



**Fundació**

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Diabetes and Obesity



## **EXECUTIVE FUNCTION TRAINING IN CHILDHOOD OBESITY: FOOD CHOICE, QUALITY OF LIFE AND BRAIN CONNECTIVITY (TOuCH)**

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## 1. Abstract

Obesity in childhood and adolescence is related to medical and psychological consequences as well as a higher risk of other comorbidities in adulthood and even with an earlier death. Guidelines for treatment have established the need to focus on reducing the caloric intake, increasing physical activity, modifying behaviour, including parents and family members as an active part of the treatment, including parental training, and enhancing motivation and intention to make behavioural and dietary changes.

Due to the limited success of long-term interventions there is a need to develop new strategies for treatment. In particular, the maintenance of weight loss is one of the main challenges nowadays. In fact, treatments very rarely result in long-lasting effects. In children with obesity, behavioural treatment only leads to small changes in relative weight and there are frequent relapses. One of the main factors that influence overweight might be decision-making. Obesity has been characterized by poor decision-making together with other executive function deficits (such as impulsivity or inhibition deficits, for instance, towards food intake). Based on the limited success of behavioural treatments and taking into account the current literature relating executive function deficits and obesity, it might be that improving executive deficits would contribute to increase the results obtained by obesity treatments.

Children with obesity very frequently present, together with executive dysfunction, poor self-esteem, social isolation and even a greatest risk of suffering from anxiety or depression. In adolescents and adults with obesity, it has been proposed that training executive functions might improve quality of life and anxiety symptoms.

The main purpose of this study was to evaluate the impact of executive function training in children with obesity in food choice, cognition and brain imaging; as well as in their emotional state and quality of life.

The design is a randomized controlled double-blind trial with cognitive training and cross-sectional and longitudinal assessments. Participants were children with obesity and ages between 9 and 12 years. Inclusion criteria were having obesity (z scores of body mass index (BMI) above percentile 95 for age and gender) and exclusion criteria were having neurodevelopmental, neurologic or psychiatric disorders. Participants were

followed at two hospitals: Consorci Sanitari de Terrassa (CST) and Hospital Sant Joan de Déu (SJD).

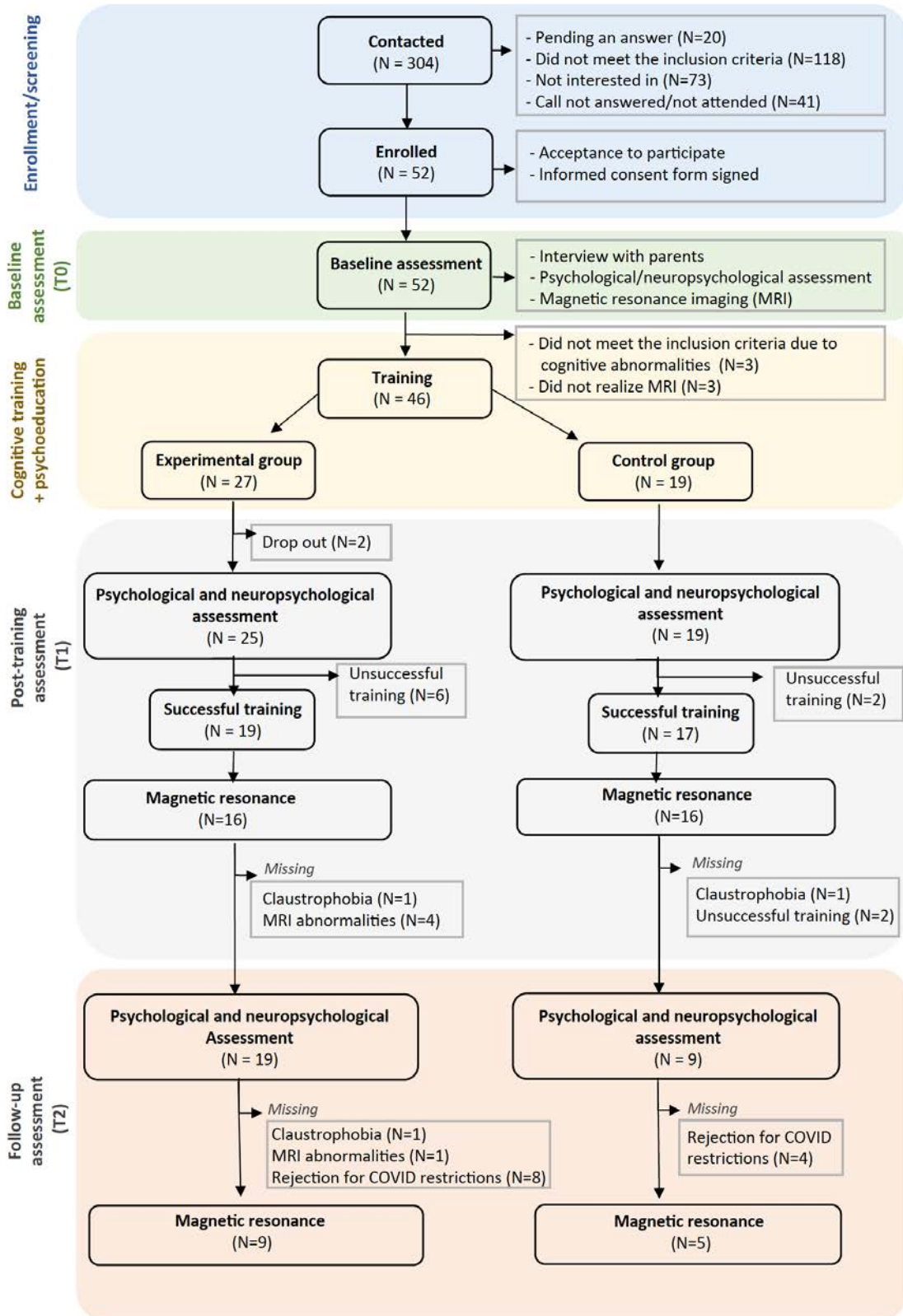
The intervention was threefold:

a) Cognitive training in executive functions. After informing families and patients and obtaining the informed consent, participants were randomly assigned to "executive functions training" (by Cogmed and Cognifit) or to the "control training group" (Cognifit). Cognitive training consisted of a working memory and executive function training of increasing difficulty. Control training was designed by the same software (Cognifit) but without increasing difficulty.

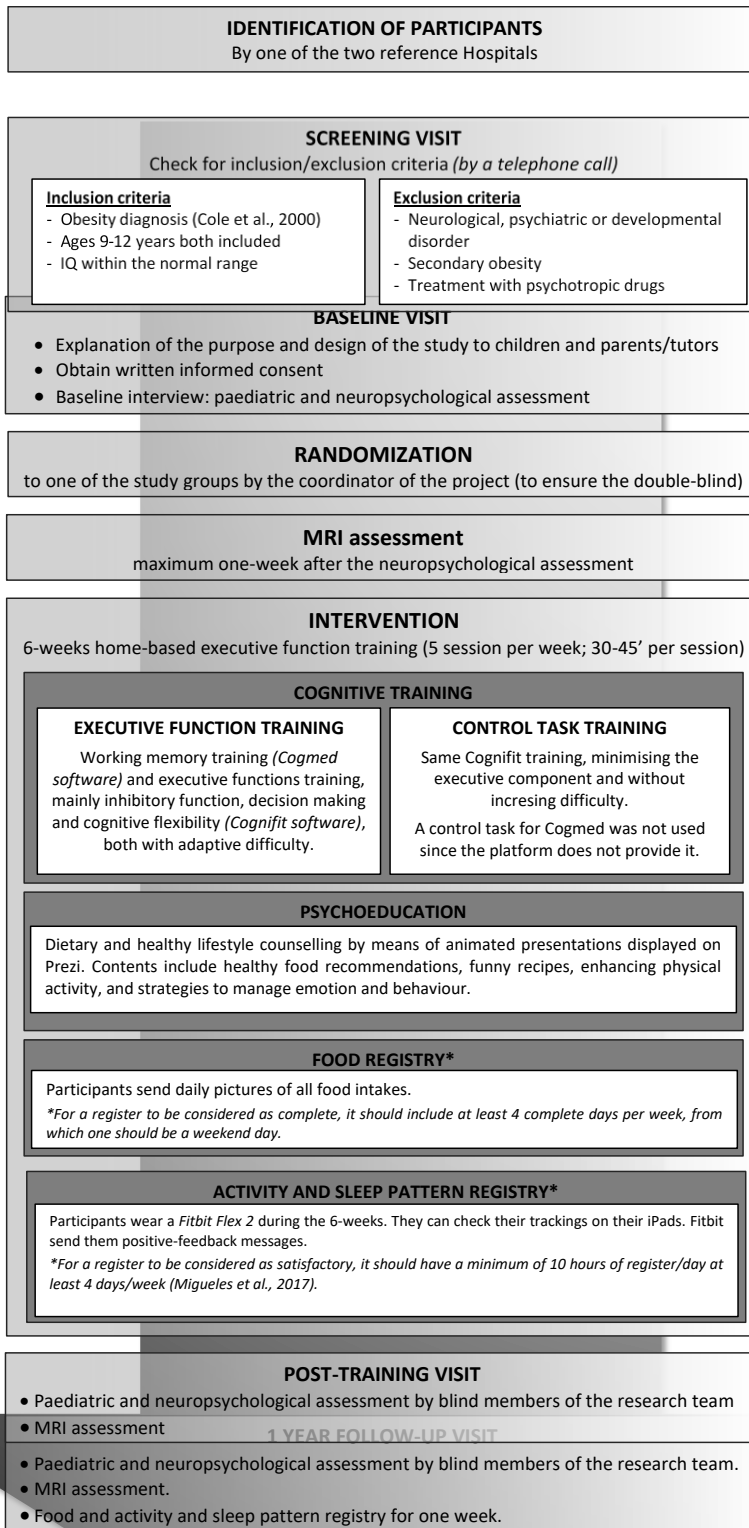
The rest of the procedure was the same for all participants, independently of the group:

b) Psychoeducation and nutritional counselling. Participants receive 30 blocs of information of lifestyle and healthy habits throughout the treatment period, consistent of a brief animated presentation with daily tips.

c) Activity and sleep pattern registry. Throughout the treatment period participants recorded their physical activity and sleep hours by means of a Fitbit Flex 2 tracker. They could visualize their records in their iPads by synchronizing the tracker, while they received feedback if they achieved daily goals.



**Figure 1.** Flow diagram of study recruitment



**Figure 2.** Diagram of the study protocol methods

## 2. Results

Table 1 shows the distribution of the groups at baseline.

	Experimental group			Control group			Group comparison	
	N	Mean	SD	N	Mean	SD	T/U	Sig.
Age (years)	19	10.32	1.108	17	10.65	.93	130.500	.302
BMI (percentile)	19	98.63	.83	17	98.52	.76	-.437	.665
Physical activity (hours)	19	2.72	1.81	17	3.21	4.38	147.500	.652
Visual IQ (scalar score)	19	10.68	2.31	17	10.35	2.15	135.500	.403
Verbal IQ (scalar score)	19	11.42	2.80	17	10.76	2.25	-.770	.447
Motivation for treatment	19	6.31	.749	16	6.63	.719	114.000	.217
	<b>N</b>			<b>N</b>			<b>X<sup>2</sup></b>	<b>Sig.</b>
Sex (F:M)	5:14			8:9			1.673	.196
Handedness (R:L)	18:1			15:2			-	.593 <sup>+</sup>
Economic income (I:II:III:IV:V)	6:7:1:2:1			3:3:4:4:0			5.485	.219 <sup>++</sup>
Hospital (CST:SJD)	14:5			12:5			.043	.836

BMI: body mass index, IQ: intelligence quotient, F: female, M: male, R: right, L: left.

In the baseline/after-training comparison, BMI and waist circumference decrease over time in both groups. Likewise, post hoc analysis of cognitive subdomains revealed significant changes over time in attention and processing speed, working memory, cognitive flexibility, and inhibitory control and planning. These improvements did not differ significantly between groups except in the case of working memory, for which the experimental group had a better accomplishment. After a Bonferroni correction, improvements in attention and speech remained significant, as well as in cognitive flexibility and inhibitory control. Regarding food choice, the results obtained in the Kidmed questionnaire did not show changes in dietary habits after treatment. The administered scales showed a significant improvement in executive function as perceived by the family in quality of life, self-esteem and psychological symptoms taking all children together, even if there were no significant differences between groups.

Furthermore, we performed an intention-to-treat analysis (ITT). From the total of 46 participants initially assigned to the experimental (n=27) or control group (n=19), 36 completed the training satisfactorily ( $\geq 75\%$  of the sessions completed), which supposed a global adherence of 78.3%. Considering group allocation, the experimental group showed 70.3% adherence and the control group 89.17%. These differences were

not statistically significant. Independently of the group, the baseline characteristics of the participants that completed the study and the ones that did not differed in some aspects. The participants who completed the study had higher levels of physical activity, higher intelligence quotient (IQ) and higher treatment motivation. Considering the data of the 26 participants taking part in the longitudinal study at 1-year follow-up (which coincided with the COVID-19 pandemic), the reduction of the BMI and waist circumference observed after treatment was not maintained. Indeed, there was a worsening of anthropometric measures at follow-up.

**Table 2.** Characteristics of the sample participating on the follow up.

	N	Baseline (T0) Mean (DS)	Post-treatment (T1) Mean (DS)	Follow-up (T2) Mean (DS)	Group comparison			
					T0 vs. T1		T1 vs. T2	
					<i>t</i> <sup>†</sup>	Sig.	<i>t</i> <sup>†</sup>	Sig.
Weight (Kg)	26	65.41 (11.22)	64.94 (10.70)	73.20 (12.81)	1.277	.213	8.696	<b>.000</b>
BMI	26	28.65 (3)	28.11 (2.68)	29.89 (3.82)	3.264	<b>.003</b>	3.835	<b>.001</b>
WC	26	90.51 (10.26)	88.82 (9)	94.46 (11.05)	2.313	<b>.029</b>	5.534	<b>.000</b>

WC: waist circumference

### 3. Relevance of the results and future implications

When designing a treatment for childhood obesity, it is mandatory to take into account several variables and provide support and psychological follow-up. In this framework, training in cognitive functions may have a relevant role, together with psychoeducation and self-consciousness of food intake and physical activity. The children participating in this project improved in psychological variables (self- and heteroperceived), such as self-esteem, quality of life, executive function and psychological symptoms. The final sample was not very large, for which reason it is hard to elucidate the relative weight of the different outcomes on the final improvement. Future studies should consider collecting larger samples in order to answer these questions. However, by carrying out this project we have shown that including cognitive training in the current treatments for obesity in children is feasible and also positive.

#### 4. Scientific outcomes

Registry of the Clinical Protocol at ClinicalTrials.gov 3 August 2018 (register No. NCT03615274).

##### **Publication**

Luis-Ruiz S, Caldú X, Sánchez-Castañeda C, Pueyo R, Garolera M, Jurado MA. Is cognitive training an effective tool for improving cognitive function and real-life behaviour in healthy children and adolescents? A systematic review. *Neurosci Biobehav Rev.* 2020 Sep;116:268-282. **IF:** 8,330. **Quartile:** Q1, first decile. **doi:** 10.1016/j.neubiorev.2020.06.019

##### **Publication**

Sanchez-Castañeda C, Luis-Ruiz S, Ramon-Krauel M, Lerin C, Sanchez C, Miro N, Martinez S, Garolera M, Jurado MA. Executive Function Training in Childhood Obesity: Food Choice, Quality of Life and Brain Connectivity (TOuCH): a Randomized Control Trial Protocol. *Frontiers in Pediatrics* 24 February 2021. **IF:** 2,634. **Quartile:** Q1. **doi:** 10.3389/fped.2021.551869

##### **Publication**

Luis-Ruiz S, Sánchez-Castañeda C, Miserachs-González S, Ramón-Krauel M, Lerin C, Sanchez C, Miró N, Martínez S, Garolera M, Jurado MA. Influence of Cognitive Training on BMI, food choice and cognition in children with obesity: Results from the TOuCH study. *Under review.*

##### **Publication**

Sanchez-Castañeda C, Luis-Ruiz S, Ramon-Krauel M, Lerin C, Sanchez C, Miro N, Martinez S, Garolera M, Jurado MA. Cerebral connectivity changes after an executive function training in children with obesity. *In preparation.*

##### **Congress presentations**

Luis-Ruiz, S., Matés, I., Sánchez-Castañeda, C., Ottino-González, J., Prats-Soteras, X. Jurado, M.A. (2018). Cognitive training as a potential treatment: Could it be applied in overweight and obesity? 72<sup>a</sup> Reunió de Primavera de la Societat Catalana de Neuropsicologia, 29<sup>th</sup> June 2018, Barcelona, Spain.



Luis-Ruiz, S., Sánchez-Castañeda, C., Miserachs-González, S., Ottino-González, J., Prats-Soteras, X. et al. (2019). Executive function training as intervention for childhood obesity: Preliminary results. 7th Meeting of the Federation of the European Societies of Neuropsychology (FESN), 5th-7th September 2019, Milan, Italy.

Luis-Ruiz, S., Sánchez-Castañeda, C., Miserachs-González, S., Ottino-González, J., Prats-Soteras, X. et al. (2019). Executive function training as intervention to childhood obesity: Preliminary results. IV Annual PhD Workshop of Institute of Neuroscience, 29<sup>th</sup> November 2019, Barcelona, Spain.

Miserachs-González, S., Luis-Ruiz, S., Sánchez-Castañeda, C., Prats-Soteras, X., Ottino-González, J. et al. (2020). Executive function training in children with obesity: BMI and quality of life. XII Congreso Nacional de Neuropsicología, 5-7<sup>th</sup> March 2020, Sevilla, Spain.

### **Academic production**

#### PhD Thesis:

**Student:** Sandra Luis Ruiz

**Title:** Disfunció executiva en obesitat infantil: correlats anatomofuncionals

**PhD program:** PHD program Psicologia clínica UB (28/09/2018)

**Thesis dissertation estimation date:** 2021.

#### Master's degree thesis (TFM):

**Student:** Sandra Luis Ruiz

**Title:** Is cognitive training an effective tool for improving cognitive function and real-life behavior in healthy children and adolescents? A systematic review

**MsC program:** Màster Universitari Psicòleg General Sanitari

**Presentation date:** June 2018

#### Graduate degree thesis (TFG):

**Student:** Sara Miserachs González

**Title:** Entrenament de funcions executives en obesitat infantil: Cognició, qualitat de vida i dieta

**Presentation date:** January 2020