2000).

In the case of the group of late preterm children or those of moderately low weight (1500-2499 g), they usually present, between 3 and 8 years of age, neuropsychological and neurosensory problems that can affect their learning (Begega et al., 2010), with deficits in verbal comprehension, perceptive reasoning, and processing speed being reported (García-Bermúdez, et al., 2012). Studies in the behavioral field have found these children to show greater hyperactivity, behavioral and psychomotor problems, less attention, greater learning difficulties, atypical behaviors, and greater externalizing problems (García-Bermúdez et al., 2012; Hornman, de Winter, Kerstjens, Bos & Reijneveld, 2016; Reijneveld, De Kleine & Van de Baar, 2006). At school age, there is also poorer executive functioning, particularly inhibition, working memory, task switching, selective attention, and sustained attention (Sastre-Rivas, 2009). Late preterm children usually do not receive specific interventions addressed to these domains or appropriate follow-up, in comparison with very premature children. Preventive interventions directed towards the stimulation of these neuropsychological domains and to the regulation of behavioral and emotional problems are highly recommended for this population (Nogueira-Cruz et al., 2012; Perales et al., 2014).

In short, the existing studies have revealed important differences in executive functioning between children born at full term and those born prematurely without neurological alterations. These findings also emphasize the importance of early intervention to improve cognitive and behavioral aspects (Spittle & Treyvaud, 2016, Spittle et al., 2016). However, to our knowledge, there are no studies that have shown the effectiveness of applying EF stimulation programs in premature children at the beginning of school age. As indicated above, at this age there are several neuropsychological deficits, including EF, which are linked to academic performance (Nogueira-Cruz et al., 2011) along with a higher probability of having psychological problems in adolescence (Hornmanet al., 2016; Shonkoff et al., 2011). Therefore, stimulation of the EF at this age is potentially of great clinical relevance.

Thus, the main objective of this study was to apply and evaluate the effectiveness of an EF stimulation program (PEFEN program: Cruz-Quintana et al., 2014) in a group of preterm children aged 4 and 5 years, in comparison with a control group. It is expected that the group of children who receive the intervention with the PEFEN program will show improved performance in EF with respect to children with similar characteristics who receive a program based on general work with curricular skills.

2. Material and methods

2.1. Participants

Initially, 80 pre-term children were recruited from the Complejo Hospitalario de Jaén (CHJ) (Spain). The following inclusion criteria were applied: (i) birth between 32 and 37 weeks of gestation and (ii) birth weight between 1500 and 2499 grams. The exclusion criterion was the existence of severe chronic pathology or disability equal to or greater than 33% (mental, sensory and / or motor). A total of 68 children (30 boys and 38 girls) participated in the entire study. Of the 12 children who withdrew, 2 were due to the death of the father, 3 due to illness, and the remaining participants were excluded for not attending at least 50% of the sessions.

At the beginning of the study the children were divided and assigned to two groups: the group that received neuropsychological intervention with the PEFEN program (NIG Group), composed of 36 children (13 boys and 23 girls), and the group that received general curricular intervention (CIG Group), composed of 32 children (17 boys and 15 girls). Assignment to each group was carried out as follows: 4 different schedules were offered for the development of the program and the parents choose one of them according to their availability, two corresponded to the NIG Group and another two to the CIG Group. At the time of choosing, the parents did not know which of the intervention programs corresponded to each schedule. Both groups were homogeneous in terms of all the socio-demographic variables analyzed (see Table 1).

-----------------Insert Table 1 here-----------------

2.2. Instruments

2.2.1. Socio-demographic data: this information was collected using both the clinical history and a semi-structured interview, and included the child's age in months, sex, weight, type of delivery, time of pregnancy, smoking during pregnancy, age of the mother, gestational age of the mother, family socioeconomic status and level of studies of the mother. Healthy habits such as school adjustment, the existence of other chronic diseases, a special diet, medication and the number of hours of sleep were also evaluated.

2.2.2. Test Factor "g" (Cattell & Cattel, 1973) that evaluates non-verbal aspects of intelligence in adults, based on the relationships between forms and figures. It is composed by four different sub-tests. In the first one ("Series") participants have 5 minutes to identify which figure follows a pre-established logical series. In the second sub-test ("Classification"), participants have to identify, from a set of five figures, which is different or has different characteristics (duration: five minutes). In the third sub-test ("Matrix") participants have to complete the figure with the option that matches with rest of the elements (duration: 4 minutes). Finally, in the last sub-test ("Conditions") participants have to choose the picture or figure that matches with the same conditions of an example (duration: 4 minutes). In the present study, it was used to obtain an intelligence measure of the mothers. The reliability of the Spanish version ranges between α = .70 and .80, with test-retest values of r = .50 - .60 (Cattel & Cattell, 1990).

2.2.3. Evaluation of the effectiveness of the intervention program (pre- and post-):

- Battery for Computerized Neuropsychological Evaluation of Children (BENCI) (Cruz-Quintana, Pérez-García, Roldan-Vílchez, Fernández-López & Pérez Marfil, 2013). This battery of tests allows for a comprehensive assessment of the basic neuropsychological domains: processing speed, visual-motor coordination, attention, language, memory, and EF. The battery is presented in a computerized format, which allows for standardized administration and the recording of data in an easy and reliable way (correct answers, errors, and reaction time), as well as being easy to execute and enjoyable for children. The BENCI includes 17 neuropsychological tests that require between 60 and 70 minutes to complete, with a break of 10 minutes in the middle of the session. In the case of the present investigation, the following tests were included: Figure Comprehension, Image Comprehension, Continuous Execution, Phonetic Fluidity, Semantic Fluidity, Working Memory, Verbal Memory, Visual Memory, and Abstract Reasoning. A brief description of each task is described below:

2.2.3.1. Figure Comprehension: After being shown a group of geometric images (small, medium, or large circles, triangles, or squares in different colors), the child must select the image that meets given criteria (shape, size, position and/or color). Correct responses are recorded.

2.2.3.2. Image Comprehension: After being shown a group of images (e.g., animals), the child must select the image that meets given criteria (animal, position, activity and/or color). Correct responses are recorded.

2.2.3.3. Continuous Execution: Blocks of letters appear on the screen, one after the other. The child is instructed to press a key when a given sequence is shown (for example, letter A following X). The remaining letters are distractors. The reaction time (in ms) and number of correct responses are recorded.

2.2.3.4. Phonetic fluency: The child has 60 seconds to state all the words he/she knows that start with a given letter. Correct responses are recorded.

2.2.3.5. Semantic fluency: The participant is told a semantic category (e.g., colors or animals) and is given 60 seconds to say aloud all of the words that it covers, recording correct responses.

2.2.3.6. Working memory: After listening to sequences of mixed numbers and colors, the child must repeat the numbers and colors (first the numbers, in ascending order, and then the colors, or vice-versa). Correct responses are recorded.

2.2.3.7. Verbal memory: After listening three times to the same series of words, the child must repeat aloud all words that he/she can remember. Correct responses in immediate (first and third test) and delayed recall and delayed recognition tests are recorded.

2.2.3.8. Visual memory: After being shown pictures of common objects, the child must state aloud all objects they can remember. Correct responses for immediate and delayed recall and delayed recognition tests are recorded.

2.2.3.9. Abstract reasoning: A group of a logical series is shown on the screen. The participant must select the element that completes the series, recording the correct responses.

The order of administration was the same for all participants, in accordance with the recommendations of Lezak et al. (2004).The BENCI battery has shown good psychometric properties in its Spanish version (Cruz-Quintana et al., 2013). The test-rest reliability, assessed through Pearson correlation coefficients and Interclass correlation coefficients showed values that varied between r = .97 (in verbal memory recall) and r = .34 (visual memory immediate). Internal consistency using Cronbach's alfa also showed values ranging from α=.92 in selective attention, to α=.62 in simple reaction time task. The convergent validity (for example: Stroop Word Colour Test for the Inhibitory Control Task, Backward Digits for the Working Memory Task, RAVEN test for the Abstract Reasoning task and Spanish Adaptation of Californian Verbal Learning Test for Verbal Memory tasks) presents acceptable and significant correlations (between r = .689 and r = .335).

2.2.4. Childhood Neuropsychological Maturity Questionnaire (CUMANIN) (Portellano, Mateos & Martínez, 2000). This is a paper-based questionnaire that allows for the simple and effective evaluation of several areas that are of great importance in detecting possible development difficulties in ages that coincide with the beginning of school, and are essential in the development of children: psychomotricity (11 items), language articulation (15), language expression (4), language comprehension (4), spatial structuring (12), visuo-perception (15), iconic memory (10) and rhythm (7). This test presents adequate values of internal consistency, with a Cronbach's alpha value that varies between α = .71 and .92 for the different subscales (Portellano et al., 2000).

2.2.5. Behavioral Evaluation of Executive Functioning - Children's Version (BRIEF-P) (Gioia, Isquith& Guy, 2000). This is a paper instrument that is completed by the parents and evaluates various executive skills: inhibition (i.e. difficulties to regulate their behavior), flexibility (i.e. difficulties in task switching), emotional control (i.e. difficulties to regulate emotional responses), working memory (i.e. difficulties to retain information in the mind), planning and coherence (i.e. difficulties to anticipate events or future consequences). This version of the BRIEF-P, adapted to children from 2 to 5 years old, consists of 63 items corresponding to sentences that describe children's behaviors, which are evaluated as: never, sometimes, or frequently (Basuela-Herreras & Luque-Cuenca, 2017). The BRIEF-P shows adequate values of internal consistency, with α values ranging between .79 and .93 for the different subscales (Veleiro&Peralbo, 2014).

2.3. Intervention Programs applied:

2.3.1. *The Stimulation Program in EF for children, known as PEFEN (Cruz-Quintana et al., 2014), administered to the neuropsychological intervention group (NIG*). This program is based on various neuropsychological models (Diamond & Lee, 2011; Shonkoff, 2010) and on the use of Mindfulness techniques. It is a versatile program for the stimulation of the EF in children from 4 to 6 years of age. It is composed of group activities that integrate various components (working memory, inhibition / self-control, flexibility, decision-making, and attention) introduced through play, as well as Mindfulness techniques adapted to children (Flook et al., 2010). The duration of the program is three months, with the difficulty of the program (low, medium, and high) increasing month by month.

The PEFEN complies with the general requirements that have been described when building programs for training in EF. On the one hand it defines the executive components to train day by day, and the tasks of the program exert an increasing demand on the child, with the activities being programmed to increase the difficulty each month with both group tasks and individual activities. On the other hand, it has, among others, tasks that entail changes to which the children are little accustomed or changes that have to be made more rapidly. The tasks include those in which they can make mistakes and thereby enable them to recognize such errors and restructure new responses; tasks focused on the inhibition of attention / action and the inhibition of thoughts and emotions; tasks that involve maintaining concentration and actively working on working memory; and creativity activities that involve adopting different perspectives when faced with objects and / or situations (Cruz-Quintana et al., 2014; Diamond & Lee, 2011).

The frequency and duration of the weekly sessions were adapted for the intervention with premature children. Each week, 2 hours and 30 minutes were invested in a single session (including a small 10-minute break) so that each level is composed of 4 sessions, with a total of 12 sessions. Some examples of activities included in the program are the following:

- "Orchestra": Its objectives are the coordination of actions and to train the control of motor behavior
- “Uses ": Flexibility, creativity, attention, and inhibition are trained.
- "The drawings speak": Creativity, inhibition, and self-control are trained.
- "Alternate Categories": Flexibility, change of criteria, working memory, and attention are trained.
- "Restless Tales": Flexibility, decision-making, and self-control of motor behavior are trained.
- "Mindfulness": The main objective is to achieve — through relaxation and attentional tasks involving sounds, objects, and movements — the training of attention and inhibition of behavior in the present moment.

2.3.2. Training program in curricular skills for the CIG. To control the effect of the presence of the therapist, this group received stimulation for general curricular skills, through computer and audiovisual resources. Examples of tasks were coloring numbers and letters, group reading of stories, as well as the viewing of different educational videos. The children of the CIG group received the same number of sessions, each of which had the same duration as the group that received the PEFEN program.

2.4. Procedure

The study was approved by the Research Ethics Committee of the Hospital Complex of Jaén (CHJ). Once the project had been approved, the facilities could be accessed and the CHJ databases searched to recruit the participants. Before beginning the study, all parents were informed of the research objectives and gave informed written consent. The participants were selected through the "Aurora" database, the hospital information system of the CHJ. This system allowed for filtering the children's clinical records, incorporating the inclusion and exclusion criteria employed in this investigation. After reviewing the medical records, we obtained the data of these children (birth-related variables) and their family, after which we proceeded to invite them by letter to voluntarily participate in the investigation. Telephone calls were then made to confirm receipt of the letter and to directly explain the procedure and objective of the investigation. At the first appointment, they were presented with the Informed Consent for their voluntary signature, and the neuropsychological pre-assessment of the child (BENCI and CUMANIN Battery) was conducted. At the same time, whilst in another room, the parents completed the socio-demographic interview, Childhood Healthy Habits Questionnaire, Cattell Test Factor "g", and BRIEF-P.

Once the individual neuropsychological pre-evaluation of each child was completed, the parents were required to choose between 4 intervention schedules for their child, selecting the one that was best suited to their timetables, without any prior knowledge of the group to which the schedule belonged. Using this procedure, the children were assigned to the neuropsychological intervention groups (NIG) or to the curricular intervention groups (CIG). After the interventions, the families were again called to conduct the individual neuropsychological post-evaluation of the children (BENCI, CUMANIN, and BRIEF-P).

Once the study was completed and data collected, the curricular intervention group received, in addition, the PEFEN Stimulation Program. Interested families were given an individualized report, which included the results obtained and relevant recommendations in each case.

2.5. Data analysis

A mixed factorial design was used with two independent variables: receiving the PEFEN Stimulation Program or not, which was a between-subject variable, and the time of evaluation (pre-post), which was the within-subject variable. Descriptive analyzes were conducted using means and standard deviations for the quantitative variables and frequencies for the qualitative variables. The differences between groups were analyzed using the t test (for independent samples and quantitative variables) and the chi-square test for qualitative variables.

To check the effectiveness of the program, the different variables evaluated were compared according to scores on the BENCI, CUMANIN, and BRIEF-P batteries. For the analysis, a general linear model of repeated measures(2x2) was used, with two levels for the between-group factor, depending on whether the participants had followed the PEFEN program: Neuropsychological Intervention Group (NIG), or had followed a curricular skills program: Curriculum Intervention Group (CIG); and two levels for the within-subjects factor, corresponding to the two times of the evaluation (Pre and Post intervention). Cohen's delta was used as a measure of the effect size of the different groups. The data were analyzed with the statistical package SPSS 17.

3. Results

3.1. Analysis of the BENCI Battery

When analyzing the results of the BENCI battery for the main effect of "time of evaluation" (changes in both groups between pre and post testing), we observed statistically significant differences in 13 of the 15 variables evaluated, including the subtests of: Verbal Comprehension (figures), Verbal Comprehension (images), Phonetic Fluidity, Semantic Fluidity, Working Memory, Verbal Memory (both in the first, third and delayed memory), Abstract Reasoning, Visual Memory (immediate, delayed, and recognition). These results appear to indicate that both groups improved between the pre - and post - tests (independently of the assigned intervention program), in most of the neuropsychological variables (see Table 2).

In the case of the interaction between time of the evaluation (pre-post) and group, this was found to be statistically significant for the Phonetic fluency subtest, F (1,66) = 4.77, p = .032 (with a particularly large effect size for the NIG, d= 1.36), and for the Delayed Visual Memory test, F (1,66) = 6.79, p = .011, d = 1.44. Marginally significant differences were found for the variables of Working Memory, F (1,66) = 3.60, p = .062, (again, with a large effect size for the NIG, d = 1.37), and for Delayed Verbal Memory, F (1, 66) = 3.83, p = .055, with a significant effect size in the NIG group (d = 1.30). These results indicate a greater increase in the scores of these four subtests for the NIG group. For the other factors, no statistically significant effects were found after exploring the interaction (see Table 2).

-----------------Insert Table 2 here-----------------

3.2. Analysis of the CUMANIN

For CUMANIN, statistically significant improvements were observed between pre and post testing for all the subtests evaluated (see Table 3). Similarly, we identified a statistically significant interaction between time of the evaluation (pre-post) and group for the Total Score, F (1, 66) = 4.96, p = .029, with a high effect size in the

NIGintervention group (d = 1.26); the Rhythm subtest, F (1,66) = 13.31, p = .001, d = .70; Verbal fluency, F (1,66) = 10.97, p = .002, d = 2.53; and a marginal effect for Attention, F (1,66) = 3.70, p = .059, d = .73. For the other factors, no statistically significant effects were found after exploring the interaction (see Table 3).

-----------------Insert Table 3 here-----------------

3.3. Analysis of the BRIEF-P (Parents)

Finally, the differences for the factors evaluated by the BRIEF-P were analyzed. We found statistically significant differences for the Inhibition factor, for the time of testing x group interaction, F (1,66) = 5.19, p = .026, and for the time of testing, F (1,66) = 5.18, p = .026. These results are due to a decrease in inhibition scores for the GIC group, while in the NIG group they remain stable following the intervention. For the remaining variables evaluated with the BRIEF-P battery, no statistically significant differences were found (see Table 4).

-----------------Insert Table 4 here-----------------

4. Discussion

The objective of this work was to apply and evaluate the effectiveness of a EF stimulation program (PEFEN Program) in a group of preterm children aged 4 and 5 years in comparison with a control group of premature children who did not receive such anintervention. The results reveal that children who had received the PEFEN program (NIG) showed improvements in their overall neuropsychological performance compared with those who had received the standard curricular program (CIG). In particular, positive changes were found in variables such as Verbal Comprehension (figures), Phonetic and Verbal Fluency, Working Memory, Visual Memory, Verbal Memory, Rhythm, and Attention. Regarding Continuous Performance, it should be noted that as the reaction time (RT) is slower, the number of correct responses(CR)increased in the NIG group following the intervention. Finally, the children in the NIG group maintained stable inhibition scores across the test phases. These results indicate that the PEFEN program generates neuropsychological benefits in the population studied.

The literature reports a whole series of interventions aimed at improving cognitive development in children with the goal of training basic cognitive processes at the beginning of school learning (Segretin et al., 2016), implemented in child populations with variousprofiles such as typical development (Diamond & Lee, 2011; Thorell et al., 2009), social vulnerability (Colombo &Lipina, 2005, Diamond et al., 2007; Hughes & Ensor, 2009) and clinical populations (Klingberg et al., 2005; McCandliss, Beck, Sandak , &Perfetti, 2003; Stevens, Fanning, Coch, Sanders, & Neville, 2008; Temple et al., 2003; Wilson, Revkin, Cohen, Cohen, &Dehaene, 2006).

Regardless of the characteristics of the indicated programs, there is a scarcity of data related to premature children or those of moderately low weight, as well as intervention programs focused on the improving EF in this population. In a study conducted in Spain with children with learning disabilities (Correa, Fernández-Alcántara, Pérez-García, Laynez-Rubio & Cruz-Quintana, 2017), improvements were reported in the performance of EF (specifically in the areas of cognitive flexibility and working memory) in a group of children with learning problems who participated in a stimulation program in EF compared with a control group without clinical problems. However, no differences were found in central variables such as attention. In the present study, the children in the NIG group showed significant changes in attentional aspects, which may be directly related to the inclusion of specific Mindfulness exercises in each of the intervention sessions. The inclusion of a specific module focused on Mindfulness is one of the most innovative features of the PEFEN program. Despite the fact that scientific evidence suggests an improvement in executive functioning when this technique is used in childhood (Nadler, Cordy, Stengel, Segal & Hayden, 2017), specific modules of Mindfulness are not found in other programs applied to both typical child population and populations with clinical problems other than prematurity.

In addition to the improvements in neuropsychological variables related to EF, children who received the PEFEN Program showed stable scores in the inhibition dimension, which could be taken to indicate that the program also has a preventive effect in premature children, promoting self-control and regulatory skills, which can be altered in adolescence (García-Bermúdez et al., 2012). In this regard, the results obtained in this study are encouraging insofar as they provide specific information on the Spanish population of premature children, showing how the PEFEN program is effective as an intervention for EF in the studied risk population.

Similarly, the results reveal an effect of the time of testing in most of the variables evaluated. This seems to indicate better neuropsychological performance over the passage of time, which is consistent with the age of the children of the present study, who are in a critical period in the development of the various neuropsychological domains (Matthew et al. al., 2006; Miyake et al., 2000). Despite this pattern of results, the differences in the interactions between the time of evaluation and group seem to indicate that the PEFEN program promotes improvements in the different domains studied. This is of great relevance, since previous research has indicated how prematurity is a risk factor for presenting neuropsychological and cognitive alterations that interfere in the performance of those capacities necessary for learning, such as language and memory (Aarnoudse-Moens et al., 2009; Barre, Morgan, Doyle & Anderson, 2011, Figueras & Bosch-Galceran, 2010, Lezak, 2004, Maggiolo, Varela, Arancibia & Ruíz, 2014, Narberhaus et al., 2007). In relation to EF in particular, the lack of information has already been pointed out with regard to premature children, particularly at early ages (García-Bermúdez et al., 2012), although problems have been reported in functions such as planning, inhibition, interference (Sartre-Riba, 2009), working memory, and flexibility (Aarnoudse-Moens et al., 2009).

The results of the present investigation have important clinical implications. While there is little information about EF in premature children, this is practically non-existent in relation to the effects of intervention programs. There is evidently a need to initiate not only follow-up programs but also intervention programs that cover the ages of 5 to 8 years. This age range is critical for the acquisition of reading, writing, and mathematical reasoning, areas in which premature children appear to show significant academic problems. In this regard, numerous studies report the relationship between EF and school performance, with working memory being one of the most studied capacities due to its relationship with the learning of subjects such as language, reading and writing, mathematics, and science (Arán-Filippetti & Richaud de Minzi, 2011). The findings of this research could be useful both in the school environment for improving the development and learning of children, and also in the clinical context for preventing the possible negative patterns of development in certain risk populations.

4.1. Limitations and future directions

However, this study suffers from a series of limitations. First, the number of participants is low. Therefore, measures of the size of the effect have been included, which allow us to verify the effects of the program without depending on group size. Secondly, the study has focused on a very specific clinical population (late preterm infants), and so we should be cautious when extrapolating these results to other areas and clinical populations (very preterm children and non-premature children). Thirdly, studies of a longitudinal nature are necessary to verify whether the long-term effects of the program are maintained.

4.2. Conclusion

In conclusion, the EF Stimulation Program (PEFEN) has shown to be an effective and versatile program of intervention for improving the development of executive functioning in children born prematurely. The group of premature children who received the PEFEN showed significant improvements in Verbal Comprehension (figures), Phonetic Fluency, Verbal Fluency, Working Memory, Visual Memory, Verbal Memory, Rhythm and Attention.

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Table 1. Mean, standard deviation, and analysis of the differences between the neuropsychological intervention group and the curricular intervention group in sociodemographic, clinical, habits and test variables of Cattell

Clinical and sociodemographic variables		**Group NIG N= 36**		**Group CIG N=32**		
		M o N	SD o %	M o N	SD o %	*t o χ²*	*p*
Age of child (Months)		61.01	7.17	59.21	5.21	1.06	.291
Sex of child						1.99	.158
	Boy	13	36.1%	17	53.1%		
	Girl	23	63.9%	15	46.9%		
Weight of child (Kg)		18.04	2.71	17.65	2.75	0.588	.559
Type of birth						2.20	.333
	Natural	15	41.7%	19	59.4%		
	Cesarean	17	47.2%	10	31.3%		
	Use of forceps	4	11.1%	3	9.4%		
Gestation period (Weeks)		35.18	1.51	34.73	1.84	1.09	.280
School adaptation						.89	.345
	Good	21	58.3%	15	46.9%		
	Poor	15	41.7%	17	53.1%		
Chronic illness						.05	.822
	Yes	6	16.7%	6	18.8%		
	No	30	83.3%	26	81.3%		
Special diet						.01	.903
	Yes	2	5.6%	2	6.3%		
	No	34	94.4%	30	93.8%		
Continuous medication						.30	.584
	Yes	4	11.1%	5	15.6%		
	No	32	88.9%	27	84.4%		
Child's hours of sleep		10.50	1.05	10.59	1.01	-.373	.711
Mother smokes						1.10	.294
	Yes	8	22.2%	4	12.5%		
	No	28	77.8%	28	87.5%		
Mother's age (years)		38.917	39.00	4.581	4.846	-.073	.942
Mother's age at pregnancy (years)		33.750	4.305	33.719	4.034	.031	.976
Socioeconomic status						1.92	.382
	Low	0	0%	1	3.1%		
	Medium	17	47.2%	18	56.3%		
	High	19	52.8%	13	40.6%		
Mother's level of education						5.55	.136
	Primary	4	11.1%	10	31.3%		
	Secondary Education/Professional Training	8	22.2%	6	18.8%		
	University	15	41.7%	7	21.9%		
	Doctorate	9	25%	9	28.1%		
Cattell scores of the mother(DS)		28.417	4.285	28.531	3.408	-.121	.904

Note. NIG = Neuropsychological (PEFEN) Intervention Group; CIG = Curriculum Intervention Group, M = Mean, SD = Standard deviation, DS = Direct Score.

Table 2. Means, standard deviations, effect size and analysis of the differences for the BENCI factors.

BENCI variables	Group	Pre		Post		*d*		*F*	*p*
		M	SD	M	SD				
Figure comprehension (Verbal)	NIG	7.86	1.69	8.53	1.59	0.40	Time	8.90	.004**
	CIG	7.91	1.35	8.69	1.09	0.63	Group	.15	.695
							TimeXGroup	.06	.814
Image comprehension (Verbal)	NIG	7.67	2.18	7.89	1.19	0.13	Time	6.03	.017*
	CIG	7.66	0.83	8.62	1.01	1.06	Group	2.15	.157
							TimeXGroup	2.37	.129
Continuous execution	NIG	60.22	7.53	65.14	5.13	0.77	Time	2.55	.115
	CIG	61.09	9.31	60.75	8.63	0.03	Group	1.89	.174
							TimeXGroup	3.37	.071
Continuous execution (TR)	NIG	1.03	0.15	0.96	0.29	0.37	Time	2.33	.131
	CIG	0.97	0.12	0.92	0.35	0.23	Group	1.41	.240
							TimeXGroup	.09	.765
Phonetic fluidity	NIG	1.31	1.49	3.72	2.06	1.36	Time	47.16	<.001***
	CIG	1.12	1.38	2.37	1.54	0.85	Group	6.51	.013*
							TimeXGroup	4.77	.032*
Semantic fluidity	NIG	5.14	2.56	7.72	2.47	1.03	Time	30.13	< .001***
	CIG	5.44	2.33	6.94	2.17	0.66	Group	.29	.589
							TimeXGroup	2.12	.150
Working memory	NIG	4.72	3.13	11.14	6.23	1.37	Time	40.46	< .001***
	CIG	4.56	1.85	8.03	5.35	0.96	Group	4.43	.039*
							TimeXGroup	3.60	.062*
Verbal memory (1st test)	NIG	2.03	1.58	3.97	1.34	1.45	Time	67.39	< .001***
	CIG	1.97	1.66	4.22	1.62	1.37	Group	.11	.735
							TimeXGroup	.36	.552
Verbal Memory (3rd test)	NIG	4,528	2.06	5.33	2.10	0.39	Time	6.63	.012*
	CIG	3.72	2.16	4.94	2.01	0.97	Group	3.56	.063
							TimeXGroup	.28	.601
Verbal Memory (Delayed)	NIG	2.47	1.87	5.08	2.16	1.30	Time	39.83	< .001***
	CIG	2.91	2.07	4.28	2.29	0.36	Group	0.21	.647
							TimeXGroup	3.83	.055*
Verbal memory (Recognition)	NIG	12.75	3.11	13.72	4	0.27	Time	4.51	.037*
	CIG	13.47	3.02	14.94	3.26	0.46	Group	2.70	.105
							TimeXGroup	.19	.667
Abstract reasoning	NIG	7.75	2.90	10	4.50	0.60	Time	19.95	< .001***
	CIG	7.37	2.88	11.47	5.54	0.97	Group	.62	.435
							TimeXGroup	1.68	.199
Visual memory (immediate)	NIG	3.64	1.97	5.44	2.06	0.90	Time	24.41	< .001***
	CIG	3.12	1.83	4.78	2.14	0.83	Group	3.03	.086

							TimeXGroup	.04	.832
Visual memory (Delayed)	NIG	2.36	1.93	4.89	1.58	1.44	Time	34.18	< .001***
	CIG	2.06	1.88	3.03	1.89	0.51	Group	10.89	.002**
							TimeXGroup	6.79	.011*
Visual memory (recognition)	NIG	38.53	9.21	41.78	6.85	0.40	Time	10.14	.002**
	CIG	38.31	8.42	43.41	4.81	0.77	Group	.30	.584
							TimeXGroup	.49	.484

*Note: * p< .05, ** p<. 01, *** p < .001d*= mild (0.2), moderate (0.5) & large (0.8)

Table 3. Means, standard deviations, effect size, and analysis of the differences for the CUMANIN factors

Variables CUMANIN	**Group**	**Pre**		**Post**		*d*		*F*	*p*
		M	DT	M	DT				
Psychomotricity	NIG	8.11	2.12	8.28	1.89	0.08	Time	5. 69	.020*
	CIG	7.09	2.08	8.19	2.10	0.52	Group	1.72	.194
							TimeXGroup	3.08	.084
Language Articulation	NIG	8.69	3.70	10.69	3.41	0.56	Time	64.73	< .001***
	CIG	7.75	4.26	10.37	3.86	0.64	Group	.52	.474
							TimeXGroup	1.18	.281
Language expression	NIG	2.14	1.22	2.78	1.10	0.55	Time	19.56	< .001***
	CIG	2.09	1.25	2.62	1.10	0.45	Group	.15	.695
							TimeXGroup	.176	.685
Language comprehension	NIG	4.06	2.18	5.33	1.85	0.63	Time	31.74	< .001***
	CIG	3.62	1.84	4.81	2.08	0.60	Group	1.21	.276
							TimeXGroup	.22	.837
Spatial structure	NIG	8.69	2.24	11	2.23	1.03	Time	41.06	< .001***
	CIG	8.56	2.14	10	2.51	0.61	Group	1.44	.234
							TimeXGroup	2.21	.142
Visuoperception	NIG	7.67	3.73	10.36	3.91	0.70	Time	74.44	< .001***
	CIG	7.56	2.47	9.66	2.39	0.86	Group	.30	.585
							TimeXGroup	1.17	.283
Memory	NIG	4.17	1.65	5.75	1.71	0.94	Time	7.95	< .001***
	CIG	4.37	1.79	5.34	2.25	0.47	Group	.09	.769
							TimeXGroup	1.04	.311
Rhythm	NIG	2.33	1.55	3.36	1.38	0.70	Time	9.23	.003**
	CIG	2.41	1.48	2.31	1.47	0.06	Group	2.29	.135
							TimeXGroup	13.31	.001*
Verbal fluidity	NIG	0.10	1.38	3.42	1.25	2.53	Time	85.72	< .001***
	CIG	0.62	1.24	1.78	1.64	0.80	Group	13.07	.001**
							TimeXGroup	10.97	.002**
Attention	NIG	13.28	3.92	15.97	3.46	0.73	Time	15.80	.001**
	CIG	10.78	4.43	11.72	3.52	0.23	Group	17.15	< .001***
							TimeXGroup	3.70	.059
Total EF	NIG	59.72	14.31	76.97	12.98	1.26	Time	220.45	< .001***
	CIG	54.06	11.48	66.81	12.60	1.01	Group	7.07	.010*
							TimeXGroup	4.96	.029*

*Nota: * p<.05, ** p<. 01, *** p < .001, d=* mild (0.2), moderate (0.5) & large (0.8)

Table 4. Means, standard deviations, effect size, and analysis of the differences for the BRIEF-P factors.

BRIEF-P Variables	**Group**	**Pre**		**Post**		*d*		*F*	*p*
		M	*SD*	*M*	*SD*				
Inhibition	NIG	9.19	6.62	9.19	6.29	0.00	Time	5.18	.026*
	CIG	11.37	5.87	8.91	6.51	0.39	Group	.43	.514
							TimeXGroup	5.19	.026*
Flexibility	NIG	2.89	3.39	2.61	2.22	0.09	Time	3.07	.085
	CIG	4.31	3.37	3.31	3.05	0.31	Group	2.75	.102
							TimeXGroup	.98	.326
Emotional control	NIG	4.92	4.32	4.80	3.88	0.02	Time	1.76	.190
	CIG	5.72	4.57	4.84	3.38	0.22	Group	.21	.648
							TimeXGroup	1.05	.308
Working memory	NIG	8.55	6.49	8.58	7.14	0.00	Time	.95	.332
	CIG	9.53	5.46	8.56	6	0.17	Group	.11	.745
							TimeXGroup	1.07	.305
Planning	NIG	5.58	3.33	5.30	4.12	0.07	Time	.49	.486
	CIG	5.87	3.60	5.69	3.48	0.05	Group	.17	.684
							TimeXGroup	1.07	.305
Coherence	NIG	3.42	3.51	3.53	2.96	0.03	Time	.42	.518
	CIG	3.31	2.43	2.81	2.52	0.20	Group	.41	.525
							TimeXGroup	1.05	.310

*Note: * p< .05, ** p<. 01, *** p < .001, d*= mild (0.2), moderate (0.5) &large (0.8)