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Comparative Assessment of Effect of Sensory Adapted Dental Environment Versus Routine Dental Environment on Anxiety, Child Behaviour and Pain Perception in Children with Autism - A Systematic Review and Meta-Analysis

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Abstract

Background: The Sensory Adapted Dental Environment (SADE), also known as the "Snoezelen room," offers a calming, nonpharmacological alternative that helps reduce anxiety and improve cooperation during dental procedures.

Aim: To assess the impact of sensory adaptive dental environment as compared to routine dental environment on anxiety among children with autism.

Methodology: This PROSPERO-registered systematic review (CRD42024623979) included interventional studies comparing dental anxiety in children with autism in routine versus sensory adaptive dental environments. Databases like PubMed, MEDLINE, and Google Scholar were searched using relevant keywords, and included studies were assessed using the Cochrane RoB tool.

Results: Out of the screened studies, four met the inclusion criteria. While anxiety, behavior, and pain differences were not statistically significant, pooled data indicated that children in the SADE group experienced less pain, anxiety, and sensory discomfort. A significant reduction in sensory discomfort was observed in SADE compared to Routine Dental Environment (RDE) (SMD -0.27, 95% CI -0.49 to -0.05, P=0.02).

Conclusion: A total of four studies were included in the meta-analysis, showing that SADE significantly reduces physiological and behavioral distress during dental cleanings in children with autism. It is a cost-effective,

scalable approach requiring minimal training for implementation.

Keywords: Autism Spectrum Disorders; Dental Treatment; Routine Dental Environment; Sensory Adaptive Dental Environment; Snoezelen Room.

Introduction

According to the National Educational Association of Disabled Students (NEADS), disabilities may include physical, learning, mental, auditory, visual, or neurological impairments [1]. Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social interaction and communication, along with repetitive and restricted patterns of behaviour that vary in severity (Lord et al., 2018). Autism can often be reliably diagnosed between 18 and 24 months of age, as characteristic symptoms become sufficiently evident during this developmental stage and can be distinguished from typical development as well as other developmental delays and disorders [2]. Dental anxiety is considered a psychophysiological condition characterized by excessive fear associated with dental treatment, often resulting in reduced patient cooperation and influenced significantly by the surrounding dental environment [3,4]. Children with ASD commonly demonstrate hypersensitivity to auditory and visual stimuli, which may contribute to elevated anxiety levels and behavioural difficulties during dental appointments. Fallea et al. (2016) reported increased dental anxiety and atypical sensory responses among uncooperative patients with intellectual disabilities [5].

Children with special healthcare needs, particularly those with autism, are at greater risk for oral diseases because of both their underlying condition and associated sensory sensitivities. Exposure to unfamiliar dental environments frequently provokes anxiety and uncooperative behaviour, thereby complicating the delivery of oral healthcare and adversely affecting oral health outcomes in children with ASD. In conventional dental settings, children with special needs are often highly responsive to sensory stimuli, which can result in maladaptive behaviours (Fig. 1). The Sensory Adapted Dental Environment (SADE) has emerged as a promising non-pharmacological therapeutic approach for managing such challenges (Fig. 2) [6]. SADE, also referred to as the "Snoezelen room," is a multisensory calming environment originally developed in the 1970s by Dutch therapists for individuals with developmental disabilities [7]. The word "Snoezelen" is derived from two Dutch terms: *snuffelen*, meaning to explore or investigate the environment, and *doezelen*, meaning to relax or doze [8].

The Sensory Adapted Dental Environment (SADE) is designed to minimize sensory overload by modifying visual, auditory, tactile, and olfactory stimuli encountered during dental treatment. Within this setting, harsh fluorescent lighting, which may flicker and increase anxiety, is replaced by dimmed lighting reflected upward, while conventional dental lights are substituted with head-mounted LED illumination (Fig. 3) [9]. Calming visual effects with slow-moving coloured projections are introduced into the child's visual field to create a soothing atmosphere [9]. In addition, dental instruments are disguised using toy-like covers to reduce fear and enhance acceptance (Fig. 3) [10]. Soft background music delivered through speakers helps mask unpleasant sounds produced by dental equipment (Fig. 3)[9]. For tactile comfort, children may be wrapped in a butterfly-shaped vest that applies gentle deep-pressure stimulation, thereby promoting relaxation and a sense of security [10]. To further reduce sensory triggers, dental personnel are encouraged to avoid strong perfumes and instead use unscented hygiene products or candles [9].

In a study conducted by Cermak et al., behavioural distress, pain perception, and sensory discomfort experienced by children with autism as well as typically developing children were assessed during dental treatment in a routine dental environment (RDE) and compared with outcomes observed in a sensory-adapted dental environment (SADE) [11]. The authors reported more favourable outcomes in the adapted dental setting [11]. Therefore, the present systematic review and meta-analysis was undertaken to evaluate the effectiveness of sensory-adapted dental environments (SADE) during dental treatment among children with Autism Spectrum Disorder.

Methodology

A systematic review of the literature along with a meta-analysis was conducted. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [12]. the Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0, and the 4th Edition of the JBI Reviewer's Manual. The protocol for this review was registered in PROSPERO under the registration number CRD42024623979 on 19/12/2024.

Eligibility criteria

Inclusion criteria

a. Population – Studies involving children diagnosed with Autism Spectrum Disorder (ASD), irrespective of gender or socioeconomic background.

b. Intervention – Studies evaluating dental treatment performed in a sensory adapted dental environment (SADE).

c. Comparison – Studies assessing dental treatment carried out in a routine dental environment (RDE).

d. Outcome – The primary outcomes considered were dental anxiety, patient distress, and intraoperative pain.

e. Study design

- Studies published in any language for which an English translation could be obtained.
- Studies published up to 31-12-2024.
- Clinical trials, in-vivo studies, randomized clinical trials, controlled clinical trials, non-randomized clinical trials, quasi-experimental studies, non-experimental studies, cohort studies, cross-sectional studies, and invitro studies.
- Studies with accessible full-text articles.

Exclusion criteria

1. Studies that were not completely available in the databases.
2. Studies published in languages other than English.
3. Single-arm studies without a comparison or control group.
4. Review articles, case reports, case series, and animal studies.
5. Studies with only abstracts available and lacking full-text access.
6. Studies that did not report the required outcomes.

Search strategy

Electronic search

Studies were selected according to the PICOS inclusion criteria specified in the review protocol. Two reviewers (S.K, R.P.) independently screened the titles and abstracts to identify potentially eligible studies, and disagreements or uncertainties were resolved through discussion with a third reviewer (P.J.). Comprehensive electronic searches were conducted using Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, CINAHL, EMBASE, and DOAJ databases with the help of controlled vocabulary and free-text terms (Table 1). Articles published until 31/12/2024 were searched without restrictions related to publication language.

Manual search of journals

A manual search was also carried out in pediatric dentistry-related journals including the Journal of Clinical Pediatric Dentistry, International Journal of Clinical Pediatric Dentistry, Pediatric Dental Journal, International Journal of Paediatric Dentistry, European Journal of Pediatric Dentistry, Contemporary Pediatric Dentistry, and AAPD Journal.

Other sources

Reference lists of all included studies and relevant review articles were hand-searched to identify additional eligible studies. Online trial registries and databases of ongoing clinical trials were also explored, including (https://clinicaltrials.gov/;www.centerwatch.com/clinicaltrials; www.clinicalconnection.com). In addition, efforts were made to retrieve proceedings from workshops, position papers, and theses wherever possible. When necessary, corresponding authors were contacted to obtain missing, unclear, or unpublished data.

Focused review question

Is there any difference in the effectiveness of sensory adaptive dental environment compared with routine dental environment in reducing anxiety, improving behaviour, and decreasing pain perception among children with autism?

Keywords and MeSH terms were combined using Boolean operators in the advanced search strategy as presented in Table 2.

Selection of studies

The titles and abstracts identified through electronic searches were independently reviewed by two authors. Full-text articles were obtained for studies that appeared to satisfy the inclusion criteria or where insufficient information was available in the abstract for decision-making. These full-text articles were then independently assessed by two reviewers experienced in the subject area to determine eligibility. Any disagreements were settled through discussion, and where consensus could not be reached, a third reviewer was consulted. Studies excluded during any stage of the screening process were documented in the table of excluded studies along with the reasons for exclusion.

Data extraction and management

Data extraction was carried out independently and in duplicate by two reviewers using specially designed data extraction forms. Any discrepancies between the reviewers were resolved by consultation with a third reviewer. Authors of certain studies were contacted when clarification or additional information was required. Data collection was performed using a standardized verification checklist containing the following items:

1. Authors, year, and title of the study
2. Country
3. Study design
4. Sample size
5. Gender
6. Intervention and control groups
7. Outcomes
8. Methods of outcome assessment
9. Results
10. Conclusion and additional information

Comprehensive details regarding publication characteristics, participant information, study settings, interventions, comparators, outcome measures, statistical analyses, results, funding sources, conflicts of interest, and other relevant aspects were carefully extracted from all included studies. All extracted data related to the primary outcomes were systematically recorded in Excel sheets.

Risk of bias assessment

The methodological quality of the included randomized clinical trials was assessed using the Cochrane RoB

tool.21 Risk of bias was evaluated across five domains, namely participant selection, allocation concealment, blinding of participants and outcome assessors, incomplete outcome data, and selective reporting. Each domain was categorized as "low risk of bias," "high risk of bias," or "unclear risk of bias."

Assessment of heterogeneity

Clinical heterogeneity among studies was assessed by examining variations in participants, interventions, and outcomes across studies. Statistical heterogeneity among treatment effect estimates was evaluated using Cochran's test and the I^2 statistic.

Heterogeneity was considered statistically significant at $P < 0.05$. According to the Cochrane Handbook, interpretation of I^2 values was as follows:

1. 0–30%: heterogeneity may not be important
2. 30–60%: may indicate moderate heterogeneity
3. 50–90%: may indicate substantial heterogeneity
4. 75–100%: indicates considerable heterogeneity

Data synthesis

Meta-analysis was planned when studies with comparable interventions and outcome measures were available. Depending on the level of heterogeneity, either fixed-effects or random-effects models were applied using the inverse variance method. In cases where statistically significant heterogeneity was identified ($P < 0.01$), a random-effects model was employed to estimate treatment effects. Conversely, when heterogeneity was not statistically significant, a fixed-effects model was used.[4] Effect estimates for dichotomous outcomes were expressed as risk ratios (RR), while continuous outcomes were reported as mean difference (MD) or standardized mean difference (SMD). Meta-analysis was performed only when studies with sufficiently similar comparisons and outcome measures were available.

Results

Study selection

The initial electronic database search on PubMed (n=13), PMC/MEDLINE (n=273), Cochrane library (n=103) and DOAJ (n=75) resulted in 464 titles. 396 articles were cited as duplicates. After screening the abstracts, 19 relevant titles selected by two independent reviewers were sought for retrieval and 49 were excluded for not being related to the topic. Following examination and discussion by the reviewers, 10 articles were selected for full-text evaluation. Hand searching of the reference lists of the selected studies did not deliver additional papers. After pre-screening, application of the inclusion and exclusion criteria and handling of the PICO questions, 4 studies remained. 4 studies were included in the qualitative synthesis which were subjected for data extraction and statistical analysis. (Fig. 5)

Study characteristics

Four studies were included in this systematic review whose general characteristics are presented in Table 3. All the included studies were RCTs, three[11,13,14] showed crossover design and one was parallel design. Among the included studies, three were conducted in USA [11,14,15] and one in Italy [13]. All the studies mentioned about the details for ethical approval.

A total of 268 children diagnosed with ASD were included in this review of which 203 were males and 65 were females. Two studies[11,14] performed dental cleaning treatment, one performed class I cavity restoration[13] and one study[15] performed extraction procedure on the included participants. In the intervention group, sensory adaptive dental environment was created which comprised of visual, auditory and tactile modifications in dental environment. For visual modifications, studies used darkening curtains, fluorescent lighting [11,14], soft lighting [4], project movies, cartoons [13]. Auditory

modifications were done by using rhythmic music [11,14] and sponge coating of dental drill to minimize noise [13]. For tactile stimulus, two studies used butterfly shaped wrap fit [11,14]. Individual sensory toys such as squeeze balls, 'pop its', etc were used [15].

The conclusions of all the included studies indicated that the use of SADE significantly improves both physiological and behavioral distress in this population during routine dental treatment. Use of SADE is relatively inexpensive, scalable, and easy to implement with minimal training.

Results of Risk of bias assessment:

Among the included studies, two [14,15] showed low risk of bias and two studies showed high risk of bias [11,13]. Risk of bias graph (Fig. 6) and Risk of bias summary (Fig. 7) shows in below figures.

Meta-analysis

Data synthesis was carried out using a descriptive synthesis, with a summary of the characteristics of each included study. For quantitative synthesis, a summary of the combined estimate related to the intervention effect was calculated using standardized mean difference (SMD) as effect measure.

1. **Anxiety**

   Intraoperative anxiety was assessed by three studies [11,14,15], which included 190 participants with SADE and 188 participants with RDE. The pooled results (Fig. 8) showed no statistically significant difference in anxiety between the two groups [SMD -0.14, 95% CI -0.34, 0.06, P=0.18], however the pooled values indicated SADE participants showed less anxiety as compared to RDE. Fixed effects model was used for analysis because of low heterogeneity (I2=0%).

2. **Child behaviour**

   Child behaviour according to Frankl behavior rating scale was assessed by two studies [11,14]. 160 participants were included in both groups. The pooled results (Fig. 9) showed no statistically significant difference in the child behaviour between the two groups [SMD 0.08, 95% CI –0.13 to 0.30, P=0.45], however the pooled values indicated SADE participants showed positive behaviour as compared to RDE. Fixed effects model was used for analysis because of low heterogeneity (I2=0%).

3. **Pain perception during treatment**

   Intraoperative pain was assessed by two studies [11,14]. 160 participants were included in both groups. The pooled results (Fig. 10) showed no statistically significant difference in the patient reported pain between the two groups [SMD -0.23, 95% CI -0.69 to 0.22, P=0.31], however the pooled values indicated SADE participants showed less pain as compared to RDE. Random effects model was used for analysis because of high heterogeneity (I2=55%).

4. **Sensory discomfort**

   Two studies [11,14] was included in the assessment of sensory discomfort. The pooled values (Fig. 11) showed a statistically significant difference between the two groups [SMD -0.27, 95% CI - -0.49 to -0.05, P=0.02]. The results indicated less sensory discomfort with SADE as compared to RDE. Fixed effects model was used for analysis because of low heterogeneity (I2=46%).

Discussion

Children with ASD frequently experience sensory processing difficulties, and there is a growing need for effective interventions that can reduce the discomfort and distress associated with these challenges. Families often report that addressing the complex sensory needs of children with ASD is highly stressful because children may react unpredictably to unfamiliar situations and overstimulating environments [16]. Therefore, when

selecting interventions aimed at improving self-regulation, it is important to consider both the therapist's level of involvement and the context in which the intervention is delivered.

The American Academy of Pediatric Dentistry advocates the use of conventional behavioural guidance techniques to assist children during dental treatment and to gradually develop their coping abilities[17]. Nevertheless, these techniques are often inadequate for children with developmental disabilities (DD) and ASD because of the unique behavioural and communication deficits associated with these conditions. In addition, sensory processing difficulties, along with other physical and psychological impairments, can further compromise cooperation and tolerance during dental procedures in children with DD. Sensory-based interventions and sensory integration therapies have therefore been incorporated into occupational therapy practices to enhance children's daily functioning and to improve adaptive responses related to sensory processing and motor planning abilities [18,19,20]. However, a systematic review evaluating sensory-based interventions reported limited evidence supporting their effectiveness in improving behaviour among children [18]. Since uncooperative behaviour is commonly recognized as a major obstacle to providing dental care for autistic children [21,22], the use of SADE may represent a promising strategy to improve cooperation, facilitate dental treatment, and promote more positive dental experiences in this population.

The findings of the present meta-analysis demonstrated that children managed under SADE experienced lower dental anxiety compared with those treated under RDE, although the difference did not reach statistical significance (p=0.18). These findings are consistent with those reported by Shapiro et al.[23] in 2009, where children exhibited significantly better cooperation in the SADE setting than in the RDE setting, resulting in fewer anxious behaviours. Furthermore, Shapiro et al.[23] observed a shorter duration of anxious behaviour among children receiving SADE, which is also in line with the results of the current study. Although our findings indicated more positive behaviour among children treated under SADE compared with RDE, the quantitative analysis revealed that this difference was not statistically significant (p=0.45).

These observations are supported by previous studies that have reported beneficial behavioural effects associated with SADE [23,24,25,26,27]. Similarly, Duker et al.[24] found no statistically significant differences between SADE and RDE groups with respect to the Children's Dental Behaviour Rating Scale (CDBRS), Frankl Scale, or Anxiety and Cooperation Scale. The authors suggested that these assessment tools might lack sufficient sensitivity to detect behavioural changes. In contrast, Kim et al.[24] reported a significant reduction in uncooperative behaviour among children with developmental disabilities treated under SADE compared to RDE when evaluated using the Frankl Behaviour Rating Scale. Likewise, Cermak et al. [11] found that significantly more personnel were required to physically restrain children with ASD in the RDE group in order to complete dental treatment compared with children treated under SADE.

A primary objective of SADE is to create a positive and comfortable dental experience for children with DD. The findings of the present review suggest that SADE may enhance patient cooperation during routine dental visits when compared to RDE. Nevertheless, further well-designed studies are required to validate the effectiveness and practicality of SADE for routine clinical application in managing children with DD. Behaviour management

has been identified as one of the most significant challenges among general dentists, with nearly 60% of practitioners reporting it as a major barrier [17,28]. By improving patient cooperation, SADE may also increase clinicians' confidence and willingness to provide dental care for children with developmental disabilities.

Conclusion

- Children with special health care needs such as those diagnosed with ASD and other developmental disturbances, benefit greatly from a multisensory-adapted dental environment in terms of physiological changes, behaviours, pain, and sensory comfort.
- SADE significantly improves both physiological and behavioral distress in this population during routine dental treatment. Use of SADE is relatively inexpensive, scalable, and easy to implement with minimal training.
- However, additional studies involving larger sample size are needed to validate these findings and arrive at more conclusive results.

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Legends Figures and Tables:

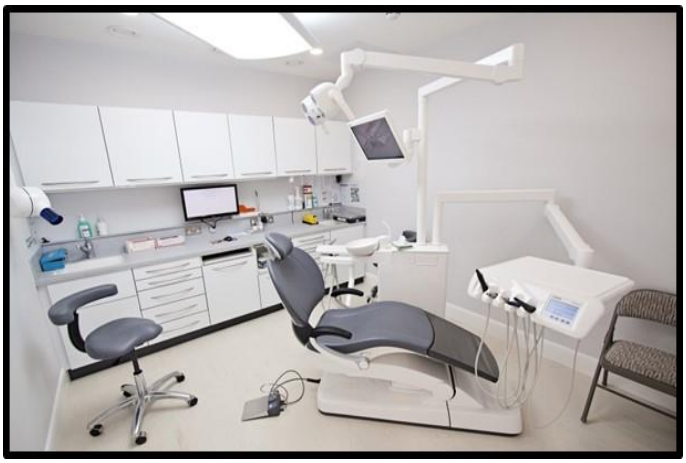

Figure 1: Routine Dental Environment

Figure 2: Sensory Adaptive Dental Environment

Figure 3: SADE armamentarium

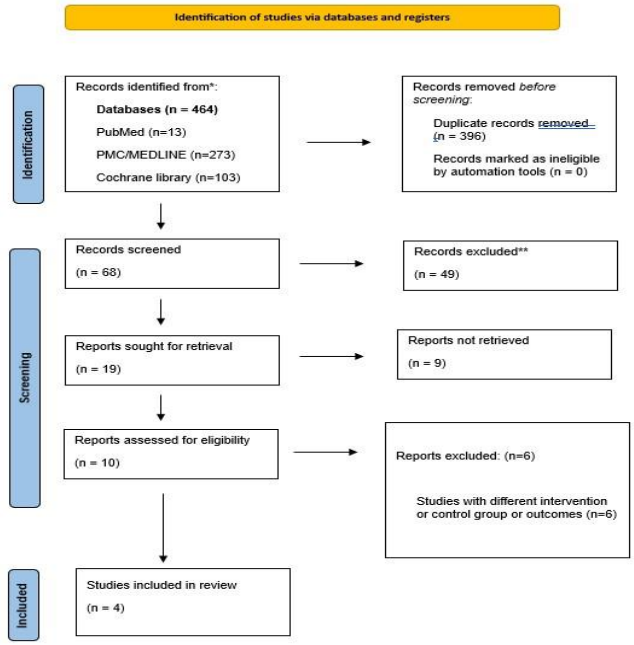

Figure 4: 2020 prisma flow chart

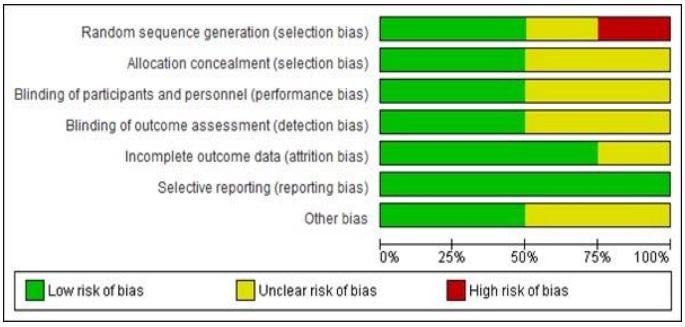

Figure 5: Risk of bias assessment

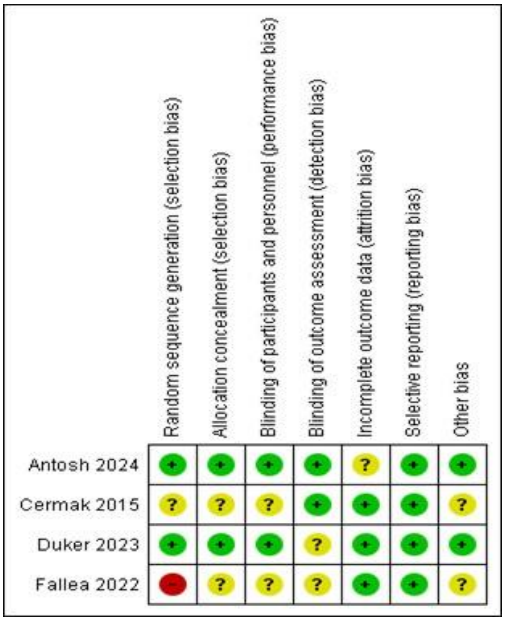

Figure 6: Risk of bias summary

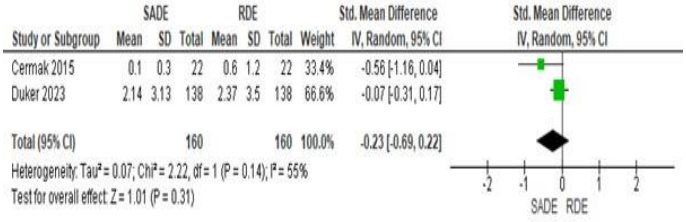

Figure 7: Forest plot for anxiety during treatment

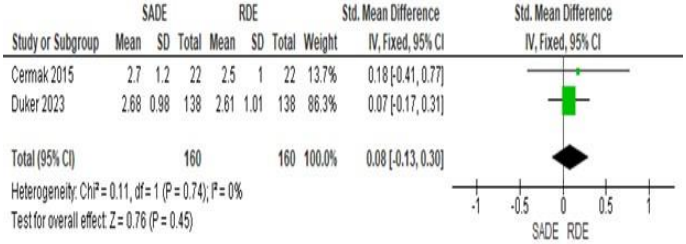

Figure 8: Forest plot for child behaviour during treatment

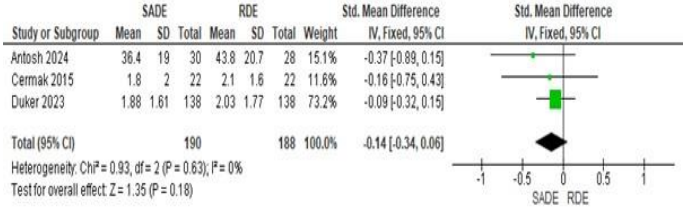

Figure 9: Forest plot for intraoperative pain

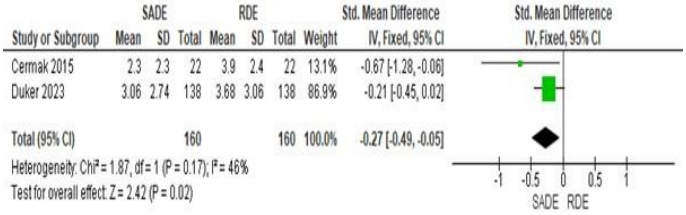

Figure 10: Forest plot for sensory discomfort

Table 1: Search strategy in different databases

PubMed	(((autism) OR (autism spectrum disorders)) AND (child OR children OR child*)) AND (dental treatment AND sensory adaptive dental environment OR SADE)) AND (routine dental environment)
PMC/MEDLINE	((("autism spectrum disorder"[MeSH Terms] OR ("autism"[All Fields] AND "spectrum"[All Fields] AND "disorder"[All Fields]) OR "autism spectrum disorder"[All Fields] OR ("autism"[All Fields] AND "spectrum"[All Fields] AND "disorders"[All Fields]) OR "autism spectrum disorders"[All Fields]) OR ("autistic disorder"[MeSH Terms] OR ("autistic"[All Fields] AND "disorder"[All Fields]) OR "autistic disorder"[All Fields] OR "autism"[All Fields])) AND (sensory[All Fields] AND adaptive[All Fields] AND ("dental health services"[MeSH Terms] OR ("dental"[All Fields] AND "health"[All Fields] AND "services"[All Fields]) OR "dental health services"[All Fields] OR "dental"[All Fields]) AND ("environment"[MeSH Terms] OR "environment"[All Fields]))) AND (routine[All Fields] AND ("dental health services"[MeSH Terms] OR ("dental"[All Fields] AND "health"[All Fields] AND "services"[All Fields]) OR "dental health services"[All Fields] OR "dental"[All Fields]) AND ("environment"[MeSH Terms] OR "environment"[All Fields]))
Cochrane Library	(((autism) OR (autism spectrum disorders)) AND (child OR children OR child*)) AND (dental treatment AND sensory adaptive dental environment OR SADE)) AND (routine dental environment)
Directory of Open Access journals	(((autism) OR (autism spectrum disorders)) AND (child OR children OR child*)) AND (dental treatment AND sensory adaptive dental environment OR SADE)) AND (routine dental environment)

Table 2: MESH terms used to search articles

Population	Intervention	Comparison	Outcome
Autism Autism spectrum disorders Children	Sensory adapted dental environment, SADE	Routine dental environment	Dental anxiety Patient distress Discomfort Pain

Table 3: Study characteristics

Study ID	Place of study	Study design	Sample size	Age	Gender M/F	Intervention – SADE	Control	Treatment performed	Outcomes assessed	Author conclusions
Cermak 2015	USA	RCT cross over	22	6-12	10/12	Darkening curtains, fluorescent lighting, rhythmic music, butterfly shaped wrap fit for tactile stimulus	Routine dental environment	Dental cleaning, fluoride application	Physiological stress, anxiety, dental behavior, pain, discomfort	Use of the sensory adapted dental environment shows utility and positive treatment effect sizes.
Fallea 2022	Italy	Non RCT crossover	50	9-10	36/--14	SADE was provided with a screen to project movies, cartoons, or advertisements, soft lighting, and a sponge-coated dental turbine drill to minimize the noise.	Routine dental environment3	Class I cavity restoration	Number of children treated	Results suggest that a sensory-adapted environment positively affects the therapeutic dental treatment in patients with ASD and reaffirm hat sensory dysregulation in children with ASD is a crucial factor influencing the successful outcome of oral care
Duker 2023	USA	RCT cross over	138	6-12	114/24	Provided using overhead fluorescent lights, darkening lights, slow moving visual effects, calming music, butterfly wrap fit for tactile stimulus	Routine dental environment	Dental cleaning	Physiological stress, anxiety - electrodermal activity, dental behavior, pain, discomfort	Findings support the use of SADE to significantly improve both physiological and behavioral distress in this population during routine dental cleanings. Use of SADE is relatively inexpensive, scalable, and easy to implement with minimal training
Antosh 2024	USA	RCT parallel	IG: 30, CG:28	7.2+-2.9	43/15	Provided using specific equipment - portable popcorn tube with fiberoptic cart, handheld marble panel, color changing floor tiles, sensory fidgets (including pop its, chewies, sensory brushes, squeeze balls, and sensory chairs), and individual sensory toys	Routine dental environment	Extraction	Anxiety using Modified Yale Preoperative Anxiety Scale (mypas)	Our study did not provide evidence that an ASE based on a patient's individualized coping plan is effective in decreasing preoperative anxiety in patients with ASD with high sensory sensitivities compared to patients in a control group.