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Technology-based parenting interventions for children's physical and psychological health: a systematic review and meta-analysis

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Review Article

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Abstract

Background. Parenting interventions have important consequences for the wellbeing and emotional competences of parents and their children. Technology provides an opportunity with advantages for psychological intervention. The aim of this systematic review and meta-analysis is to analyze the characteristics and effectiveness of technology-based interventions for parents to promote children's physical health or psychological issues.

Methods. We conducted a systematic review and meta-analysis for articles about parenting skills for prevention or treatment of children's physical or psychological concerns using technology. We explore the aim of the intervention with parents, kind of problem with children, intervention model, instruments, methodological quality, and risk of bias. A random-effects meta-analysis was conducted.

Results. Twenty-four studies were included in the systematic review and a meta-analysis of 22 studies was performed to find out the effects of intervention depending on the kind of problem, intervention model, follow-up, type of intervention, type of control condition, and type of outcome data. Results show the usefulness of technology-based therapy for parenting interventions with moderate effect sizes for intervention groups with statistically significant differences from control groups.

Conclusions. Technology-based parenting programs have positive effects on parenting and emotional wellbeing of parents and children. Attendance and participation level in technology-based treatment increase compared with traditional parenting intervention.

Background

Parenting intervention has two consequences, one to parents' own wellbeing, and the other, to their children's behavior (Patterson *et al.*, 2004; Beauchaine *et al.*, 2005; Robles and Romero, 2011). At the same time, there is considerable evidence from the research that parenting competences and style may be either protection or risk factors for the development and maintenance of psychological disorders in childhood and adolescence (Gómez *et al.*, 2005). This point has been studied in parenting self-efficacy as a predictor of child psychological adjustment, where direct and indirect relationships were found with development of children and adolescent self-efficacy, academic performance, and other abilities (Jones and Prinz, 2005). Likewise, in health psychology, the beliefs, values, and attitudes of parents present in the original diagnosis may be transferred to their child, who could acquire dysfunctional coping strategies (Lindahl Norberg *et al.*, 2011; Whittingham, 2014).

Thus, parenting intervention can have an important role in the emotional and general wellbeing of both parents and their children. A review by Kaminski *et al.* (2008) analyzing the treatment components with the greatest effects on parenting intervention found that training in positive interaction skills between parents and children has effects on both parenting skills and externalizing problems in children. On the other hand, emotional communication skills have positive effects on parenting skills. Eccleston *et al.* (2015) in an analysis of the efficacy of parenting and adolescents' intervention with chronic illnesses found positive effects on the mental health of parents of children with cancer. Some improvements were found in medical symptomatology in children with diabetes and chronic pain. Those changes are observed mainly in cognitive-behavioral therapy (CBT) which has reduced symptoms in children with chronic medical conditions, as well as improving parents' problem-solving strategies and mental health.

Furthermore, concerning psychological issues, a review by McConachie and Diggle (2007) analyzing the effects of parenting intervention in parents of children with autism spectrum disorder (ASD) found that parenting intervention can improve communication skills, parent–child interaction, parenting style, and parents' depressive symptoms. A review by Barlow *et al.* (2010) analyzed parenting-based group intervention for improving emotional

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and behavioral problems in children under 3 years of age. However, few studies were included in these reviews, and while changes are observed in external reports of children's psychological and emotional adjustment, they are not in the parents' self-report.

Despite the promising results of such intervention, therapists and professionals have usually had trouble setting up parenting interventions, more so when the children have medical or psychological concerns. Attendance at these intervention programs is only 35–50% of sessions, and one out of three who agree to participate never go at all (Heinrichs *et al.*, 2005; Lozano-Rodríguez and Valero-Aguayo, 2017). Although in a review by Eccleston *et al.* (2015) 82% of parents of children with chronic diseases complete the interventions.

Technology-based interventions therefore can offer an opportunity to facilitate parenting treatment with some advantages. For example, treatments with virtual scenarios or stimuli provide a safe intervention context, in which contextual key elements more effective than imaginary strategies are under the therapist's control. Web-based intervention can cross geographical and time barriers making access to intervention possible for patients who were unable to attend before (Wiederhold and Wiederhold, 2006; Riva, 2009; Vilardaga *et al.*, 2014). Furthermore, using mobile devices for treatments (smartphone, tablet, wearable technologies, etc.) provides the opportunity to assess patients' behavior in real-time and in their natural context, that is Ecological Momentary Assessment (EMA; Shiffman *et al.*, 2008) which enables antecedents to be analyzed, and motivates and improves generalized intervention (Wenze and Miller, 2010; Roth *et al.*, 2014; Vilardaga *et al.*, 2014). Another contribution is Ecological Momentary Intervention (EMI; Heron and Smyth, 2010), which enables access to psychological intervention in patients' daily lives, also in real-time and in their own natural environments.

In a review by Morawska *et al.* (2015), a series of recommendations for the design and implementation of parental interventions in chronic diseases are indicated. First, these interventions must be designed in line with an appropriate medical management of the disease and carried out in the context of the child. Second, interventions must be brief and efficient. Third, it needs to be adaptable to a variety of chronic diseases, taking into account common needs and difficulties. Finally, the intervention must be flexible to changes and circumstances. According to these recommendations, the technology-based interventions can provide several benefits for these points. First, technology-based interventions must have scientific and professional support; in addition, it allows interventions in natural contexts, facilitating the generalization and the ecology of the intervention. Second, technology-based interventions are not time limited; it can be adapted to the needs and restrictions of the patient. Third, technology-based interventions can take into account these common difficulties or transdiagnostic processes, and can also be adapted to the specific needs of the disease from a series of software configurations or algorithms. Finally, technology-based interventions can be flexible and customized according to family circumstances.

Among the technologies used for psychological and health interventions, we found Virtual Reality (VR), that is, the use of virtual scenarios in which the subject interacting with stimuli to implement the treatment. For example, in a study by Nilsson *et al.* (2009), the effect of VR as a distraction of pain in children and adolescents with cancer was analyzed, showing positive effects in pain reduction. Online and web-based intervention is defined as administration of treatment components from a distance, by means of a self-applied or guided web page, videoconferencing, etc. For example, a web-based intervention for young people with eating disorder symptoms was effective in reducing eating symptoms and comorbid psychopathology (Aardoom *et al.*, 2016). Finally, the use of software for implementing psychological interventions has also been developed as mobile device applications (Apps), that is, mHealth. An example of the use of this technology was the monitoring of mood, stress, and coping strategies at different times of the day through a mobile application to promote emotional awareness in adolescents, which showed effects on depression symptoms (Kauer *et al.*, 2012).

Although reviews on technology-based interventions have focused mainly on adults (Spek *et al.*, 2007; Cuijpers *et al.*, 2009), a review by Nieuwboer *et al.* (2013) exploring online-based parenting training found improvement in attitudes, parenting knowledge, and parenting abilities, as well as behavioral and attitudinal improvement in children. In adolescent mental health disorders, like depression, anxiety, or post-traumatic stress disorder, adolescent and family-based interventions have improved children's behavior problems, depressive–anxiety symptoms, and parenting practices (Hollis *et al.*, 2017; MacDonell and Prinz, 2017).

To our knowledge, there is no published systematic review or meta-analysis of technology-based parenting intervention in physical or psychological health. Thus, the present study aimed to provide a systematic review and meta-analysis of the efficacy of preventive and treatment parenting interventions using technology (Internet, VR, smartphone or other mobile devices) for parents to promote children's physical health (like cancer, chronic pain, etc.) or psychological issues [like attention-deficit hyperactivity disorder (ADHD), ASD, etc.], as well as, to explore the maintenance of the effects of the intervention at follow-up. This study described the sample and treatment characteristics, and the assessment instruments used. The efficacy of the interventions was analyzed according to the treatment model (e.g. CBT *v.* psychoeducational), the type of intervention (e.g. preventive *v.* indicated), the type of population (e.g. physical health *v.* psychological issues), type of control condition (e.g. waiting list *v.* alternative treatment), and type of outcome (e.g. self-efficacy *v.* parental knowledge). The methodological quality of the studies was also analyzed.

Method

Data search and extraction strategy

Information sources and search strategy

The PsycInfo, Scopus, PubMed, PsyArticles, and ProQuest electronic databases were searched systematically. There was no time limit (up to August 2017). The following search terms were used in English: parent* OR famil* in combination with 'intervention' and 'internet', 'virtual reality', 'web', 'app', 'mobile', and 'online'. See online Supplementary Appendix A for the search strategy.

Eligibility and selection of studies

This systematic review and meta-analysis was conducted in accordance with the PRISMA (Moher *et al.*, 2009) recommendations. The PICOS strategy (Participants, Intervention, Comparison, Outcome, Studies) was used to define the research question with clear inclusion criteria. This review included studies that are applied: (P) to parents (including biological parents, guardians, foster parents,

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but not to other relatives such as grandparents, uncles, etc.), (I) who receive preventive or treatment interventions (National Research Council and Institute of Medicine, 2009) for the improvement of parenting skills or psychological problems of parents (e.g. parental styles, parental stress, parent–child interactions, etc.), with the aim of promoting physical health (e.g. feeding, health care) or psychological issues (e.g. behavior management, neurodevelopmental disorders, etc.) of their children under 18 years of age. This intervention used technology in at least one of the components, among which it is included; Internet, mobile devices, VR, video, podcast, or audio, etc., in a self-delivered or guided by a therapist format. (C) Compared with a control group, either waiting list, active control, treatment-as-usual condition, or other. In order to assess its effects (O) on parenting style (e.g. parenting self-efficacy, parental knowledge, parenting interaction, etc.) when it was the primary outcome. If not, the outcome that intervention aimed to achieve, consisting of the parenting style measured or the purpose of intervention in a (S) quasi-experimental or a randomized controlled trial (RCT) design, but not studies that described only intervention or study protocols without results.

The following National Research Council and Institute of Medicine (2009) classification should be considered. The preventive level includes universal prevention interventions, that is, aimed at the general population (e.g. mental health promotion); selective prevention, that is, for those who show risk factors above the average (e.g. parents who show difficulties in managing behavior of their children); and indicated prevention, for those who do not meet diagnostic criteria for a disorder, but show warning signs (e.g. parents of children who show disobedience, aggressiveness, etc.). The treatment intervention level includes interventions that are aimed at patients who have identified symptoms or signs of a diagnosable disorder by the DSM-V (American Psychiatric Association, 2013) or ICD-10 (World Health Organization, 1992) (e.g. cancer, chronic pain, ASDs, negativist–defiant disorder, etc.).

Data extraction

The following variables were extracted from the articles included: aim of intervention with parents, prevention or treatment category (including treatment intervention, universal prevention, selective prevention, and indicated prevention), child diagnosis (or aim with children if there is no diagnosis), sample size, parents' mean age, percentage of mothers, study design, control group (classified as waiting list, treatment-as-usual, or alternative treatment), treatment model, intervention format (including individual or group; online, mobile devices, VR, etc.; and self-delivered or therapist-guided), length, follow-up length (if any), and outcome. For meta-analysis, the primary outcome was selected when measuring the parenting style. If not, the outcome that intervention aimed to achieve, consisting of the parenting style measured or the purpose of intervention. Post-treatment and follow-up means and standard deviations were selected for the meta-analysis.

Study selection and extraction data procedure.

The initial search was carried out by the first author (J.M.F), who identified the studies that met the inclusion criteria of the titles and the abstract. Afterwards, the duplicates were eliminated. The systematic search was supervised by another author (I.G.). Subsequently, the studies were analyzed by reviewing the full text, and decisions on the inclusion of the article were made through a discussion (J.M.F. and I.G.). One author (J.M.F.) extracted the data and analyzed it to determine the quality and risk of bias in the studies and for the meta-analysis that was reviewed and supervised by two other authors (A.G. and I.G.).

Assessment of study quality and risk of bias

All studies were assessed using the Instrument for Quality Assessment for Trials of Treatments in Mental Health (Moncrieff *et al.*, 2001), which consists of 23 items scored on a three-point Likert scale (0 = poor, 1 = fair, 2 = good). This test evaluates method quality, including objective, methods, design, results, quality of analysis, and conclusions. The instrument shows excellent reliability of 0.75–0.86. The mean score for mental health trials is 16.3 (S.D. = 6.3) to 20.9 (S.D. = 7).

Risk of bias was assessed with the Cochrane 'Risk of Bias' Tool (Higgins and Green, 2011) using Review Manager 5 (RevMan 5) for MacOs. The result of this analysis provides three risk levels (unclear, low, and high risk of bias) in selection, performance, detection, attrition, and reporting bias.

Statistical analysis

A random-effects meta-analysis was conducted with the outcome variable (see Table 1). The within-group effect sizes were calculated for all studies included and for subgroup by intervention model, kind of problem (health or psychology), type of intervention, type of control condition, and type of outcome. Hedge's g was used with the outcome variable post-treatment scores to perform these effect size analyses (Hedges and Olkin, 1985), that is, the standardized mean difference between two groups with a 95% confidence interval (CI). To ensure that the score direction was correct and equivalent for all instruments (e.g. a higher score means less self-efficacy), instrument scores were multiplied by −1. If the studies had different comparison groups as independent variables, they were included as separate studies. In studies with more than one intervention group, only the technology-based and control groups were included in the analysis (regardless of other comparison groups).

Heterogeneity of effect sizes was tested with I^2, which indicates low (<25%), moderate (50%), or high (75%) heterogeneity. These analyses were performed with the Review Manager 5 (RevMan5) program for MacOs (Higgins and Green, 2011)

Results

Systematic review

Included studies

Figure 1 shows a PRISMA flow chart for the studies included. Four hundred and nine articles were identified in the search, from which 153 duplicates were removed. The remaining titles and abstracts (n = 256) were screened by keywords, which eliminated another 124 articles. Then the full text of the 132 remaining articles was screened, eliminating 107 articles for the following reasons: in 18 studies the family did not receive treatment; 65 studies addressed usability, feasibility, or protocols; seven studies did not use technology; physical concerns or psychological issues were not the objective in eight studies; seven were case studies; one was a follow-up study; and two studies did not have comparative data. Finally, 24 studies were included in the systematic review. Three studies were excluded from the meta-analysis because they did not have clear dependent variables or data, so 22 studies were finally included in the meta-analysis. See Fig. 1

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Table 1. Overview of included studies

First author	Year	Aim of intervention with parents	Child diagnosis/aim	*N*	Age (M)	% fem	Design	Comp	Intervention	Format	Length	Follow-up	Outcome	*Q*
Antonini	2014	Positive parenting skills	TBI (T)	37	–	–	RCT	AT	PCIT	O/I/G	10 w.	8 m.	Parent interaction	23
Baker	2017	Positive parenting skills	Behavioral problems (IP)	200	35.7	92	RCT	WL	Triple P – CBT	O/I/S	8 w.	9 m.	Parenting efficacy	31
Breitenstein	2017	Parenting skills	Behavioral problems (IP)	79	40	100	RCT	AT	Psychoeducation	T/I/S	12 w.	6 m.	Parent self-efficacy	26
Bruning Brown	2004	Parenting health habits	Eating disorders (UP)	69	–	96	Q-exp	WL	Psychoeducation	O/I/S	4 w.	–	Parent self-criticism	17
Cernvall	2015	Parent stress (PSD symptoms)	Cancer (T)	58	38	67	RCT	WL	CBT	O/I/G	10 w.	–	Post-traumatic stress	26
Choi	2016	Parenting skills	Mental health (UP)	214	43	88.7	Q-exp	AT	CBT	O/I/S	4 w.	1 m.	Parent Knowledge	18
Cotter	2013	Parenting skills	Youth violence (UP)	144	40.6	77	Q-exp	AT	CBT	O/I/S	5 w.	–	Parent self-efficacy	21
Cullen	2017	Parenting health habits	Healthy diet (UP)	126	40	79	RCT	AT	Psychoeducation	O/I/S	8 w.	4 m.	Parent self-efficacy	16
Deitz	2009	Parent self-efficacy	Mental health (SP)	99	42	45	RCT	WL	Psychoeducation	O/I/S	4 w.	–	Parental knowledge	21
Ehrensaft	2016	Parenting stress and skills	Behavioral problems (UP)	52	23	100	RCT	WL	Triple P – CBT	O/I/S	8 w.	–	Parenting scale	23
Franke	2016	Positive parenting skills	ADHD (IP)	33	37.1	18	RCT	WL	Triple P – CBT	O/I/G	12 w.	6 m.	Parent self-efficacy	27
Hinton	2017	Positive parenting skills	Intellectual disability (T)	98	–	88	RCT	TAU	Triple P – CBT	O/I/S	9 w.	–	Parenting efficacy	34
Marsac	2013	Parent stress (PSD symptoms)	TBI (T)	100	41.02	83	RCT	TAU	Psychoeducation	O/I/G	20 min	6 w.	Parent knowledge	26
Morawska	2014	Parenting skills	Behavioral problems (SP)	139	36.99	92.8	RCT	WL	Triple P – CBT	OP/I/S	2 w.	–	Parent self-efficacy	29
Palermo	2016	Parenting skills	Chronic pain (T)	273	–	94.1	RCT	AT	CBT	O/I/G	8 w.	6 m.	Activity limitations	35
Raj	2015	Parent stress	TBI (T)	40	32	–	RCT	TAU	PCIT	O/I/G	16 w.	6 m.	Parent self-efficacy	26

Salonen	2011	Parent self-efficacy	Health care (UP)	742	31,2	67	Q-exp	WL	Psychoeducation	O/I/S	6 w.	–	Parent self-efficacy	17
Sanders	2012	Positive parenting skills	Behavioral problems (IP)	169	37.37	91	RCT	TAU	Triple P – CBT	O/I/S	8 w.	6 m.	Parent self-efficacy	25
Sanders	2014	Positive parenting skills	Behavioral problems (IP)	193	38.41	47	RCT	AT	Triple P – CBT	O/I/S	8 w.	6 m.	Parent self-efficacy	20
Sanders	2008	Positive parenting skills	Behavioral problems (IP)	454	–	–	RCT	TAU	Triple P – CBT	OD/I/S	12 w	6 m.	Parent self-efficacy	27
Son	2014	Parent skills – self-efficacy	Atopic dermatitis (T)	40	35	100	Q-exp	WL	Psychoeducation	O/I/S	2 w.	–	Parent self-efficacy	22
Sveen	2017	Parent stress	Burns care (T)	62	37.35	67.74	RCT	WL	Psychoeducation	O/I/G	6 w.	12 m	Parenting stress	30
van Beelen	2014	Parenting health care	Child safe (UP)	1292	33	93.58	RCT	TAU	Psychoeducation	O/I/G	4 w.	–	–	26
Wade	2006	Parent stress	TBI (T)	40	–	90	RCT	AT	CBT	O/I/G	4 w.	2 m.	Problem solving	20

Problem of interest: PSD, post-traumatic stress disorder; Child diagnosis/aim: ADHD, attention-deficit hyperactivity disorder; TBI, traumatic brain injury; T, treatment intervention; UP, universal prevention; SP, selective prevention; IP, indicated prevention; Design: RCT, randomized controlled trial; Q-exp, quasi-experimental design; Comp, comparison condition; AT, alternative treatment; TAU, treatment-as-usual; WL, waiting list; Intervention: CBT, cognitive-behavior therapy; PCIT, Parent–Child Interaction Therapy; Format: I, individual; O, online; OP, online podcast; OD, online with DVD support; T, tablet device; S, self-administered; G, therapist-guided/support; Length: min., minutes; w., weeks; Follow-up: m., months; Q, quality assessment for trials of treatments in mental health.

See online Supplementary Appendix B for references.

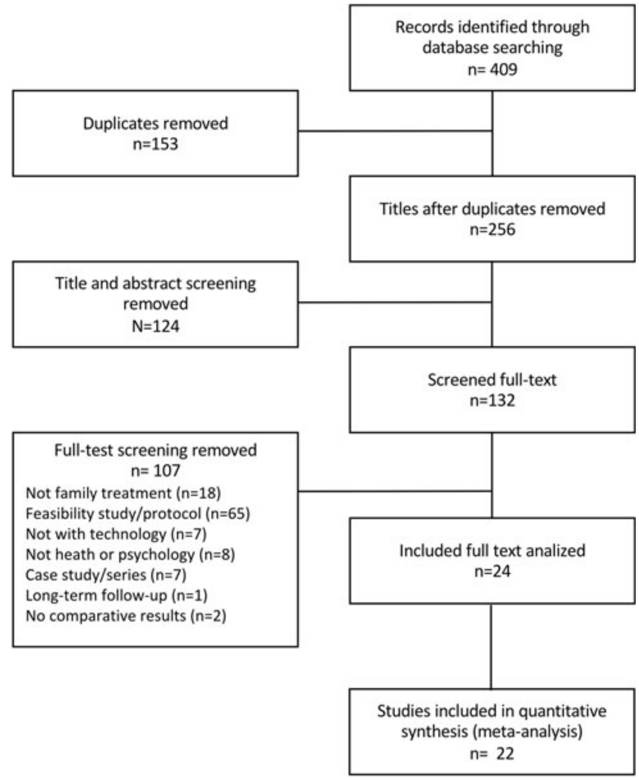

Fig. 1. PRISMA flow chart.

for process details (see online Supplementary Appendix B for included references).

Sample description

Parenting intervention for children with disruptive behavior problems (e.g. oppositional defiant disorders, aggressive behavior, prevention of conduct problems) ($n = 8$; 33.3%) was the main problem treated by technology-based interventions. Sample sizes were from 33 to 1292 subjects ($M = 198.04$; S.D. = 281.63). Not counting the largest study (van Beelen, 2014), the sample size was from 33 to 742 subjects ($M = 155$; S.D. = 171.9). Participants' mean age (parents) was from 31 to 40 ($M = 35.78$; S.D. = 6.13). Mothers made up 79.05% of the sample, and in 60% of the studies, over 80% of them were mothers.

Among the problems for intervention, we found that 54.16% of the studies aimed at parents of children with psychological issues ($n = 13$) including disruptive behavior or conduct problems ($n = 8$; 33.3%), neurodevelopmental disorders, specifically, ADHD and intellectual development ($n = 2$; 8.3%), general mental health prevention ($n = 2$; 8.3%), and prevention of eating disorders ($n = 1$; 4.2%). In contrast, 45.83% of the studies dealt with physical concerns ($n = 11$) including brain injury ($n = 4$; 16.7%), health care, specifically, burn care, health safe, and infant care ($n = 3$; 12.5%), cancer ($n = 1$; 4.2%), chronic pain ($n = 1$; 4.2%), atopic dermatitis ($n = 1$; 4.2%), and diet health habits ($n = 1$; 4.2%) (see Table 2).

Regarding the aim of intervention with parents, we found that 54.2% of the studies aimed to improve parenting skills ($n = 13$), 20.8% aimed to improve parental stress ($n = 5$), including symptoms of post-traumatic stress disorder ($n = 2$), 12.5% of the studies are related with health habits ($n = 3$), and 12.5 of the studies aimed to improve parenting self-efficacy ($n = 3$).

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Table 2. Study characteristics

	M (s.d.)/%
Parent mean age	35.78 (6.13)
% female	79.05%
Kind of problem	
Psychological issues	54.16%
Physical health	45.83%
Design	
RCT	79.2%
Quasi-experimental	20.8%
Control condition	
Waiting list	36.8%
Alternative treatment	33.3%
Treatment-as-usual	25%
Follow-up assessment	
With	62.5%
Without	37.5%
Treatment condition	
Psychoeducative	37.5%
Triple P	33.3%
CBT	20.8%
PCIT	8.3%
Intervention classification	
Treatment	37.5%
Universal prevention	29.2%
Selective prevention	8.3%
Indicated prevention	25%
Treatment format	
Online	87.5%
Podcast	4.16%
DVD	4.16%
Tablet	4.16%

Finally, in an analysis of the number of participants who completed intervention, we found a dropout rate of 3.03–54.2%, with a mean of 16.76% (s.d. = 16.11).

Study characteristics

The characteristics of the studies are given in Table 1. Nineteen of the studies (79.2%) used RCT and five (20.8%) had a quasi-experimental design. Of all the studies, the control group in 41.7% ($n = 10$) consisted of a waiting list, in 33.3% ($n = 8$) of an alternative treatment, and in 25% ($n = 6$) treatment-as-usual. Of the RCT studies, 36.8% ($n = 7$) had control groups consisting of a waiting list, 31.6% ($n = 6$) an alternative treatment, and 31.6% ($n = 6$) treatment-as-usual. Of the studies with a quasi-experimental design, 50% ($n = 2$) had a waiting list as the control group and 50% ($n = 2$) an alternative treatment (see Table 2).

Among the alternative treatments, we found that 62.5% ($n = 5$) of the studies consist of an Internet resource comparison group with publications or information links, 25% ($n = 2$) of the studies consist of parents' group workshops, and 12.5% ($n = 1$) use a workbook as an active control group. Finally, 60% ($n = 15$) of the studies included a follow-up design.

Treatment characteristics and conditions

In total, 37.5% ($n = 9$) of the studies used a psychoeducational intervention, in which the therapeutic components were aimed at understanding the child's illness, symptom management, child care, contingency management, self-efficacy training, and working with parents' beliefs and attitudes.

In total, 33.3% ($n = 8$) of the studies were based on Triple P Intervention, which aims at educational and parenting training to enhance positive parenting, optimize contingency management, children's misbehavior management, self-care, and parents' well-being.

In total, 20.8% ($n = 5$) of the studies were based on CBT. Their goal was to improve coping strategies for emotional distress, relaxation techniques, conflict management, writing down thoughts and emotions, emotional education (perception, expression, and regulation), positive contingency management (positive reinforcement, communication strategies, etc.), and self-care.

In total, 8.3% ($n = 2$) used Parent–Child Interaction Therapy (PCIT) as the intervention. All the studies that used this model were based on children's contingency management (consequences, rules, positive parenting, etc.), stress coping strategies, emotion regulation, problem-solving using games, relapse prevention, and child development techniques.

According to the National Research Council and Institute of Medicine (2009) classification of interventions, we found that 37.5% ($n = 9$) of the studies are treatment intervention, 29.2% ($n = 7$) of the studies are universal prevention, 25% ($n = 6$) of the studies are indicated prevention, and 8.3% ($n = 2$) of the studies are selective prevention.

The average length of treatment was 7 weeks. Psychoeducational treatment took an average of 4 weeks (s.d. = 3.8), Triple P took 13 weeks (s.d. = 4.8), CBT 6 weeks (s.d. = 2.6), and PCIT 13 weeks (s.d. = 4.2).

In total, 87.5% ($n = 21$) of the studies had an individual online format. One of them ($n = 1$) used a tablet for intervention (Breitenstein *et al.*, 2016), one ($n = 1$) used web-based intervention with podcast (Morawska *et al.*, 2014), and one of the studies ($n = 1$) used web-based intervention with DVD support (Sanders *et al.*, 2008). In total, 62.5% of the studies ($n = 15$) were self-administered and 37.5% of the studies ($n = 9$) had therapist support, including weekly meetings, videoconference, phone contact, or feedback.

Outcome

We found a certain amount of variability in the instruments used to assess the effects of parenting intervention. Parenting variables included self-efficacy, parental knowledge, parenting scales, parent–child interaction, problem-solving, limitations in daily living, and post-traumatic stress. See Table 3 for more details.

Overall study quality

The studies included had a rating range of 16–35 points ($M = 24.41$; s.d. = 5.19) on the Moncrieff Scale. See Table 1 for detailed scores. The rating range of 18 out of 24 studies was above average, while six studies had an average rating range. Most of the studies had sample sizes of fewer than 50 subjects per group (58.3%), while 16.6% of the studies had over 100 subjects per group. In 62.15% of the studies, allocation was randomized, but without blinding

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Table 3. Instruments for outcomes

Outcome	Instruments
Self-efficacy	– Parenting Task Checklist (Sanders and Woolley, 2005) – Parenting Self-Efficacy Scale (Gordon, 2011) – Parent Self-Efficacy (Cullen *et al.*, 2000) – Parenting Sense of Competence (Johnston and Mash, 1989) – Caregiver Self-Efficacy Scale (Bothroyd, 1997) – Parent Self-efficacy (Salonen *et al.*, 2009) – Parental Self-Efficacy with Eczema Care Index (CEMQ; Mitchell and Fraser, 2011) – Toddler Care Questionnaire (Gross and Rocissano, 1988) – Child Adjustment and Parent Efficacy Scale-Developmental Disability (CAPES-DD; Emser *et al.*, 2016)
Parent knowledge	– Parent Knowledge Questionnaire-Revised (PKQ-R; Marsac *et al.*, 2011) – Parental Knowledge Scale (Choi *et al.*, 2010)
Parenting	– Parenting Scale (Arnold *et al.*, 1993)
Parenting interaction	– Dyadic Parent–Child Interaction Coding System (DPICS; Eyberg and Robinson, 1981)
Problem solving	– Social Problem-Solving Inventory (SPSI – short version; D'zurilla and Nezu, 1990)
Daily activity	– Child Activity Limitations Interview (CALI; Palermo *et al.*, 2004)
Stress/post-traumatic	– Post-traumatic Stress Disorder Checklist (PCL-C, Weathers *et al.*, 1993) – Parenting Stress Index (PSI-SF; Abidin, 1990).

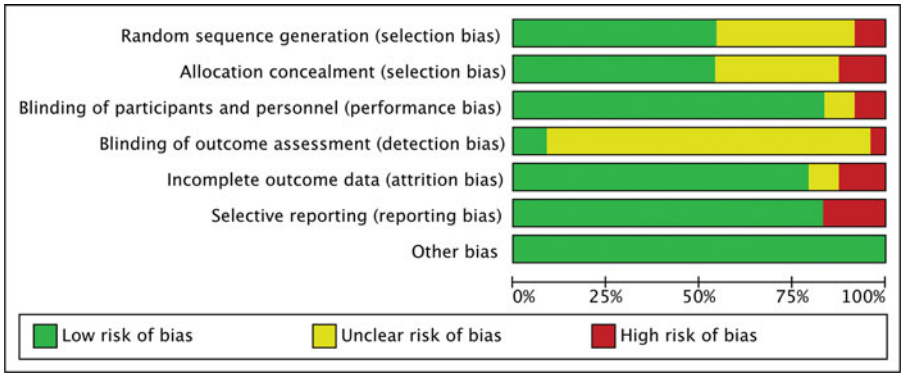

Fig. 2. Risk of bias graph presented as percentages across all included studies.

subjects or without testing. The criteria for which the studies scored highest were: conclusions clearly justified ($M = 1.87$; S.D. = 0.44), appropriate statistical analysis ($M = 1.79$; S.D. = 0.41), and clear presentation of results ($M = 1.75$; S.D. = 0.44). The criteria with the weakest methodological quality were: assessment of side-effects of intervention ($M = 0.04$; S.D. = 0.20), blinded evaluator ($M = 0.04$; S.D. = 0.20), and power calculation report ($M = 0.29$; S.D. = 0.62).

Risk of bias

Risk of bias analysis showed a certain amount of variability among the studies (see Fig. 2). Eighty-eight percent of the studies were unclear about whether outcome assessment was blinded and so there may have been a detection bias. A possibility of selection bias was found in 50% of the studies. Twelve percent specifically showed a high risk of randomized selection and 16% showed a high risk of allocation concealment. Finally, 80% of the studies showed low bias risk in performance, attribution, or notification (see online Supplementary Fig. S1).

Meta-analysis

Primary analysis

A primary analysis compared intervention and control groups at post-test means ($n = 22$; see Fig. 3). Ten of the studies show a statistically significant positive effect size from $g = 0.54$ to $g = 3.55$. However, in 12 of studies the 95% CIs include zero, that is, there is no statistically significant difference between intervention and control groups. The overall effect size was moderate ($g = 0.61$, 95% CI 0.37–0.85) with considerable heterogeneity ($I^2 = 86\%$). A statistically significant difference was found ($Z = 5.05$, $p < 0.00001$) in favor of the intervention group (see Fig. 3).

Analysis of follow-up efficacy

Efficacy at follow-up was analyzed ($n = 13$; see Table 4). The mean scores of the follow-ups in the studies were used for this analysis. Six of the studies showed statistically significant positive effect sizes for intervention groups of 0.39–1.74. Seven of the studies showed no statistically significant difference between the groups. The overall effect size is small ($g = 0.42$, 95% CI 0.22–0.62) with moderate heterogeneity ($I^2 = 67\%$) and a statistically significant difference ($Z = 4.09$, $p < 0.00001$) in favor of the intervention group (online Supplementary Fig. S2).

Subgroup analysis

Intervention model: A subgroup meta-analysis was conducted to test differences in effect size between intervention and control group post-treatment scores by intervention model ($n = 22$; see Table 2, online Supplementary Fig. S3).

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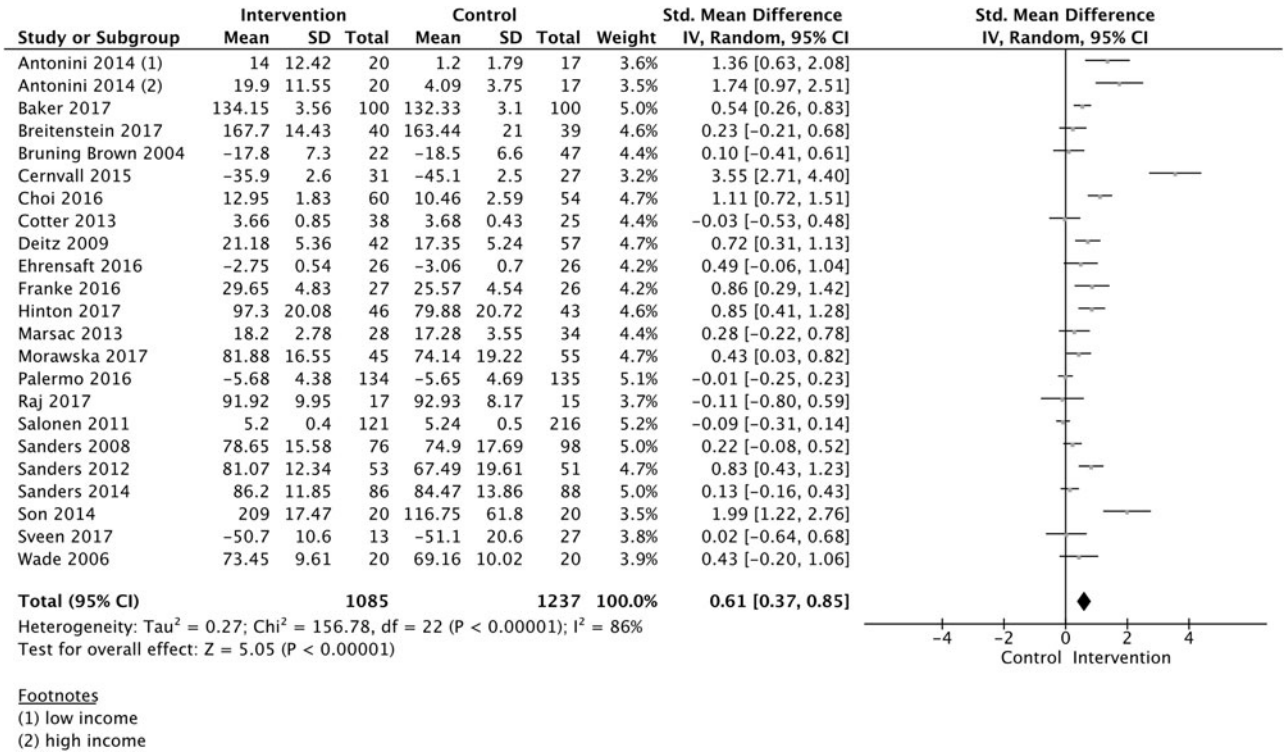

Fig. 3. Forest plot of effect sizes intervention programs and control conditions.

A small effect size ($g = 0.20$; 95% CI 0.05–0.35) with high heterogeneity ($I^2 = 82$) was found in the studies using psychoeducational treatments ($n = 7$). Two of the studies had a positive effect of 0.72–1.99. This mean size was not statistically significant ($Z = 2.58$; $p = 0.01$).

The CBT studies ($n = 5$) had an overall small–moderate effect size ($g = 0.49$; 95% CI 0.32–0.67) with high heterogeneity ($I^2 = 94$). Positive effect sizes of 0.11–3.55 were found in two of the studies. Statistically significant differences were found in CBT ($Z = 5.45$; $p < 0.00001$).

The random-effects mean effect size of studies using the Triple P model ($n = 8$) was small ($g = 0.4$; 95% CI 0.27–0.53), with high heterogeneity ($I^2 = 67$). Statistically significant differences were found ($Z = 6.01$; $p < 0.01$). Five individual studies showed positive effect sizes of 0.43–0.85.

The random-effects mean effect size of studies with PCIT ($n = 3$) was large ($g = 0.94$; 95% CI 0.52–1.36), with high heterogeneity ($I^2 = 86$) and statistically significant differences ($Z = 4.36$; $p <$ 0.01). Two of the studies showed positive effects from 1.74 to 1.36.

The overall random-effects mean effect size between groups was small ($g = 0.38$; 95% CI 0.3–0.47), with high heterogeneity ($I^2 = 86$), and statistically significant differences were found between intervention models ($Z = 8.83$; $p < 0.00001$). The intervention model weight observed for Triple P was 42.5%, for psychoeducational intervention, it was 30.8%, for CBT it was 22.7% and for PCIT it was 4.1%.

Kind of problem: A subgroup meta-analysis was conducted to test for differences in post-treatment effect size of studies dealing with psychological issues ($n = 13$; see Table 4) and studies about physical concerns ($n = 9$).

The effect size for studies related to psychological issues was small ($g = 0.46$; 95% CI 0.25–0.66), with moderate heterogeneity ($I^2 = 70$), and statistically significant differences ($Z = 4.34$; $p < 0.00001$). In seven studies, the effect size was positive, from 0.43 to 1.11, but six of the studies had no effect (with 95% certainty).

On the other hand, effect sizes for studies related to physical concerns were large ($g = 0.87$; 95% CI 0.33–1.41), with high heterogeneity ($I^2 = 92$), and no statistically significant differences ($Z = 3.18$; $p = 0.001$). For four studies, effect sizes were positive, from 1.36 to 3.55.

Finally, statistically significant differences were observed between groups ($\chi^2 = 2$; $p = 0.16$), with moderate heterogeneity ($I^2 = 86$) and moderate positive effect size ($g = 0.60$; 95% CI 0.36–0.83). Studies related to psychological issues had a higher weight (60.1%) than physical concerns (39.9%) (online Supplementary Fig. S4).

Intervention classification: A subgroup meta-analysis was conducted to test for differences in post-treatment effect size of studies by intervention classification, that is, treatment intervention ($n = 9$), universal prevention ($n = 5$), selective prevention ($n = 2$), and indicated prevention ($n = 6$) (online Supplementary Fig. S5)

The effect size for treatment intervention studies was large ($g = 0.97$, 95% CI 0.37–1.56), but no statistically significant difference ($Z = 3.2$; $p = 0.001$). In five studies, the effect size was positive, from 0.85 to 3.55.

However, there was no statistically significant difference between intervention and control groups in overall effect size of universal prevention studies ($g = 0.31$; 95% CI −0.18 to 0.8) with moderate heterogeneity ($I^2 = 86$).

The effect size for selective prevention studies was moderate ($g = 0.57$; 95% CI 0.28–0.85) with no statistically significant difference ($Z = 3.87$; $p = 0.0001$) and the effect size for indicated prevention studies was small ($g = 0.43$; 95% CI 0.20–0.67) with no statistically significant difference ($Z = 3.60$; $p = 0.00003$) (Table 4)

Control condition: A subgroup meta-analysis was conducted to test for differences in post-treatment effect size of studies by control

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Table 4. Subgroup analysis at post-test

Subgroup analysis	Weight	*g*	95% CI	I^2
Follow-up				
Total	**100**	**0.42**	**0.22–0.62**	**67**
Intervention model				
CBT	22.6	0.49	0.32–0.67	94
PCIT	4	0.94	0.52–1.36	86
Psychoeducative	30.8	0.20	0.05–0.35	82
Triple P	42.4	0.4	0.27–0.53	67
Total	**100**	**0.39**	**0.31–0.47**	**86**
Kind of problem				
Psychological	60.1	0.46	0.25–0.66	70
Health	39.9	0.87	0.33–1.91	92
Total	**100**	**0.60**	**0.36–0.83**	**86**
Classification of intervention				
Treatment	39.3	0.97	0.37–1.56	91
Universal prevention	22.8	0.31	−0.18 to 0.8	86
Selective prevention	9.4	0.57	0.28–0.85	1
Indicated prevention	28.5	0.43	0.2–0.67	61
Total	**100**	**0.61**	**0.37–0.85**	**86**
Control condition				
Alternative treatment	34.5	0.56	0.16–0.95	85
Waiting list	42.8	0.79	0.33–1.24	91
TAU	22.4	0.45	0.11–0.79	66
Total	**100**	**0.61**	**0.37–0.85**	**86**
Type of outcome				
Self-efficacy	71.2	0.35	0.13–0.56	72
Parental stress	9.7	1.17	−1.68 to 5.24	98
Parental knowledge	19.2	0.73	0.27–1.18	70
Total	**100**	**0.55**	**0.27–0.82**	**86**

CBT, cognitive-behavioral therapy; PCIT, Parent–Child Interaction Therapy; TAU, treatment-as-usual; *g*, Hedge's *g* test; CI, coefficient interval; I^2, heterogeneity.

condition, including alternative treatment ($n = 7$), waiting list ($n = 10$), and treatment-as-usual ($n = 5$) (online Supplementary Fig. S6).

The largest effect size is found for studies with waiting list control condition ($g = 0.79$; 95% CI 0.33–1.24) in comparison with alternative treatment ($g = 0.56$; 95% CI 0.16–0.95) and treatment-as-usual condition ($g = 0.45$; 95% CI 0.11–0.79) (Table 4).

Type of outcome: Finally, a subgroup meta-analysis was conducted to test differences in effect size between intervention and control group post-treatment scores by outcomes, including self-efficacy ($n = 11$), parental stress ($n = 2$), and parental knowledge ($n = 3$) (online Supplementary Fig. S7). For this analysis, five studies were excluded because they were the only ones with this outcome (Bruning Brown *et al.*, 2004; Wade *et al.*, 2006; Antonini *et al.*, 2014; Palermo *et al.*, 2015; Ehrensaft *et al.*, 2016)

Studies that used measures of parental knowledge had a larger positive effect size ($g = 0.73$; 95% CI 0.27–1.18) compared with studies that measured self-efficacy ($g = 0.35$; 95% CI 0.13–0.56). However, no effects are found for parental stress measures ($g = 1.78$; 95% CI −1.68 to 0.5.24). No statistically significant differences are obtained for any of the subgroups (Table 4).

Discussion

The aim of this paper was to provide a systematic review and meta-analysis of studies on technology-based parenting intervention for parents to promote or treat psychological issues and physical concerns of children.

Of the total search results, 24 studies with a total sample size of 1292 participants were included. Technology-based parenting intervention was mainly for behavioral problems (like oppositional defiant disorders, aggressive behavior, prevention of conduct problems, etc.). This is consistent with the reviews of traditional parenting intervention, that is, not technology employed (Nieuwboer *et al.*, 2013; Lozano-Rodríguez and Valero-Aguayo, 2017). The results show moderate effect sizes for intervention groups with statistically significant differences

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from control groups, which may show that technology-based parenting programs have positive effects on parenting. Nevertheless, heterogeneity among the studies is high. Technology-based parenting intervention shows large effect size for parental knowledge and small effect size for the parental self-efficacy, but does not show effects on parental stress.

Of the interventions, Triple P had a small effect size with moderate heterogeneity. This decrease in heterogeneity can be explained by the Triple P treatment's structured and sequenced protocol, and its proven effectiveness (in face-to-face treatment). The assessment instruments used in Triple P treatment are often the same. However, PCIT had a higher effect size as an intervention.

CBT effect sizes in this study were consistent with other systematic reviews in which CBT (face-to-face) achieved successful outcomes in parents of children with chronic illnesses (Eccleston *et al.*, 2015). From a transdiagnostic perspective, one of the weightier components that could form the basis for a change in parenting is emotion regulation (Maliken and Katz, 2013). Emotion regulation components, for example, emotional perception, emotional management, and regulation, are present in the majority of the studies analyzed.

Psychoeducational interventions show small effect sizes; this result is consistent with the research that indicates that interventions with behavioral components are more effective in eHealth interventions (Cushing and Steele, 2010). This point can also be related to the results of the effects for universal prevention, which mostly follows a model of psychoeducational intervention. On the other hand, treatment interventions, aimed at parents with children with diagnosis, show a large effect size, while selective or indicated prevention interventions, that is, those that show risk factors or danger signs, show moderate and small effect size, respectively. This point shows that interventions with children who have a diagnosed health or psychological problem show greater intervention effects.

Regarding the kind of problem, intervention for psychological issues had a higher weight but small effect size. Intervention for physical concerns had a higher effect size than psychological issues, but large heterogeneity.

On the other hand, when the intervention is compared with the waiting list condition, a large effect size was found. But when the intervention is compared with an active control condition (e.g. alternative treatment), the effect size is small. This result suggests that although there are positive effect sizes among different conditions, the intervention with technology is not as powerful when compared with an active treatment.

Mean scores for methodological quality were high for the majority of the studies. One of the main methodological problems is the lack of double-blinding and assessment of the treatment's side-effects. That coincides with the risk of bias observed in those studies, such as detection bias, that is, the lack of therapist or researcher blinding so as not to know allocation to intervention or control.

Another methodological limitation observed is the lack of assessment of long-term treatment effects in a follow-up assessment. The results of the meta-analysis do not show significant differences in the follow-up outcomes between intervention and control groups. Although the follow-up outcomes were not statistically significant, the results show a positive effect trend for intervention group, but the effect size is small.

This systematic review and meta-analysis has provided some promising evidence of the practical implications for technology-based parenting intervention in children with physical or psychological problems, with moderate effect sizes. However, those interventions which had been tested traditionally in face-to-face therapy, e.g. Triple P intervention, showed less variability, because they were designed based on validated treatment protocols. Finally, a promising result is the improvement in attendance and participation level in technology-based treatments, which increased considerably at 83.24% compared with traditional parenting intervention, which is 30–50% (Heinrichs *et al.*, 2005). This result can therefore be taken as an indication that technology-based treatments could increase the number of recipients of such intervention.

This systematic review and meta-analysis should be interpreted considering some limitations. First, there is a wide variety of instruments for assessing the effects of intervention. The primary outcome usually varied between interventions, but even when the outcome was the same, e.g. self-efficacy, the instruments employed were different and self-reported. It was attempted to alleviate this limitation with random-effect and subgroup analyses, but the results are still highly heterogeneous. Second, the small sample size limits its usefulness as scientific evidence for technology-based interventions. Finally, it is important to consider a publication bias, as all the studies included in the meta-analysis had been published and the majority of their results are favorable to the intervention group.

The results of this study show that parenting intervention with technology can be beneficial to both parents and children. Technology-based parenting intervention has only emerged since 2004, and a very few RCTs have been done. In fact, 65 studies were excluded from this meta-analysis for this reason, and therefore, one direction for future research should be the contribution of scientific evidence validating this type of treatment.

Overall, the findings of this study suggest evidence of the usefulness and efficacy of parenting intervention with technology for psychological and physical health in childhood and adolescence. The effects of these interventions have a positive impact on parenting and on children's wellbeing, and are therefore beneficial to parenting.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291719000692

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