

## Biofeedback-based Interventions for Disruptive Behaviour Disorders among Children and Adolescents: A Systematic Review

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### ABSTRACT

Biofeedback is a self-regulation technique in which individuals learn to consciously monitor and regulate one's physiological functions. The use of biofeedback along with psychotherapy has been demonstrated to be effective in development of cognitive and behavioural skills across a wide range of clinical disorders. The aim of the present study is to conduct a systematic review of the existing literature published on the use of biofeedback-based interventions for alleviating disruptive behaviour problems among children and adolescents. Research articles were searched on PubMed database using descriptors such as "biofeedback", "externalizing traits", and "disruptive behavioural problems" were used and only articles published between 2010 and 2024 were selected. After applying inclusion and exclusion criteria, 03 articles, all randomized controlled trials, were analysed. Results suggest that biofeedback techniques are valuable tools in interventions involving children and adolescents, both as a therapeutic technique, and as an effective tool for healthy individuals to enhance their well-being and thereby, better quality of life.

**Key words:** *Disruptive Behaviour Disorders among Children and Adolescents.*

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### Introduction

#### Biofeedback

Biofeedback can be defined as a self-regulation technique that involves the use of specialized equipment to provide real-time feedback on internal physiological processes, such as heart rate, muscle tension, sweat gland activity and skin temperature (Frank et al., 2010). By gaining awareness and control over these autonomic processes, individuals can learn to self-regulate and effectively manage a wide range of physical and psychological conditions (Shapiro, 1979).

Biofeedback utilizes a range of modalities to provide real-time feedback on physiological processes, including: Electroencephalograph (EEG) biofeedback, also known as neurofeedback (monitors brain activity allowing individuals to gain awareness and control over their neural functioning), Heart Rate Variability (HRV) biofeedback (focuses on the variations in the time intervals between heartbeats), Electromyograph

(EMG) (measures muscle tension and activity), Galvanic Skin Response (GSR) biofeedback also referred to as a Skin Conductance or Electrodermal Activity meter (measures electrical changes in the skin, associated with sympathetic nervous arousal) (Moss, 1998; Bhat, 2010; Frank et al., 2010). These diverse biofeedback modalities allow clinicians to tailor interventions to the specific needs and goals of each individual (Giggins et al., 2013; Cuthbert & Lang, 1976).

A typical biofeedback loop consists of four components: a biosensing unit, a data transfer unit, a data processing unit, and a feedback unit. The biosensors measure specific physiological parameters, a data transfer unit transfers the data to a data processing unit and immediately present related information back to the user with an external audiovisual display (a feedback unit) (Reiner, 2008; as cited in Yu, 2018).

Biofeedback is grounded in the principles of operant conditioning, where individuals are rewarded for exhibiting the desired physiological

responses. This reinforcement helps to strengthen the connection between the individual's conscious efforts and their physiological outcomes, allowing them to develop effective self-regulation strategies over time (Gaume et al., 2016).

### Role of Biofeedback in Psychotherapy

Biofeedback techniques can help users improve self-awareness of internal states and learn self-regulation skills to manipulate specific physiological functions in a healthy direction. In clinical applications, biofeedback techniques often serve as a particular intervention or addition to cognitive and behavioural therapy.

The role of biofeedback in psychotherapy has become increasingly recognized and accepted as our understanding of the mind-body connection has evolved. By empowering individuals to cultivate a deeper awareness of their internal states and the capacity to actively influence them in the healing process, biofeedback has demonstrated its effectiveness in the treatment of a wide range of stress-related and psychosomatic conditions (Shapiro, 1979; Glick & Greco, 2010; Frank et al., 2010; Kouzak et al., 2020). Thus, this integration of biofeedback training with conventional psychotherapy has the potential to enhance the psychotherapeutic experience (Werbach, 1977; Biofeedback, 2008).

Biofeedback is often integrated with cognitive-behavioural therapy, behaviour therapy and other psychotherapeutic approaches, creating a synergistic effect (Moss, 1998; Sarti, 1998). By combining the insights gained from biofeedback along with cognitive and behavioural strategies, patients can develop a more comprehensive understanding of their condition and implement effective self-regulation techniques (Shapiro, 1979; Huang et al., 2006; Glick & Greco, 2010). This interactive process fosters a sense of self-efficacy and empowerment, as patients learn to actively manage their physiological states and thereby restore or maintain autonomic balance (Frank et al., 2010; Saha et al., 2015).

In clinical settings, an experienced therapist uses biofeedback interventions and explains the procedure to the client and asks him to use the feedback so that optimum condition can be achieved (Yu, 2018).

### Disruptive Behaviour Disorders (DBDs)

According to 2019 Global Burden of Disease study, there was a high prevalence of mental disorders affecting children and youths, indicating that more than 1 of 10 (or 293 million) individuals aged 5 to 24 years globally live with a diagnosable mental disorder in terms of burden, around one-fifth of all disease-related disability (considering all causes) was attributable to mental disorders among this population (WHO, 2021).

Childhood and adolescence are considered sensitive periods for the development of mental health problems due to the dynamic changes occurring in the brain during these stages of life (Zeanah et al., 2011). The adolescent brain undergoes significant reorganization, with different cognitive and behavioural systems maturing at varying rates. (Guyer et al., 2016) This asynchronous development between brain regions can result in a disjunction between the maturation of cognitive, emotional, and social-emotional processes, creating a potentially volatile period where adolescents may struggle to regulate their thoughts, feelings, and behaviours (Steinberg, 2005). Adolescents exhibit heightened social sensitivity, becoming increasingly attuned to social cues, evaluations, and the perceived impressions of their peers (Somerville, 2013). This heightened social sensitivity can "dial up" socioemotional processes, leading adolescents to be more emotionally reactive to experiences of inclusion or exclusion, and to place greater emotional significance on real or perceived social evaluation. (Steinberg, 2005; Somerville, 2013). The vulnerability of this sensitive period is further compounded by the onset of many mental health disorders, which often emerge during adolescence. Adolescents may be more susceptible to the development of conditions such as depression, anxiety, and substance abuse disorders due to the interplay between their evolving brain structures, heightened social sensitivity, and the unique challenges encountered during this developmental stage (Steinberg, 2005; Somerville, 2013).

It is essential to recognize the sensitive period of childhood and adolescence as a critical window for shaping mental health trajectories. (Fusar-Poli, 2019) The reorganization of regulatory systems

during this time can present both risks and opportunities, with adolescents potentially experiencing heightened vulnerability to mental health problems due to the disjunctions between their developing brain, behavioural, and cognitive systems. By recognizing the sensitive period of childhood and adolescence, we can better understand the formative years and how they shape mental health trajectories. The dynamic changes occurring in the brain, coupled with the unique social and emotional challenges faced during this time, can create a perfect storm for the emergence of mental health problems.

However, this sensitive period also presents opportunities for intervention and prevention. By supporting healthy brain development, promoting emotional regulation, and fostering positive social experiences, we can help adolescents navigate this critical stage of life and set them up for long-term mental health and well-being (Steinberg, 2005; Casey et al., 2010; Guyer et al., 2016; Lockhart et al., 2018).

#### Disruptive Behaviour Disorders (DBDs)

Disruptive Behaviour Disorders (DBDs) is a group of disorders characterized by difficulties in the self-control of emotions and behaviours. The resulting behaviours or actions violate the rights of others and/or that bring the individual into significant conflict with societal norms or authority figures. Such disorders form a category in the DSM-5, i.e., Disruptive, Impulse Control and Conduct Disorders, which include a wide variety of disorders such as Oppositional Defiant Disorder (ODD), Intermittent Explosive Disorder (IED), Conduct Disorder (CD), Pyromania, Kleptomania, and other specified/unspecified disruptive, impulse-control and conduct disorder (APA, 2013).

Such severe, developmentally inappropriate and long-lasting disruptive behaviours are a major concern to mental health professionals. These behaviours occur in various settings, and have significant deleterious long-term consequences (including legal repercussions) for children and adolescents including poor educational attainment, poor interpersonal relationships, unemployment, substance abuse, suicidal behaviour, and antisocial personality disorder etc.

(Fergusson et al., 2005; Odgers et al., 2008). In addition to this, approximately 40% of the individuals diagnosed with DBD display elevated callous-unemotional (CU) traits, characterised by a lack of empathy and generally deficient affect (Rowe et al., 2010).

Notably, as highlighted in meta-analytic studies, evidence-based medical treatment and psychotherapies for DBD only yield small to moderate effect sizes (Bakker et al., 2017; Erford et al., 2014; Fossum et al., 2008). More specifically, children and adolescents with elevated levels of callous-unemotional (CU) traits often respond poorly to empirically-supported psychological treatments. Furthermore, with children and adolescents with DBD, their distress is focused outward and it directly affects other people. Lack of insight adds to the severity and complexity of these disorders, resulting in low compliance to interventions and treatments.

Thus, in this article, we aim to identify and systematically collate evidence from existing published research studies evaluating the efficacy of biofeedback video games for disruptive behaviour disorders, with an emphasis on CU traits among children and adolescents. For the purpose of this article, only two disruptive behaviour disorders, ODD and CD are considered. The terminologies of “problems” and “disorders” are used interchangeably throughout this article.

#### Aims and Objectives

To date, several studies have investigated the efficacy of biofeedback training on various applications. The greater part of the literature on biofeedback training focuses on alleviating physical or psychosomatic disorders such as headache (Nestoriuc et al., 2008), hypertension (Greenhalgh et al., 2010), chronic pain (Turk et al., 1979), and stroke rehabilitation (Glanz et al., 1997). A great deal of previous research has examined the efficacy of biofeedback training on internalizing disorders such as anxiety disorders (Moore, 2000). However, a very few research studies have replicated these findings for externalizing disorders among children and adolescents (Aggensteiner et al., 2024).

In view of all that has been mentioned so far, we present a systematic review of the studies that have used biofeedback-based interventions for alleviating disruptive behaviour problems among children and adolescents. Based on this review, we aim to: (1) assess and synthesize the effectiveness of biofeedback training or biofeedback-based interventions on disruptive behaviour problems; (2) identify the research gaps in the research studies using biofeedback training or biofeedback-based interventions.

## **Materials and Methods**

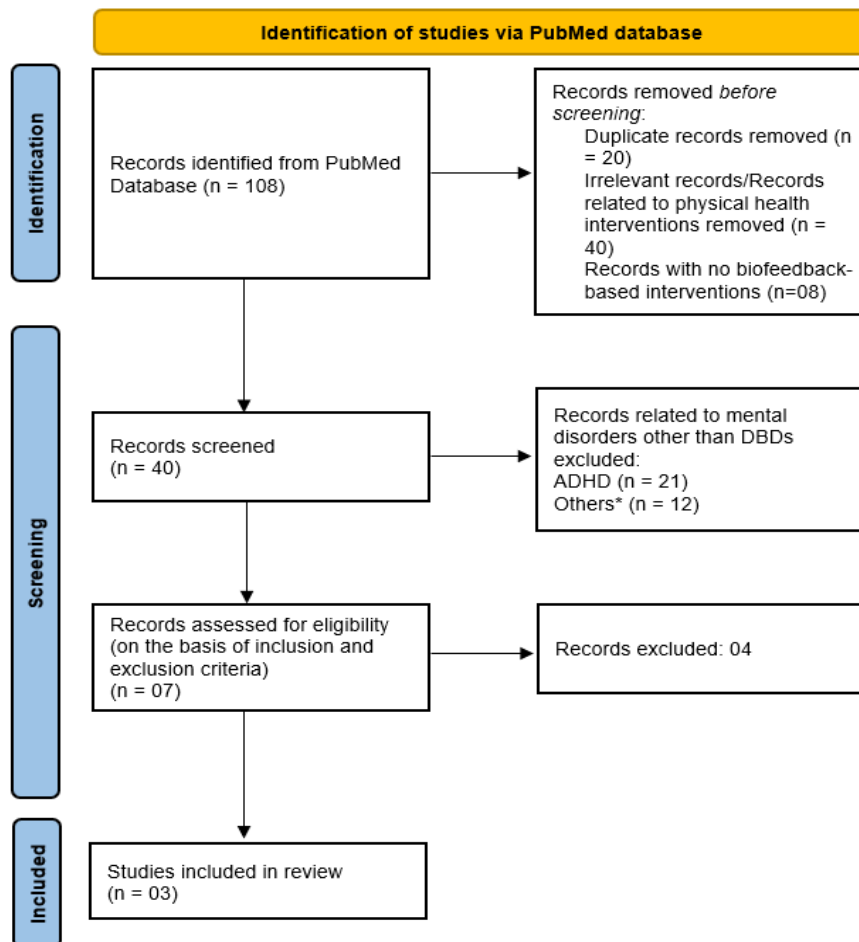
### **Data Sources and Search Strategies**

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was followed to conduct this review. The authors

searched PubMed using the keywords “Biofeedback AND externalizing traits OR Disruptive Behaviour Problems” from the September 2014 until September 2024 (during the last 10 years).

### **Selection Criteria**

Articles were included if the following inclusion criteria were met (a) the study used a biofeedback training (video game-based biofeedback training were also included); (b) the intervention targeted mental disorders or sub-clinical conditions or assisted in a professional psychotherapeutic setting; (c) the study conducted a pre/post measurement; and (d) the sample consisted of children and adolescents. An overview of included and excluded studies is depicted in Figure 1.



\* Others include Neurodevelopmental Disorders (Autism=02), Other Mental Disorders (PTSD=02), Mental Health Problems (Alcohol-use = 02; Stress = 01), Enhancement of Positive Emotions (01), and Genetic Disorders (04)

Figure 1: Flow chart of included/excluded studies.

## Selection Procedure

Only studies published in peer-reviewed journals, written in English were extracted. The studies were considered for review if they were a randomized controlled trial (RCT) or conducted as a pre-post study, if they measured effects of biofeedback-based interventions, and if the sample consisted of children and adolescents. Initially, the research articles were screened on basis of information contained in their titles, abstracts, and keywords independently by the authors. When a decision on inclusion or exclusion could not be reached solely based on this preliminary information, the full text was retrieved.

## Results

As a result, 108 studies published up to September 2024 were identified. Out of these, three research studies using biofeedback-based interventions met the inclusion and exclusion criteria and were identified as relevant to the current review. Following information from the included studies was collected: authors, year of publication, sample size, sample characteristics, intervention characteristics, study duration, and outcome measures (refer to Table 1 and 2 for detailed overview of the biofeedback-based interventions).

Table no. 1: Characteristics of sample included Biofeedback-based Interventions

Authors and title	Mental disorder/ Psychological skills for Mental health enhancement	Biofeedback- based intervention	Study Design	Study Sample	Mode of Biofeedback
Schuermans et al., 2018 Using a Videogame Intervention to Reduce Anxiety and Externalizing Problems among Youths in Residential Care: an Initial Randomized Controlled Trial	High-risk youths with clinical anxiety and externalizing problems	Dojo	Randomized Controlled Trial (RCT)	37 youths (31 males and 06 females) Mean age of Dojo condition: 13.67 (1.82) and of control condition: 14.26 (1.94)	Heart rate (HR)
Aggensteiner et al., 2024 Randomized controlled trial of individualized arousal-biofeedback for children and adolescents with disruptive behavior disorders (DBD)	Disruptive behaviour disorders [including conduct disorder (CD) and oppositional defiant disorder (ODD)]	Skin Conductance Level (SCL) arousal- biofeedback training	Randomized Controlled Trial (RCT)	37 children (aged 8–14 years)	Skin Conductance Levels (SCL)
Böttinger et al., 2024 Exploring real-time functional magnetic resonance imaging neurofeedback in adolescents with disruptive behavior disorder and callous unemotional traits	Disruptive behaviour disorders [including conduct disorder (CD) and oppositional defiant disorder (ODD)] and elevated callous unemotional traits	Neurofeedback training	Randomized Controlled Trial (RCT)	27 participants (12–18 years of age, 22 % female)	fMRI

Table No. 2: Intervention duration, comparison treatment and outcome measures of the included studies

Schuurmans et al., 2018	4 hours, divided into eight sessions of 30 minutes of gameplay  Frequency: Twice a week (for four consecutive weeks)	Treatment as usual (TAU) (as per individual requirements): Individual therapy (e.g., CBT) and/or medication (e.g., Ritalin); Group therapy (e.g., social skills training) and/or family therapy (e.g., multisystematic therapy)	The Dutch version of the Spence Children's Anxiety Scale (SCAS; Spence 1998)  The Dutch version of the Strengths and Difficulties Questionnaire (SDQ; Goodman 1997; van Widenfelt et al. 2003).  User evaluation (statements regarding their satisfaction with the game on a 5-point scale)  Gaming Experience (average hours of gameplay a week for each participant)
Aggensteiner et al., 2024	Each session lasted about one hour.  20 training sessions within 20 weeks (Experimental Group)  6 sessions within 20 weeks of individual psychoeducation and counselling with cognitive-behavioural (TAU Group)	Active treatment as usual (TAU) including psychoeducation and cognitive-behavioural elements.	the Overt Aggression Scale (MOAS)  Child Behavior Checklist completed by parents (CBCL)  the Inventory of Callous-Unemotional Traits (ICU) rated by parents  the self-reported Reactive and Proactive Questionnaire (RPQ)
Böttinger et al., 2024	10 sessions of individualized real-time fMRI neurofeedback (rtfMRI-NF) within 10 weeks	6 sessions of Active treatment as usual (TAU): Individualized Behavioural Treatment consisted of selected elements of standardized manuals for the training of social competencies and aggression (Soziales Kompetenztraining (SKT), Anti-Aggressivitäts-Training (AAT: Weidner, 2011) and Assertiveness-Training-Program (ATP: Pfingsten, 2009)), which were individually combined to encounter the personal needs of each participant.	the Modified Overt Aggression Scale (MOAS: Kay et al., 1988)  the Inventory of Callous-Unemotional Traits (ICU: Frick, 2004)  the Reactive-Proactive Aggression Questionnaire (RPQ: Raine et al., 2006)  CBCL subscales: CD and ODD - to address important subtypes and dimensions of aggression  the Pubertal Development Scale (PDS: Carskadon and Acebo, 1993)

All the research studies targeted symptoms of Disruptive Behaviour Disorders/Externalizing Problems. The sample size ranged from 08 to 37 participants and the age group ranged from 8 to 18 years. Of the three included studies, two were randomized controlled trials (RCT). Most studies compared two study groups: an intervention group in which the treatment was a biofeedback video game or biofeedback intervention and a control group/active control group receiving usual care or no care. Exception was the study of

Schuermans et al., (2015) in which no comparison was done with control group.

A search of the literature revealed few controlled studies investigating the use of biofeedback-based interventions among children and adolescents with disruptive behaviour problems.

In one of the randomized controlled studies in this field, Schuurmans et al. (2018) attempted to study the effectiveness of a biofeedback videogame intervention (Dojo) among high-risk youths with clinical anxiety and externalizing problems. A total of 37 participants with clinically elevated levels of anxiety and externalizing problems were recruited from residential institutions. Participants were randomly assigned to either the Dojo or treatment as usual (TAU) condition, was categorised on the basis of gender and intellectual disability level. The Dojo intervention consisted of 8 sessions of 30 minutes each, where participants played the Dojo videogame twice a week for 4 weeks. The Dojo intervention was delivered in addition to the participants' usual treatment program. The TAU condition received their usual treatment. The findings suggest that playing the Dojo videogame intervention led to reductions in self-reported anxiety and externalizing problems, as well as mentor-reported anxiety, immediately after the intervention. However, the effects on self-reported anxiety and externalizing problems were not maintained at the 4-month follow-up, but the effect on mentor-reported anxiety was maintained. The study did not find any effects on mentor-reported externalizing problems.

Contrary of previously mentioned study, Böttinger et al. (2024) carried out a study to investigate the feasibility, clinical efficacy, and specificity of individualized real-time functional magnetic resonance imaging neurofeedback (rtfMRI-NF) of either the amygdala (AMG) or insula (INS) compared to treatment as usual (TAU) in adolescents with disruptive behavior disorder (DBD) and elevated callous-unemotional (CU) traits. For the study, a total of 27 adolescents aged 12-18 years (22% female), diagnosed with conduct disorder (CD) and/or oppositional defiant disorder (ODD) along with elevated callous-unemotional (CU) traits were recruited for the study. The sample was randomly

assigned either 6 sessions of treatment as usual (TAU) – 6 sessions of psychotherapy within 10 weeks or 10 sessions of individualized rtfMRI-NF training targeting either the amygdala or insula, with 3 different types of feedback runs (simple, video, and transfer) in each session. The participants in the rtfMRI-NF group received visual feedback of their target brain region's activity during up-regulation and down-regulation trials. The clinical outcomes were assessed before and after treatment and it was found that both the neurofeedback and treatment-as-usual groups showed comparable and significant improvements on measures of disruptive behaviour disorder symptoms, despite no significant improvement on the primary outcome measure. The primary outcome measured in this study was the Modified Overt Aggression Scale (MOAS), which is a measure of aggressive behaviour.

Aggensteiner et al. (2024) makes a similar point in his study to investigate the efficacy of individualized arousal-biofeedback for reducing aggression in children and adolescents with disruptive behaviour disorders (DBD). 37 children and adolescents aged 8-14 years diagnosed with oppositional defiant disorder (ODD) and/or conduct disorder (CD) based on structured clinical interviews were recruited for the study. The two treatment groups were generally well-matched on baseline characteristics, except for higher scores on the Reactive and Proactive Aggression Questionnaire (RPQ) in the biofeedback group. The participants were randomly assigned to either an individualized skin conductance level (SCL) biofeedback training group or an active control group receiving treatment as usual (TAU). The SCL biofeedback training consisted of 20 sessions over 20 weeks, with 3 different types of feedback runs to train up- and down-regulation of SCL. SCL was measured using a specialized EEG system with electrodes on the fingers. The TAU group received 6 sessions of psychoeducation and cognitive-behavioural counselling. The findings revealed that individualized SCL biofeedback training was not superior or inferior to an active control treatment (TAU) for reducing aggressive behaviour in children and adolescents with DBD. Both the SCL-BF and TAU groups showed

significant improvements in the primary outcome of aggressive behavior (MOAS) with a small effect size. The primary outcome measured in this study is the change in parents' ratings of aggressive behavior as measured by the Modified Overt Aggression Scale (MOAS). The SCL-BF group showed significant within-group improvements in aggressive behavior, with a small-to-medium effect size, while the TAU group did not. Both groups showed large improvements in externalizing symptoms on the CBCL, as well as medium-to-large improvements in the ODD and CD subscales, but no significant differences between groups. The SCL-BF group showed significant improvements in their ability to self-regulate their skin conductance levels, particularly in the up-regulation condition, with significant improvements seen after around 10 sessions. The ability of the SCL-BF group to self-regulate their skin conductance levels, particularly during the video condition, was significantly related to improvements in secondary outcomes such as externalizing symptoms, ODD, callous-unemotional traits, and conduct disorder, but not the primary outcome of aggressive behaviour.

## **Discussion**

To date, a number of systematic reviews and meta-analysis have been conducted to evaluate the effectiveness of biofeedback training or biofeedback-based interventions (Van Doren et al., 2019; Zayeni et al., 2020; Dormal, Vermeulen, & Mejias, 2021; Kothgassner et al., 2022) in the prevention or treatment of psychiatric disorders in children and adolescents. To the best of my knowledge, this is the only systematic review assessing the effectiveness of biofeedback training on disruptive behaviour disorders or externalizing problems among children and adolescents. The greater part of the literature on efficacy of biofeedback video games focuses on emotion regulation, for instance, in Reynard et al., (2022). Little is known about the efficacy of biofeedback-based interventions to enhance significant correlates of disruptive behaviour such as empathy and moral reasoning. Moreover, it can be explored if biofeedback video games, particularly multiplayer role-playing biofeedback videos games can play a role in

social information processing and moral development.

Our results are in congruence with those from previous meta-analyses and literature reviews on use of biofeedback video games for therapeutic purposes (Girard, Ecalle, & Magnan, 2013). These reviews highlight the importance of certain conditions which can help evaluate the effectiveness of serious games. Following is a detailed analysis of the best practices with reference to three randomized controlled studies retrieved through our literature review.

In all three of the randomized controlled studies (Schuurmans et al., 2018; Aggensteiner et al., 2024; Böttinger et al., 2024) retrieved in the systematic review, the researchers compared the experimental group (trained using biofeedback-based intervention) to a group trained using a evidence-based psychotherapeutic techniques, thereby increasing the internal validity of the findings (Girard, Ecalle, & Magnan, 2013).

In order to assess whether acquired knowledge and skills have been transferred into everyday lives, or if it has led to reduction of symptoms, parents and teachers' evaluations along with self-reports play a significant role. In addition, follow-up evaluations after the final training session add up to this information significantly. Supporting this view, in one of the randomized controlled trial studies (Schuurmans et al., 2018) retrieved in our systematic review, a 4-month follow-up was conducted to determine if the skills acquired in game and the beneficial effects in daily life will persist over time.

Another important component is the design of the game as it may influence the effectiveness of the biofeedback video game. Video games act as a vector of therapy, using a wide variety of mechanisms to achieve therapeutic benefits. Hence, the game's design and storyline elements should be described in studies since they can be so varied, and content may be an influencing factor that needs to be considered. Baranowski et al. (2008) and Whyte, Smyth, & Scherf (2015) highlighted that game elements such as immersive storylines, gameplay mechanics, nature of goals, rewards and feedbacks, adaptative levels of difficulty matching player



personality characteristics (to avoid too much boredom or frustration in order to maintain a high level of engagement), and providing choices supporting player autonomy can influence the effectiveness of the biofeedback video game. Overall, all three of the research studies briefly described the incorporation of these game design elements in their games and the procedures used to generalize what is learned in the game outside of it.

Together, all of these studies highlight the beneficial aspects of utilizing biofeedback video games for therapy among children and adolescents. Traditional psychotherapies when integrated with play are well received by children and adolescents and dropout rates were low. These games, utilizing mind-body technique can represent potential alternatives or adjunct to usual care for this population, as pointed out by the most rigorous RCTs in our selection, such as Dojo (Schuurmans, 2018).

However, the research studies remain narrow in focus dealing only with emotion regulation or relaxation techniques. There is a need for further investigation to evaluate how biofeedback video games can impact various underlying deficits in children and adolescents with disruptive behaviour problems and thereafter identify an assortment of game elements or mechanisms which can help alleviating them. Examine potential mediating mechanisms of biofeedback video games.

In addition, the nature of disruptive behaviour problems is heterogenous and hence biofeedback video games based on transdiagnostic biomarkers might help in increasing the long-term effectiveness of these biofeedback video games. Subsequently, there is a need for further investigation into individualized treatments targeting individual specific symptoms, given the heterogeneity of the disorder. One of the key characteristics of DBDs or more specifically, Disruptive, Impulse Control and Conduct Disorders is that the underlying causes of the problems in the self-control of emotions and behaviours can vary greatly across the disorders in this category and among individuals within a single diagnostic category. The presence of elevated CU traits increases the severity of these

disorders to a greater extent (Frick et al., 2014). The need for engaging and interactive preventive interventions become even more important because these children and adolescents lack insight about their problems.

Finally, the integration of biofeedback with VR constitutes a very powerful research line. It would permit to provide users with engaging interfaces of the physiological targeted stimuli, which could in turn positively impact on the therapeutic outcomes.

The mind-body techniques, such as biofeedback video games can be the most clinically valuable instruments for delivering psychotherapy since psychological disorders (especially useful for enhancing self-regulatory behaviours, including attention and emotional regulation) and therapies can hold a certain social stigma, and that it can be difficult for socioeconomically disadvantaged youths in need of mental health care to access proper treatment. These games or interventions can become a relevant self-help resource, overcoming all those barriers by being easily accessible at home, through internet. In addition, these interventions are easy to disseminate in schools, making them cost-effective tools for prevention of various psychological disorders among children and adolescents. Furthermore, these games should be accessible for parents and educators, so that it reaches a substantial population and benefit from users feedbacks that could help the developers in return developers to improve the effectiveness of these interventions.

A number of studies have postulated that risk factors leading to serious disorders, such as DBDs and Antisocial Personality Disorder (APD) can be identified at early stages of development, during childhood with reasonable accuracy e.g., (Haapasalo & Tremblay, 1994). Hence, a greater number of studies should be conducted at every stage, promoting universal, selective, indicated prevention, to alleviate disruptive behaviour among children and adolescents.

It is important to highlight a significant research gap in the area of biofeedback-based interventions. There is limited empirical evidence in India regarding efficacy on children and adolescents with disruptive behaviour problems.

These findings need to be interpreted with caution, however. This is because the authors searched PubMed database only for relevant research studies, hence a lot of studies which might be available in other databases were not covered. The grey literature was also not explored.

### **Conclusion**

Biofeedback constitutes an effective and non-invasive procedure, whose basic operating principle is the conscious registration of normally unconscious body procedures (e.g., brain activity, electrocardiogram, electromyography, or skin conductance) (Gaume et al., 2016) that are represented by a visual, haptic, or audio signal.

The period from childhood to early adulthood involves increased susceptibility to the onset of mental disorders, with implications for engaging and effective preventive interventions. Biofeedback video games can now be considered as an innovative adjunct or alternative in the prevention and treatment of disruptive behaviour disorders/externalizing problems among children and adolescents. The present results are significant in at least two major respects. First, a greater number of randomized controlled trials shall be conducted to assess the efficacy of biofeedback interventions for disruptive behaviour disorders/externalizing problems among children and adolescents. Second, it would be valuable to include more varied correlates of disruptive behaviour disorders as part of the game design. Efforts should be made to make these high-quality serious games available to parents and educator. Future research evaluating the efficacy of biofeedback video games as part of the treatment of child and adolescent psychiatric disorders should include long terms follow-up evaluation. This systematic review also highlighted that biofeedback video games hold promise as a powerful new therapeutic and preventive tool in the treatment of disruptive behaviour problems (Zayeni, Raynaud, & Revet, 2020). When incorporated into community programs, biofeedback-based videogames can foster emotional intelligence competencies in children without access to traditional mental health services.

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