8 APPRAISAL

8.1 SUMMARY OF THE FINDINGS

The internal validity of effectiveness of adaptive yoga intervention is established based on visual analysis, the effectiveness is supplemented by non-overlap method NAP and statistical significance using Cohen's d. The impact of intervention shows effectiveness across all cognitive, behavioural, and emotional domains; and across participant replications. This establishes external validity of the impact.

Effect size using NAP shows for the 122 observable parameters across baseline vs. intervention phases (institute and home settings) having 18% as not significant, 24% as moderately significant, 44% as significant and 14% as insignificant. Similarly, effect size using *Cohen's d* shows 34% of data has significant effect, 8% of data shows moderately significant and 13% of data shows less significance. 32% of data shows the intervention impact is positive, however, insignificant and 13% of data shows opposite effect.

8.2 CONCLUSION

This is a single case experimental design to study the impact of adaptive yoga intervention on the children with multiple disabilities with ASD and ID. The result suggests that a long term, consistent one-to-one adaptive yoga intervention can effectively improve the cognitive, behavioural, and emotional conditions of children having ASD and with ID. The results are observed to be satisfactory and shows mild to moderate change in each of the psychological areas for all six participants. This study establishes the potential of yoga interventions in the field of multiple disabilities.

8.3 IMPLICATIONS OF THE STUDY

This study now establishes the change in functional behavior across cognitive, behavioural,

and emotional domains for children with ASD and with ID along with empirical evidence. This study now is subject to further research by replications across increased number of participants, on other psychological parameters, geographical conditions, varied severity levels with similar combinations of multiple disability, longitudinal study etc. In future, cross functional effectiveness of other therapies practiced along with yoga intervention as a complementary therapy can be researched.

The study will unlock the perspectives of caregivers, institutions in assessing the feasibility and acceptability of yoga practices in the context of their daily routines and overall care strategies.

8.4 APPLICATION OF THE STUDY

This study unfolds multiple applications. In the field yoga, this study proposes an approach to design and deploy adaptive teaching methodology without compromising the principles of classical yoga. This learning principle spans across multiple age groups and conditions, like children, adult and geriatric conditions having difficulty in following regular yoga practices. This study unlocks the possibility of institutionalizing the yoga practice as an additional therapy for children or people with special needs. The outcome of this study can be shared with caregivers and practitioners to appreciate, apply in their engagements handling children with special needs.

8.5 STRENGTH OF THE STUDY

The strength of the study are as follows:

- A systematic empirical study establishes the functional relationship between yoga intervention and its impact on psychological health of children with multiple disability having developmental disorders.
- A multiple stakeholder involvement provides confidence in parents and clinical

practitioners to observe and appreciate the gradual change in children cognitive, behavioural, and emotional faculty due to yoga intervention.

- An adaptive *yoga* teaching approach and simplification of *yogāsanas* without compromising the principles of yoga made this ancient technique more acceptable and accessible.
- The use of Single Case Experimental Design (SCED) is able to establishes both internal and external validity even with smaller subjects by power of continuous assessments, replication, randomization and rigor in design methodology.

8.6 LIMITATIONS OF THE STUDY

The limitations of the study are as follows:

- This study was done with small size of participants and one interventionist.
- There was no clear evidence for attendance of practice in home settings. Thus, the results obtained in home settings can be a carry forward effect from institute intervention or due to continued practice, is inconclusive.
- There is a scope to consider the factor of change from one setting to another setting and validate the effect.
- There is scope to blind the assessors in study by randomizing the participant assignment for evaluation.
- The caregiver's involvement and dedication as one of the predictors was not taken into consideration for this study.
- The participants continued with their other regular therapies along with this intervention may have cross functional effects that was kept out of scope for this study.

8.7 SUGGESTIONS FOR FUTURE STUDIES

- Scope for scaling the study with larger replications with a greater number of yoga

interventionists.

- Scope for cross functional effects comparing yoga intervention and other interventional therapies for the children.
- Scope for a comparative study of specific *yoga* interventions like *āsana* and *prāṇāyama* and its impact on respective cognitive, behavioural, and emotional domains of the children with multiple disabilities. i.e., a multiple interventions strategy of *yoga* interventions and its impact.
- Scope for a comparative study on effectiveness of classical yoga teaching methodology and *yoga* practices verses adaptive *yoga* teaching methodologies and adaptive *yoga* practices.

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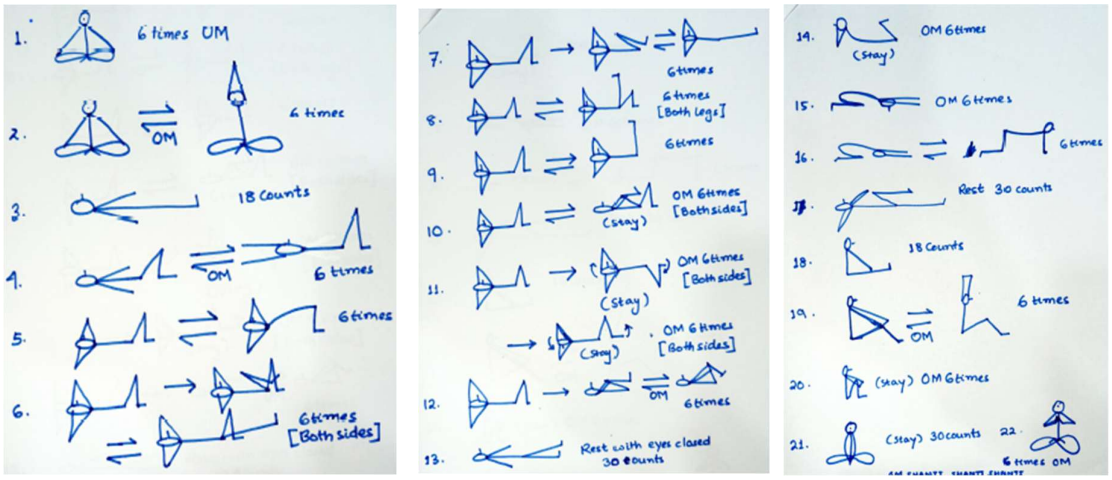
APPENDIX – 1: SAMPLE COURSE PLAN

Sample Course Plan (45-60 minutes)		
Seq No.	**Activity**	**Duration & Remarks**
1	Starting Prayer "*AUM*" Chanting	3 Rounds (in any comfortable seated position)
2	Arms Up and Down with Syllable Chanting	Any choice of syllable
3	Standing *Samasthiti*	-
4	*Tādāsana* (Palm Tree)	6 Rounds (with heels down)
5	*Uttānāsana* (Standing Forward Bend)	6 Rounds
6	*Shavāsana* (Corpse)	-
7	Lying Supine *Samasthiti*	-
8	*Dvīpādapīṭham* (Bridge)	6 Rounds
9	*Apānāsana* (Knees to Chest)	6 Rounds
10	*Shavāsana* (Corpse)	-
11	Lying prone *Samasthiti*	-
12	*Bhujangāsana* (Cobra)	-
13	Prone rest	-
14	Kneeling *Samasthiti*	-
15	*Bālāsana* to *Mārjariāsana* (Child to Cat)	6 Rounds
16	Seated rest	-
17	*Dandāsana* (Seated *Samasthiti*) (Stick)	6 Rounds (with arms raised across the ears)
18	Seated rest	-
19	Closing Prayer "*AUM Shanti*"	3 Rounds in any comfortable seated position)

APPENDIX – 2: SAMPLE SESSION PLAN

Sample yoga protocol prescription shared with the caregiver as reference during the transition workshop before the start of home setting intervention.



APPENDIX – 3: SAMPLE INTERVENTION & ASSESSMENT PLAN

Subject	
Intervention Start Da	06-Apr-22
Intervention End Dat	06-Jan-23
No. of Assessments	26
Baseline Assesment	8
Assessment Setting	12
Assessment Setting	6

Legend
Baseline
Intervention (Set1)
Intervention (Set2)
Assessment

Dec-21

Mo	Tu	We	Th	Fr	Sa	Su
		1	2	3	4	5
6	7	8	9	10	11	12
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Jan-22

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Feb-22

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Mar-22

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Apr-22

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May-22

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Jun-22

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Jul-22

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Aug-22

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Sep-22

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Oct-22

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24	25	26	27	28	29	30
31						

Nov-22

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28	29	30				

Dec-22

Mo	Tu	We	Th	Fr	Sa	Su
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APPENDIX – 4: INFORMED CONSENT FORM

INFORMED CONSENT FORM

This Informed Consent Form (ICF) is for the parents of children diagnosed with autism spectrum disorder and intellectual disability by NIEPMD. This is for only those who we are asking to participate in this study of impact of *yogāsana* on psychological areas.

Name of the study: Impact of *yogāsana* integrated with chanting of syllable on children with autism spectrum disorder and intellectual disability (multiple disabilities) for cognitive, emotional, and behavioural skills.

Name of Principal Investigator: <<name>>, Research Scholar, **e-mail:** <<email>>

Name of Organization(s): NIEPMD and S-VYASA Yoga University

This Informed Consent Form has two parts:

Part I: Information Sheet (to share information about the study with you)

Part II: Certificate of Consent (for signatures if you agree that your child may participate)

You will be given a copy of the full Informed Consent Form

PART I: Information Sheet

Introduction

I am <<Name>>, a research scholar at Swāmi Vivekānanda Yoga Anusandhāna Samsthāna (S-VYASA). I am a certified yoga professional. I am visually challenged person with partial sight, however, can manage my day today activities independently. I am doing research study on the effect of yogāsana on children with multiple disabilities at NIEPMD (Divyangjan), Chennai. I am going to give you information about the study and inviting you and your child to participate in this study. You do not have to decide today whether you will participate in this research. Before you decide, you can talk to anyone you feel comfortable with.

There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them to me again or the NIEPMD point of contact.

Purpose of the Research

Children having Autism Spectrum Disorder(ASD) with Intellectual Disability (ID) in general have cognitive, emotional and behavioural challenges. With help of yogāsanā practice this study will try to see any change in these psychological areas of these children.

Type of Research Intervention

One-to-one yogāsana practice with proper breathing. This practice will be along with yoga teacher, child and parent or caregiver.

Participant Selection

This study includes children having ASD with ID, age between 7-12 years, joining along with their parent or caregiver. The parent or caregiver willing to participate in this study for a period of nine months.

Voluntary Participation

Your decision to have your child participate in this study is entirely voluntary. It is your choice whether to have your child participate or not. If you choose not to consent, all the services you and your child receive at NIEPMD will continue and nothing will change. You may also choose to change your mind later and stop participating, even if you agreed earlier, and the services you and/or your child receives at NIEPMD will continue.

Procedures and Protocol

Description of the Process

The yogāsana practice will be done at NIEPMD. You will stay with your child during each of the sessions and participate in the practice along with the yoga teacher(myself). For the purpose of this study, your child will have to discontinue the regular yoga practice as part of the NIEPMD school. This will be the only yogāsana practice throughout the duration of the study.

This study requires continuous observations and assessments to see the effectiveness. The assessments will be done by the NIEMD professionals on regular intervals before, during and after the study. This study will require access to the current status of your child and medical history to compare with against the observation during the study.

The practice will include simple and basic yoga postures according to the comfort and capacity of the child and will be further simplified if required. Any yogāsana practice is beneficial if integrated with appropriate breathing. To achieve this we will include syllable chanting to regulate exhalation during the practice. This will in turn improve the inhalation naturally [Explained with simple demonstration].

Before we start practicing with children, we will arrange few practice sessions for parents to understand your role during the session, getting familiar and comfortable with the yogāsana course plan. We will also arrange similar sessions throughout nine months of practice if required.

Duration

The yogāsana practice will be given by me one-to-one along with you for 45 minutes in first 3 months and 60 minutes next three months everyday, five days a week for six months at NIEPMD. We will ask you to continue the practice plan of 60 minutes at home on your own in absence of yoga teacher for next three months in same manner. Once in two weeks I will take one session during last three months to support the practice or clearing any doubts. Overall the study will be for nine months.

Side Effects and Risks

This practice will be an easy and safe as per the child's comfort and capacity. However, in general, there are contra-indications associated with yogāsanās if not performed properly and without expert guidance. This is recommended to follow the practice as prescribed by the yoga teacher only, to avoid any such adverse situations. In case of any discomfort experienced due to practice expressed by the child, this needs to be brought into the notice of the yoga teacher immediately to help understanding the problem and correct the practice accordingly.

Benefits

Yoga has proven to be a very useful for overall health and wellbeing. We will attempt to see if yogāsanās are beneficial for children with special needs with multiple disabilities on the psychological areas. The results of this work will be known only at the end of the study. There may not be any other benefit for your child but his/her participation is likely to help us find the answer to the research question. There may not be any benefit to the society at this stage of the research, but future generations are likely to benefit and will open doors for other researchers in this field.

Reimbursements

This yogāsana practice will be offered at no charge to you. All assessments will be carried out at NIEPMD. You will not be provided with any other incentives to take part in this research.

Confidentiality

The information that we collect from this study will be kept confidential. Information about you and your child that will be collected from the study will be put away and no-one but the researcher (myself), professionals assessing from NIEPMD will be able to see it. Any information about your child will have a number on it instead of his/her name for the purpose of reporting and publication. The detailed assessments reports will be maintained as records and copy will be available with NIEPMD and myself and my research support staff. The personally identifiable information about the subject will be protected and will not be shared with or given to anyone except authorised personnels from NIEPMD, myself and my research support staff.

Sharing the Results

The knowledge that we get from doing this research will be shared with you before it is made widely available to the public. Confidential information will not be shared or published.

Right to Refuse or Withdraw

You do not have to agree to your child taking part in this research. If you do not wish to do so and refusing to allow your child to participate, will not affect your treatment or

your child's treatment at NIEPMD in any way. You and your child will still have all the benefits that you would otherwise have at NIEPMD. You may stop your child from participating in the research at any time that you wish without either you or your child losing any of your rights as a client here. Neither your treatment nor your child's treatment at NIEPMD will be affected in any ways.

Who to Contact:

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact following:

- <<name>>, <<phone no.>>, <<email>>
- <<name>>, <<phone no.>>, <<email>>

This proposal has been reviewed and approved by NIEPMD Research Committee, undersigned by << >>, Dy. Registrar, NIEPMD, Chennai and S-VYASA Doctoral Committee, undersigned by << >>, Dean of Academic, S-VYASA, Bengaluru. These are the designated committees whose task it is to make sure that research participants are protected.

<<name>> (Research Scholar): Tel: <<phone no.>>. Email: <<email>>
NIEPMD: Tel: <<email>> Email: <<email >>
S-VYASA University: Tel: <<phone no.>> Email: <<email>>

Part II: Certificate of Consent

Certificate of Consent

I have been invited to have my child and me participate in research of yogāsana and its impact on children having autism with intellectual disability. I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily for my child and myself to participate as a participant in this study.

Name of Participant:
Name of Parent or Guardian:

Signature of Parent or Guardian:

Date : _____

Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the parent of the potential participant, and to the best of my ability made sure that the person understands that the following will be done:

1. Participation of the children along with the parent for the entire period of intervention.
2. Only the prescribed yogāsana practice will be administered for nine months.
3. First six months of practice will be along with yoga teacher in NIEPMD and last three months will be independently at home.

I confirm that the parent was given an opportunity to ask questions about the study, and all the questions asked by the parent have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

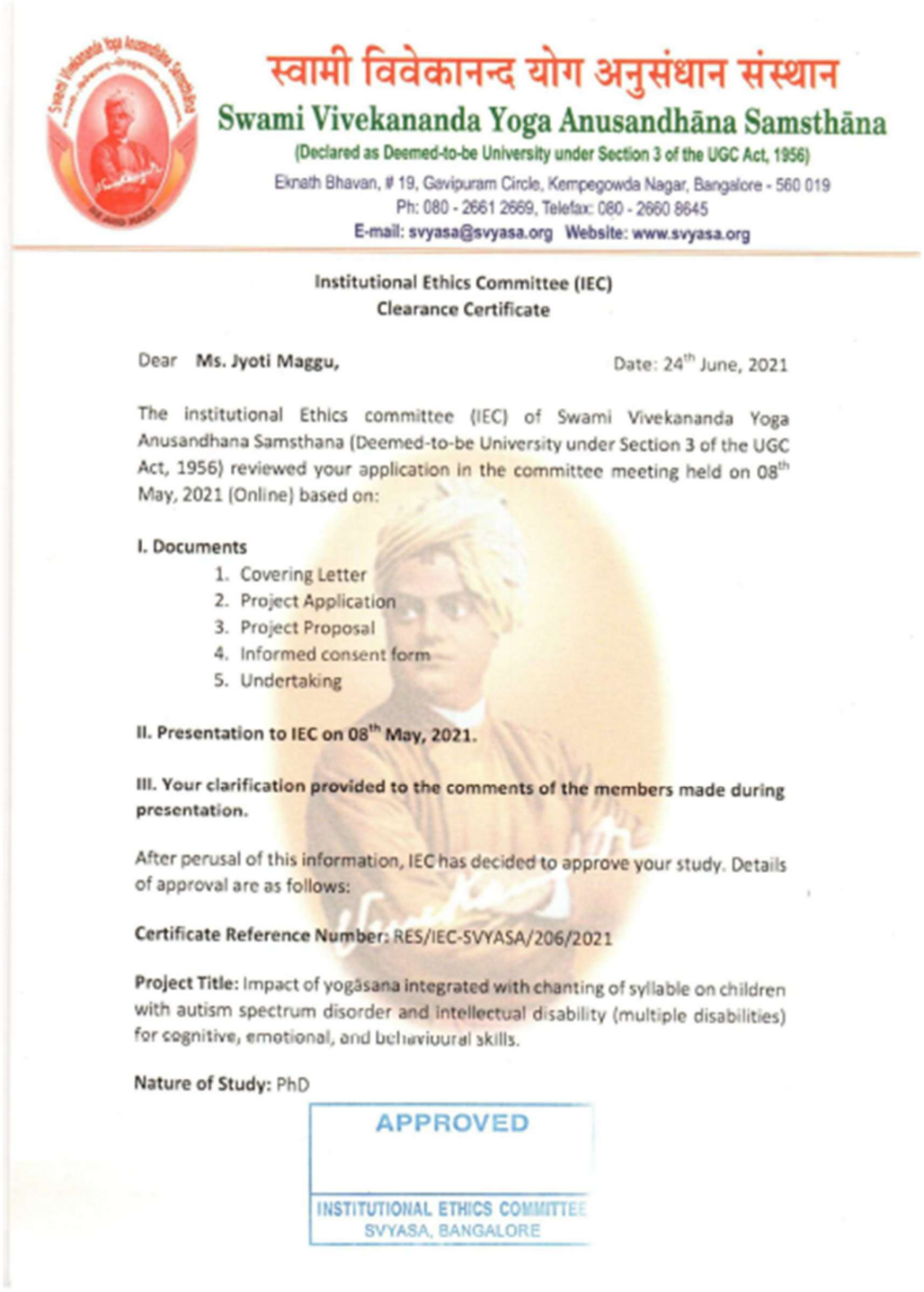
Name of Researcher/person taking the consent:

Signature of Researcher /person taking the consent:

Date : _____

Day/month/year

APPENDIX – 5: INSTITUTIONAL ETHICS COMMITTEE LETTER



स्वामी विवेकानन्द योग अनुसंधान संस्थान

Swami Vivekananda Yoga Anusandhāna Samsthāna

(Declared as Deemed-to-be University under Section 3 of the UGC Act, 1956)

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Ph: 080 - 2661 2669, Telefax: 080 - 2660 8645

E-mail: svyasa@svyasa.org Website: www.svyasa.org

Institutional Ethics Committee (IEC)
Clearance Certificate

Dear **Ms. Jyoti Maggu,** Date: 24th June, 2021

The institutional Ethics committee (IEC) of Swami Vivekananda Yoga Anusandhana Samsthana (Deemed-to-be University under Section 3 of the UGC Act, 1956) reviewed your application in the committee meeting held on 08th May, 2021 (Online) based on:

I. Documents

1. Covering Letter
2. Project Application
3. Project Proposal
4. Informed consent form
5. Undertaking

II. Presentation to IEC on 08th May, 2021.

III. Your clarification provided to the comments of the members made during presentation.

After perusal of this information, IEC has decided to approve your study. Details of approval are as follows:

Certificate Reference Number: RES/IEC-SVYASA/206/2021

Project Title: Impact of yogāsana integrated with chanting of syllable on children with autism spectrum disorder and intellectual disability (multiple disabilities) for cognitive, emotional, and behavioural skills.

Nature of Study: PhD

APPROVED

INSTITUTIONAL ETHICS COMMITTEE
SVYASA, BANGALORE

स्वामी विवेकानन्द योग अनुसंधान संस्थान
Swami Vivekananda Yoga Anusandhāna Samsthāna
(Declared as Deemed-to-be University under Section 3 of the UGC Act, 1956)
Eknath Bhavan, # 19, Gavipuram Circle, Kempegowda Nagar, Bangalore - 560 019
Ph: 080 - 2661 2669, Telefax: 080 - 2660 8645
E-mail: svyasa@svyasa.org Website: www.svyasa.org

Authorised Personnel: Ms. Jyoti Maggu, Dr. Ravikumar Itagi

Approval Period: 02 Years

Condition of approval

- Research must be conducted according to the approved proposal.
- Report has to submitted to IEC on completion of study.
- Violation/deviation from the approved proposal has to be notified to IEC.
- The authorised personnel will comply to request for audit from IEC.
- IEC retains right to withdraw or amend this approved clearance certificate.

Please contact undersigned member Secretary if you have any queries / need clarification.

IEC wishes you all the best.

Dr. Ramesh M N
Member Secretary,
Institutional Ethics Committee,
S-VYASA, Bengaluru.

Member Secretary
Institutional Ethics Committee
Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA)
No. 19, Eknath Bhavan, Gavipuram Circle
K.G. Nagar, Bangalore-560019

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Deemed to be University u/s 3 of the UGC Act, 1956
#19, 'Eknath Bhavan', Gavipuram Circle, Kempe Gowda Nagar, Bengaluru – 560 109
ph: 080-2661 2669 | e-mail: info@svyasa.edu.in | www.svyasa.edu.in

Institutional Ethics Committee (IEC-SVYASA)
Addendum

Ref: RES/IEC-SVYASA/206/2021/ADD1

To,

Date: 30th June, 2025

Jyoti Maggu
PhD Scholar,
S-VYASA Yoga University,
Bangalore

Reference:

1. IEC approved study number (RES/IEC-SVYASA/206/2021)
2. Request for the change in the study title in the email dated 16th May 2025.

Dear Jyoti Maggu,

In response to your request for the change in study title from "Impact of Yogāsana Integrated with Chanting of Syllable on Children with Autism Spectrum Disorder and Intellectual Disability (Multiple Disabilities) for Cognitive, Emotional, and Behavioural Skills" to "Impact of Adaptive Yogāsana on Psychological Health of Children having Autism Spectrum Disorder and with Intellectual Disability (Multiple Disabilities): A Single-Case Experimental Design" for the previously IEC-SVYASA approved study (RES/IEC-SVYASA/206/2021), and finding the justification provided (email dated 23rd June 2025) to be acceptable, we hereby are issuing an addendum to the certificate issued on 24th June, 2021.

The IEC-SVYASA approves the change. All the other terms and conditions mentioned (if any) in the original certificate continue to hold good.

Please retain the original certificate and append this addendum for all official purpose.

Best Wishes,

Dr Ramesh M N
Member Secretary,
Institutional Ethics Committee,
S-VYASA, Bengaluru.

Member Secretary
Institutional Ethics Committee (IEC)
S-VYASA University,
Bengaluru

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Swami Vivekananda Yoga Anusandhāna Samsthāna
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Eknath Bhavan, # 19, Gavipuram Circle, Kempegowda Nagar, Bangalore - 560 019
Ph: 080 - 2661 2669, Telefax: 080 - 2660 8645
E-mail: svyasa@svyasa.org Website: www.svyasa.org

Date: April 1st, 2021

DOCTORAL COMMITTEE CLEARANCE CERTIFICATE

This is to certify that **Ms. Jyoti Maggu** (Registration No: PhD/Res/02/Jan16), a research scholar under the Division of Yoga & Physical Sciences has successfully presented her research topic titled **"Impact of Yogāsana Integrated with Chanting of Syllable on Children with Multiple Disabilities (Autism Spectrum Disorder and Intellectual Disability) For Cognitive, Emotional, And Behavioural Skills."** on 8th March 2021 at 12:00PM at S-VYASA, a Deemed-to-be University under the Research Supervisors. **Dr. Itagi Ravi Kumar,** Associate Professor of Division of Yoga & Physical Sciences. The study was approved by the doctoral committee.

The research scholar is allowed to continue her research work further under the research supervisor.

Dr. R Chandrasekhar
Dean of Academic
S-VYASA, Deemed-to-be University,
Bengaluru

NATIONAL INSTITUTE FOR EMPOWERMENT OF PERSONS WITH MULTIPLE DISABILITIES (Divyangjan)

(Dept. of Empowerment of Persons with Disabilities (Divyangjan), MSJ & E, GOI)

ECR, Muttukadu, Kovalam Post, Chennai 603 112, Tamil Nadu

Fax: 044-27472389 Tel: 044-27472104, 27472113&27472046

Website: www.niepmd.tn.nic.in E-mail: niepmd@gmail.com

No.: NIEPMD/R&D.20 (14)/2021/ March 03, 2021

To,

Smt.Jyoti Maggu
Research Scholar,
Swami Vivekananda Yoga Anusandhana Samsthana,
Bangalore.

Sub: Permission to collect Data from NIEPMD-reg.
Ref.: Your Email dated 26th February 2021.

Madam,

With reference to your review letter for collecting data from NIEPMD for your Ph.D., Study titled **"Impact of Yogasana Integrated with Chanting of Syllable on Children with Autism Spectrum Disorder and Intellectual Disability (Multiple Disabilities) for Cognitive, Emotional and Behavioral Skills"** is approved by the Research Committee of NIEPMD. Accordingly, you are permitted to collect required data from clients of NIEPMD. The Department of Special Education & Clinical Psychology will extend the necessary support for data collection.

Thanking you,

(Dr.A.Amarnath)
Dy. Registrar (A) (Offg.)

NIEPMD Chennai-603 112

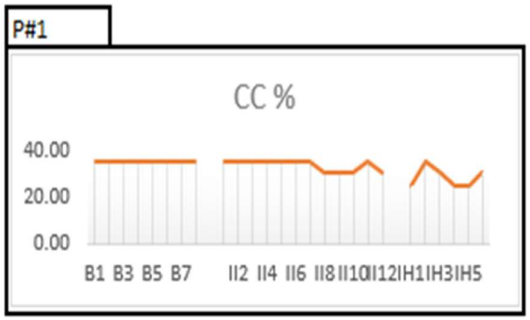
Copy to:

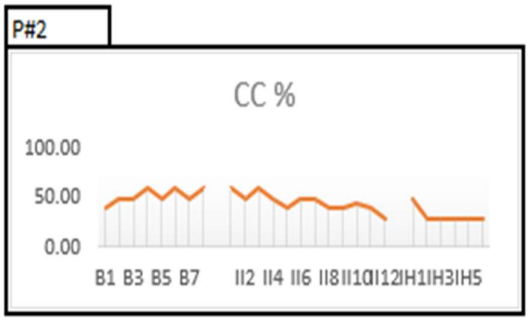
1. HoD-Spl. Edn.
2. HoD-Cli. Psy.

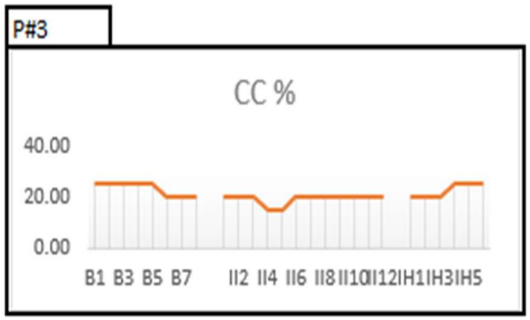
Dr. A. AMARNATH,
M.A., M.Phil., Ph.D., P.G.Dip., Dev.Reha., M.Ed(MD).,
Dy. Registrar (Admin.)
National Institute for Empowerment of Persons with Multiple Disabilities (Divyangjan) (NIEPMD)
DEPwD, MSJ&E, Govt. of India
ECR, Muttukadu, Kovalam, Chennai-603112.

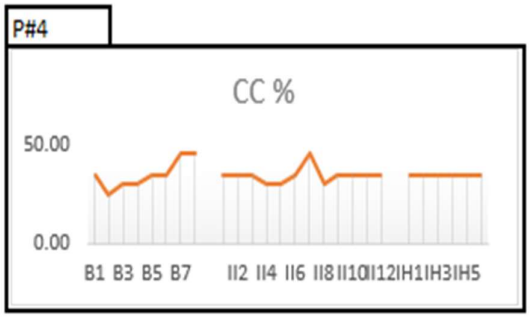
APPENDIX – 6: COGNITIVE PARAMETERS

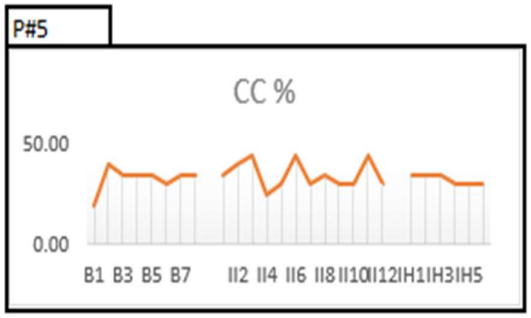
Graphs 1: Cognitive Component

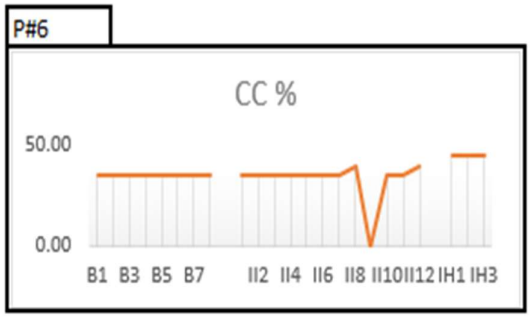




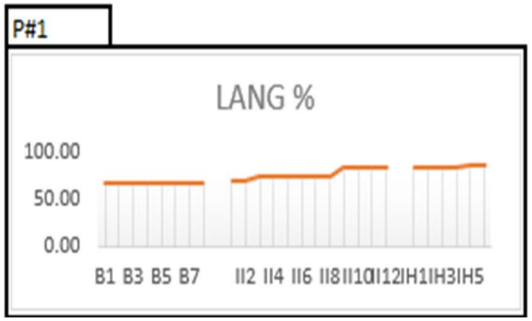


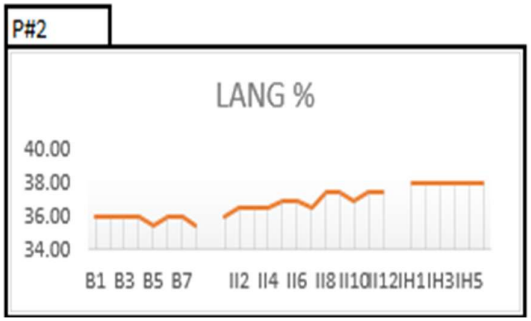


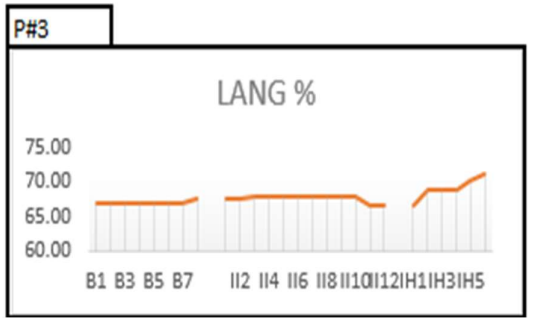


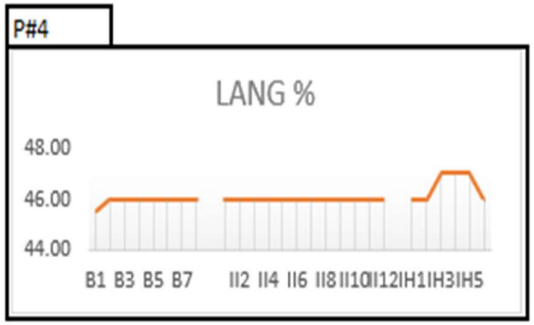


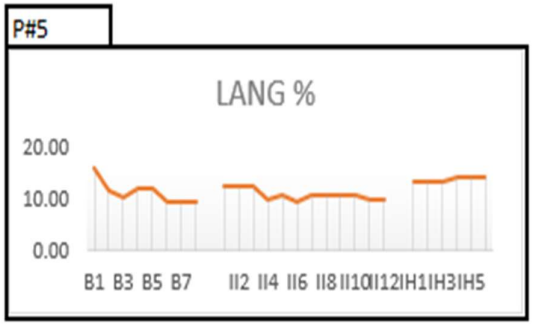
Graphs 2: Language

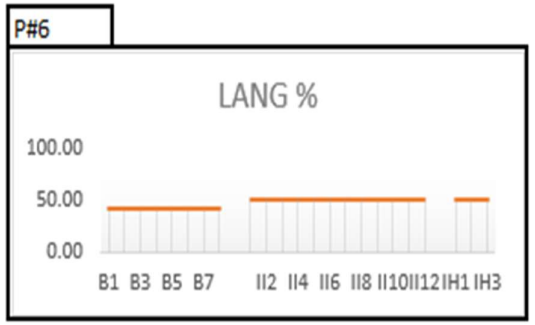




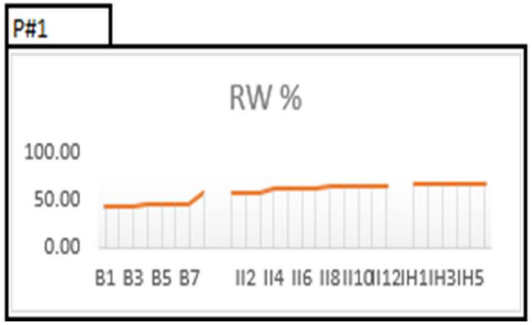


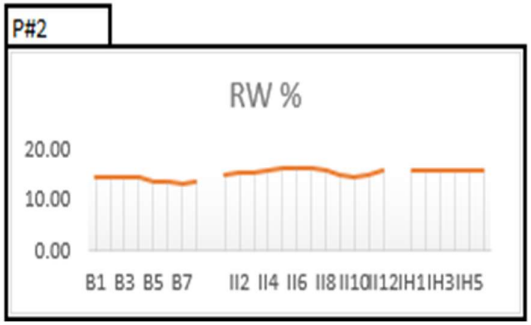


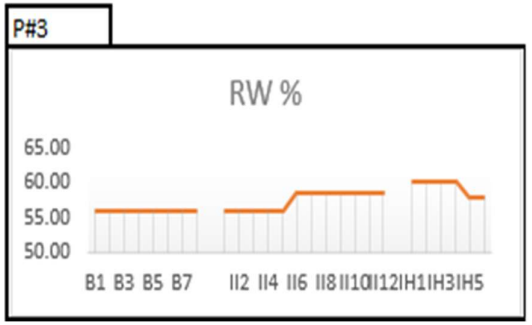


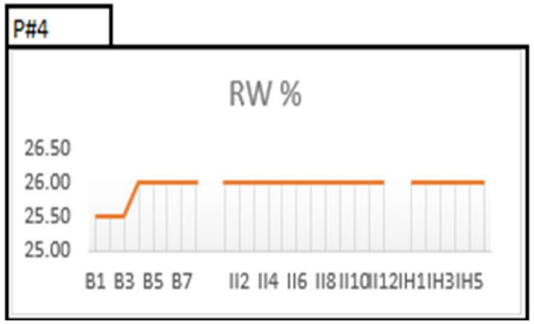


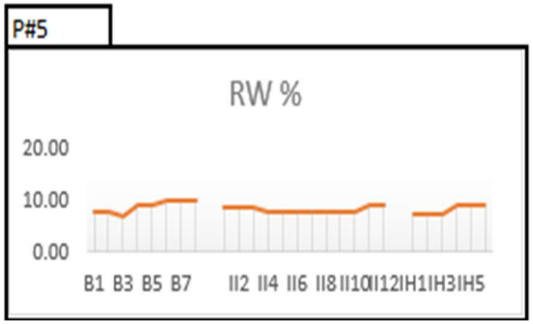
Graphs 3: Reding-Writing

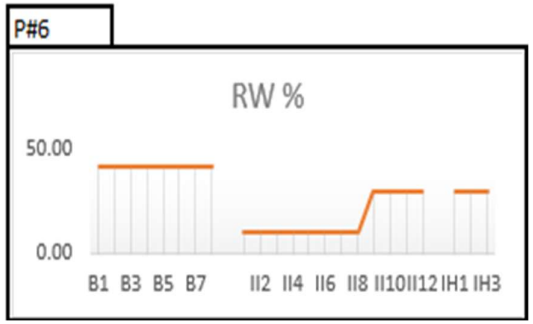




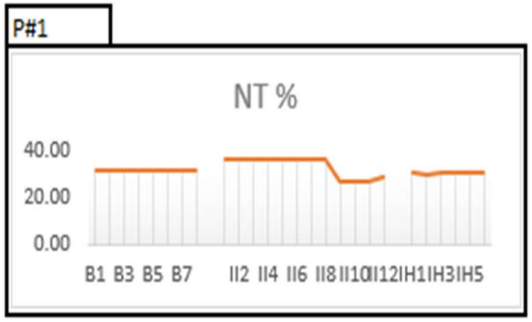


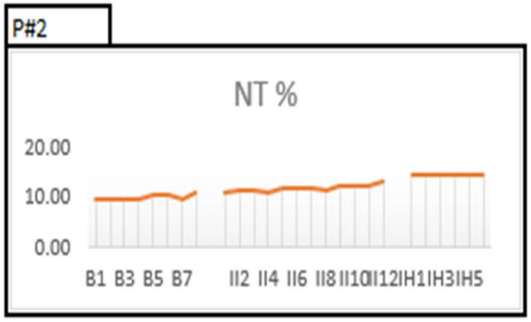


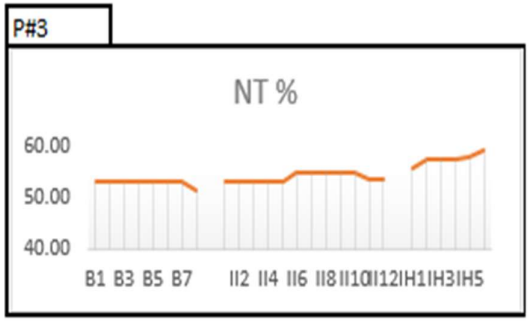


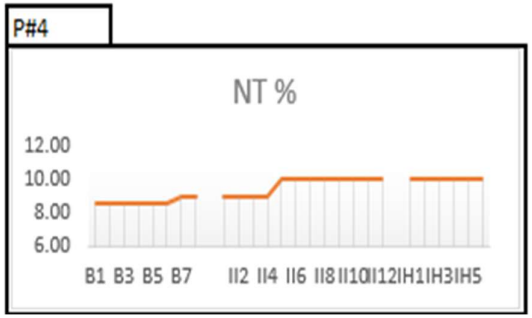


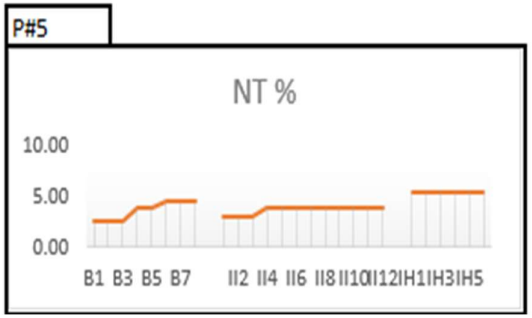
Graphs 4: Number-Time

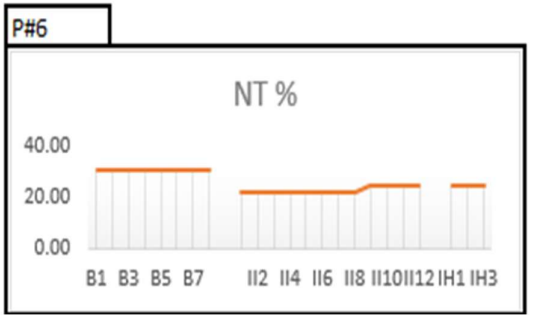






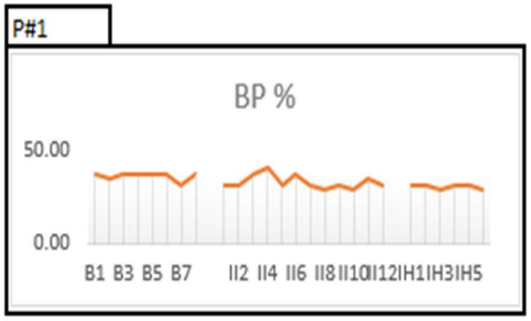


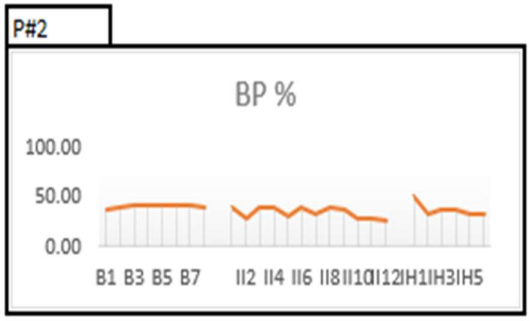


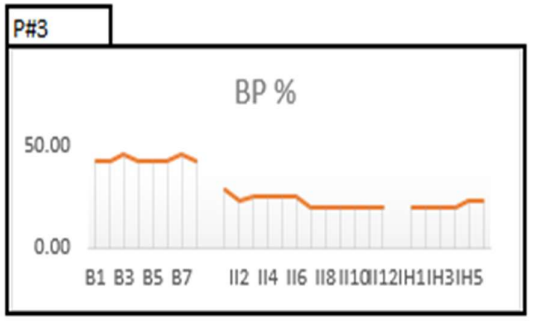


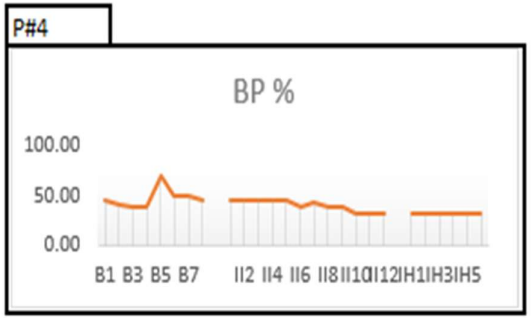
APPENDIX – 7: BEHAVIOURAL PARAMETERS

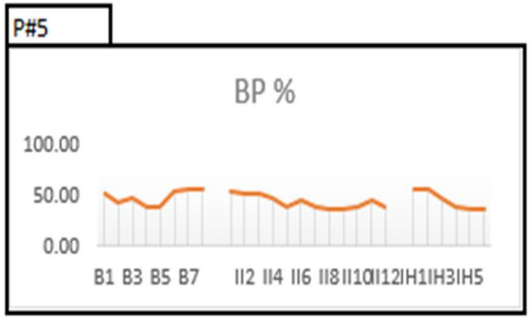
Graphs 5: Behaviour Patterns

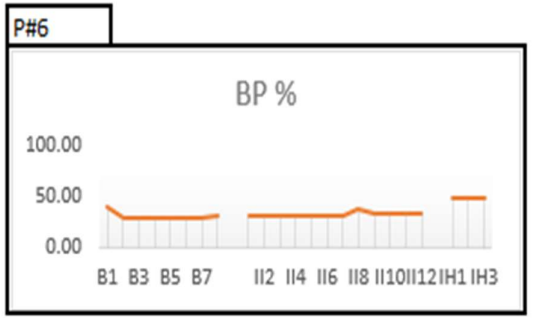




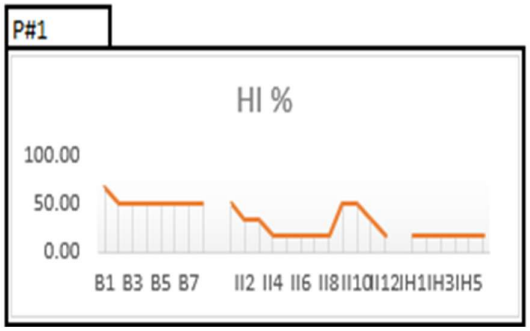


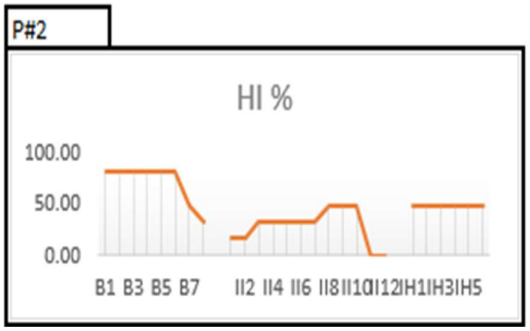


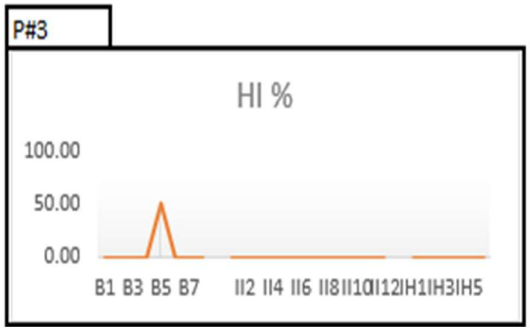


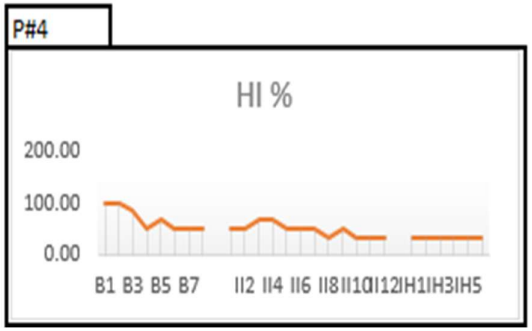


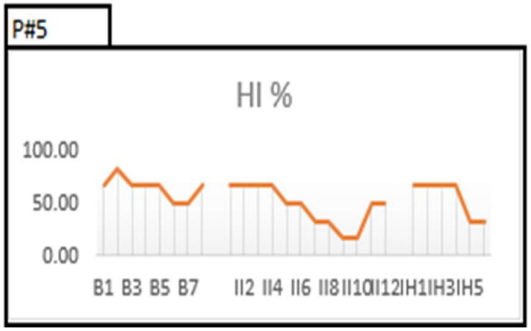
Graphs 6: Hyperactivity and Inattention

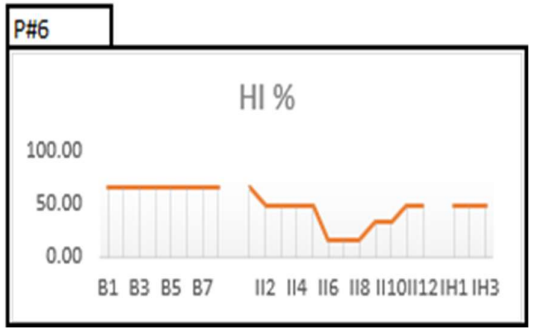




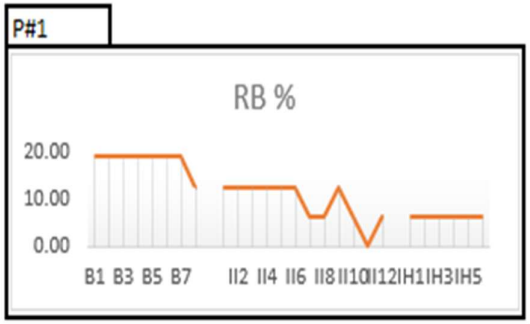


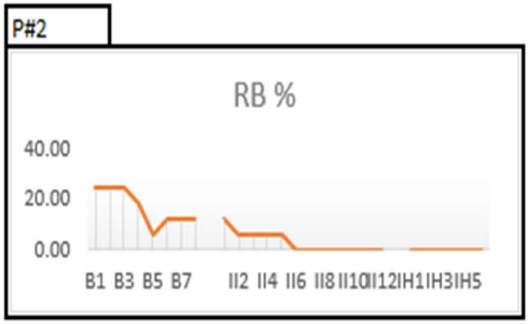


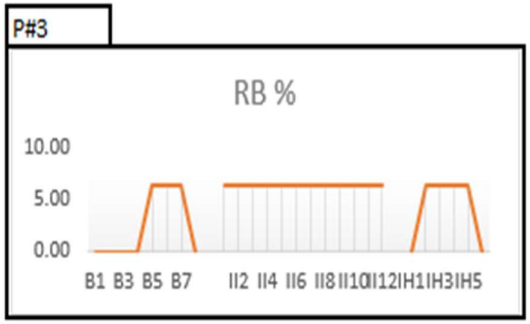


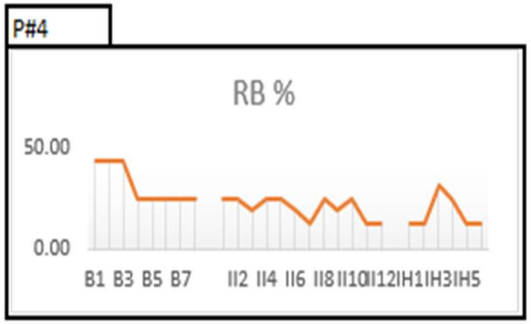


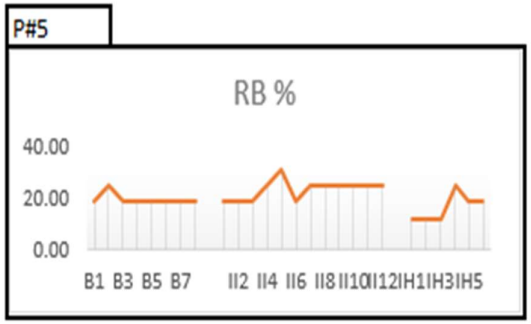
Graphs 7: Repetitive Behaviour

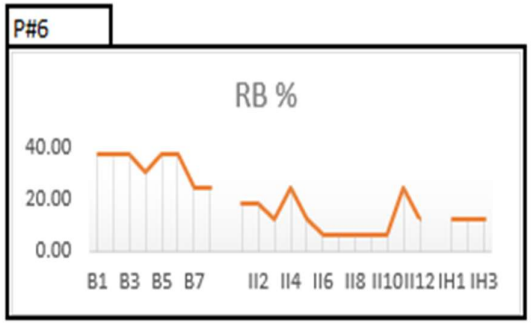






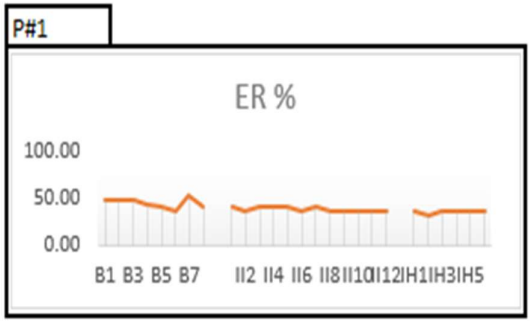


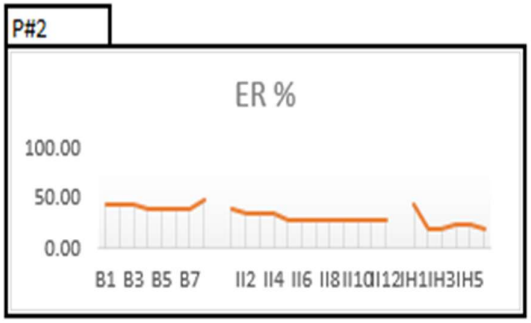


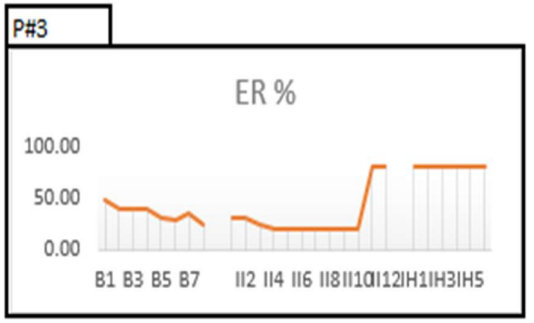


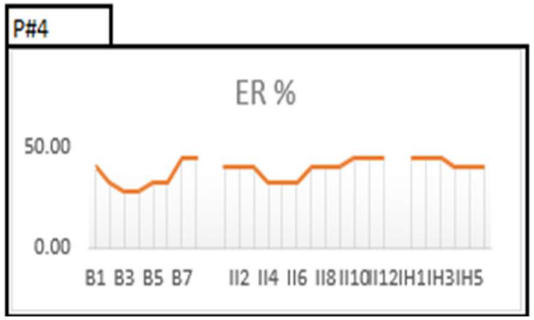
APPENDIX – 8: EMOTIONAL PARAMETERS

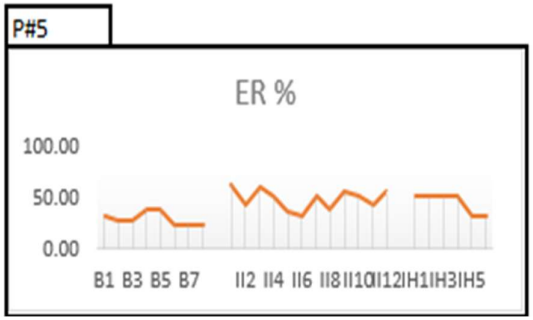
Graphs 8: Emotional Responsiveness

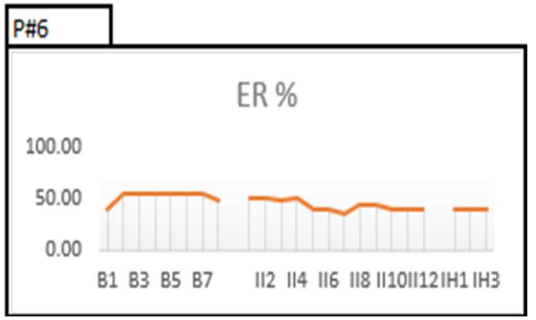




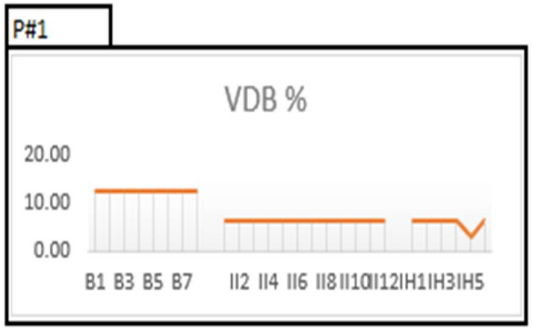


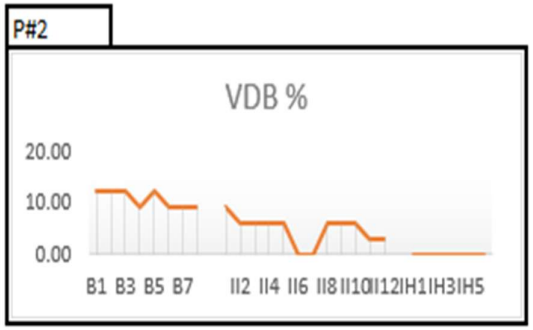


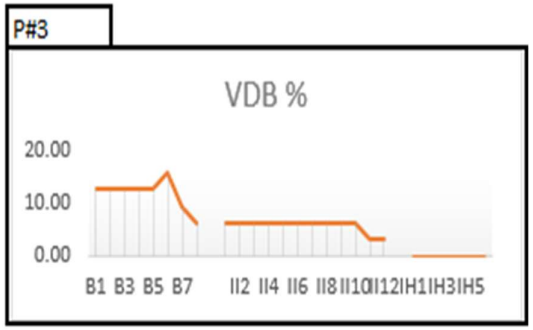


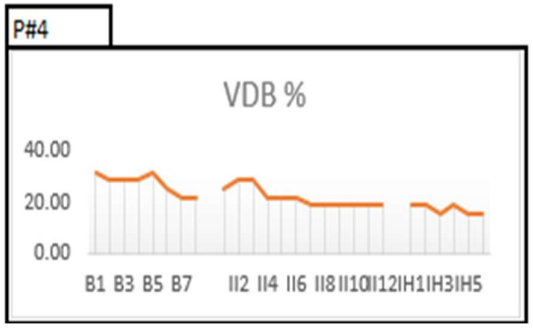


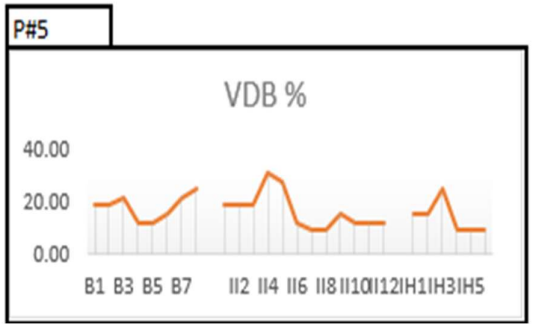
Graphs 9: Violent and Destructive Behaviours

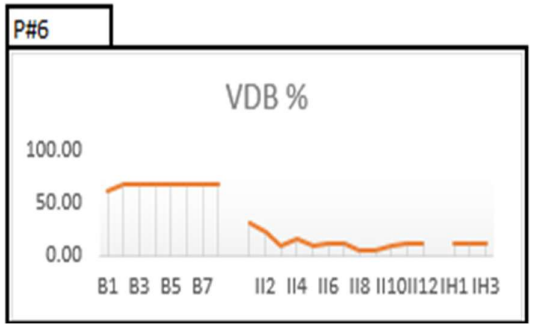




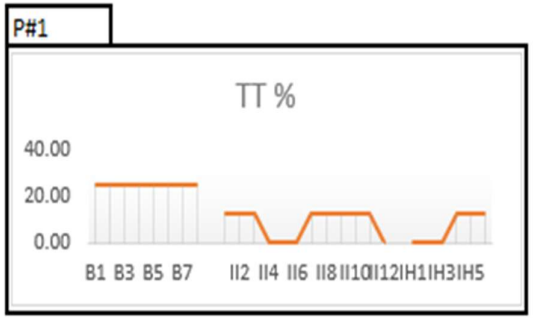


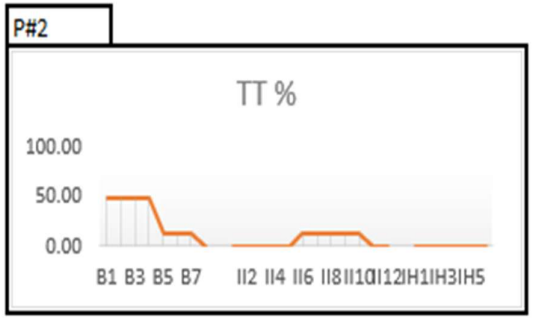


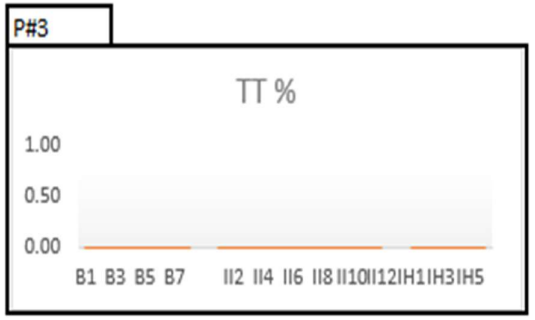


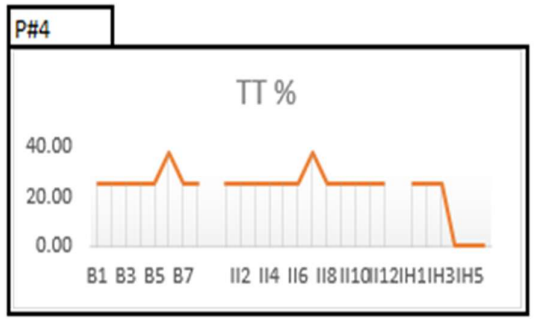


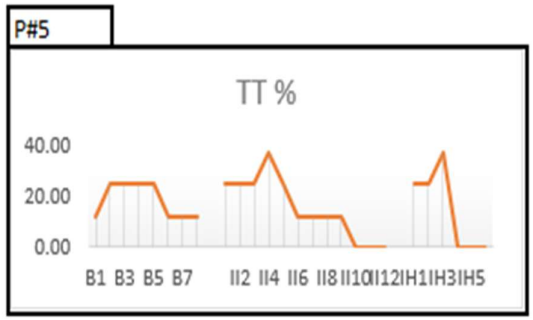
Graphs 10: Temper Tantrums

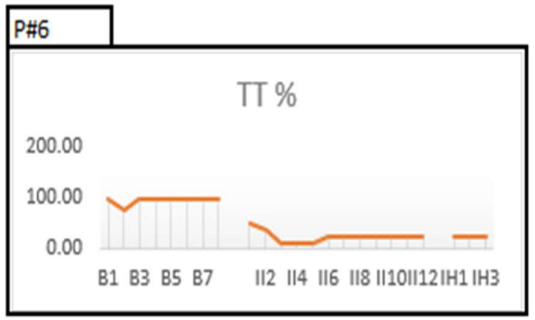




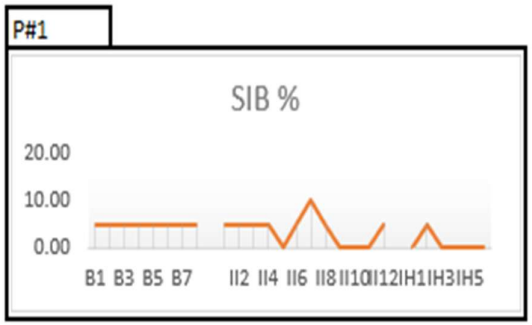


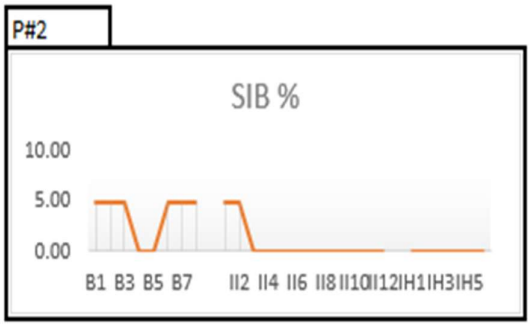


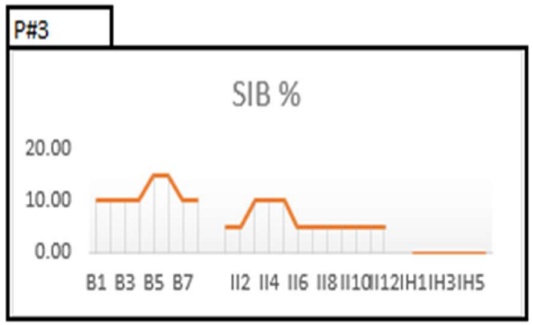


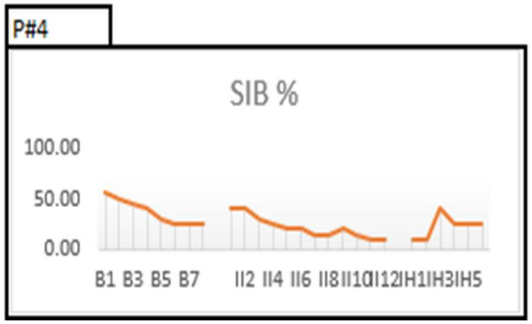


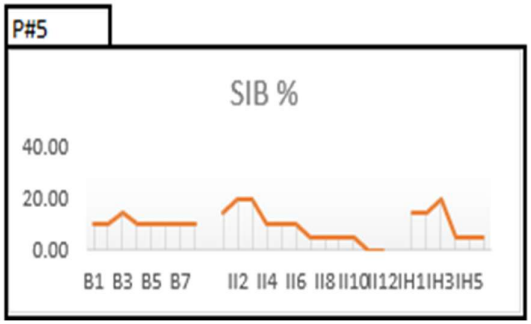
Graphs 11: Self-Injurious Behaviours

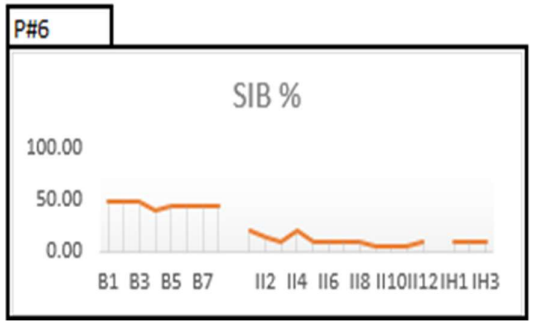




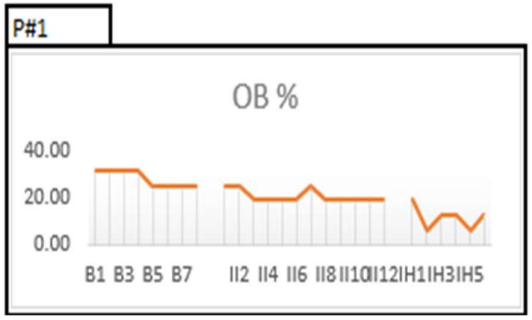


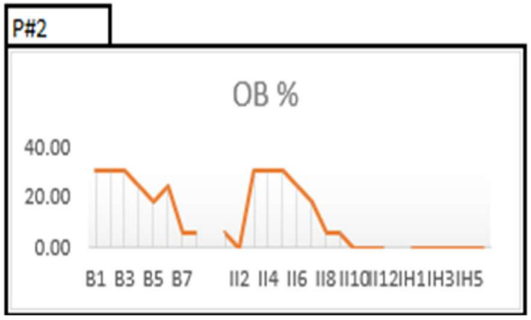


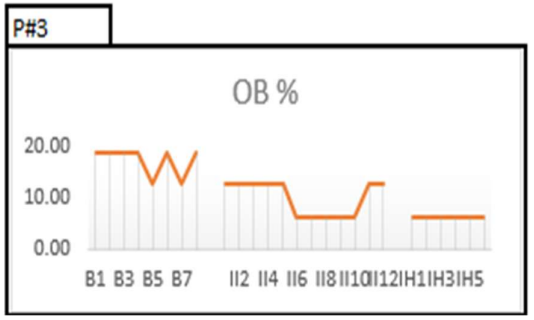


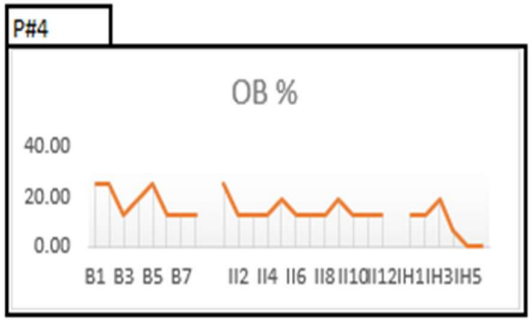


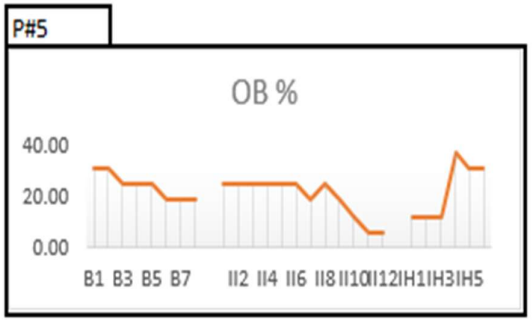
Graphs 12: Odd Behaviours

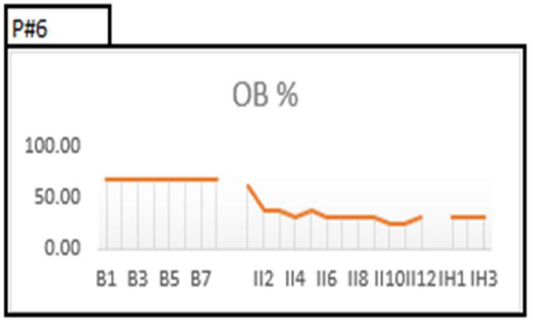












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Adaptive yoga for psychological health of children having autism spectrum disorder and with intellectual disability: single case experimental design

Jyoti Maggu[1], Soubhagyalaxmi Mohanty[1] & Karthikeyan Sundaravadivel[2]

Children with multiple disabilities have developmental issues in psychological domains. Adaptive *yoga* tailored to individual abilities promises positive results on children with special needs. This study applies multiple baseline single-case experimental design (SCED) to establish functional relationship between *yoga* and psychological health of children with autism spectrum disorder (ASD) and intellectual disability (ID). A multiple baseline SCED (AB1B2), with phases (A) baseline without intervention, (B1) intervention in the institute with a yoga teacher and caregiver, and (B2) intervention at home with the caregiver. The experiment was replicated across six children aged 7–12 years with mild ASD and ID. The study assessed the impact of a 180-day adaptive *yoga* intervention on twelve parameters across cognitive, behavioural, and emotional domains. Assessments were administered using the Indian Scale for Assessment of Autism (ISAA) and Behavioural Assessment Scales for Indian Children with Mental Retardation (BASIC-MR) tools. The study involved caregivers, yoga teacher, and clinical psychologists. The visual analysis established the functional effect of yoga intervention. The effectiveness of impact was supplemented by percentages of non-overlapping pairs and *Cohen's d* shows moderate to significant impact among all the participants in at least three instances across psychological domains. The experiment establishes both internal and external validity.

Trial registration **CTRI/2021/08/035389; DoR: 04/08/2021.**

Keywords Adaptive *yoga*, Multiple disabilities, Autism spectrum disorder, Intellectual disability, Psychological health, Single case experimental design

Children with multiple disabilities, particularly those diagnosed with autism spectrum disorder (ASD) and with intellectual disability (ID), represent a uniquely vulnerable population facing profound challenges in various aspects of psychological health. These children often struggle with cognitive delays, behavioural issues, and emotional dysregulation, which can significantly impede their ability to engage in daily activities, form social connections, and to reach developmental milestones.

In a recent study, parents of children with both intellectual and developmental disabilities (IDD) and with ASD reported greater psychological distress compared to those with IDD alone. Specifically, symptoms of hyperactivity, emotional difficulties and conduct problems in children with ASD were significant contributors to this distress[1].

The study indicates that conditions like ASD and with ID exhibit significantly more symptomatology, including anxiety, mania, schizophrenia, stereotypies/tics, self-injurious behaviour, eating disorders, sexual disorders, and impulse control[2]. These conditions are also associated with a greater negative impact on family financial and employment burdens[3].Without the necessary services and supports, preferably starting in the earliest years of life, these conditions can result in significant and lifelong impairments[4].

Compounding difficulties of children with developmental disorders often require specialized care beyond standard interventions. Traditional therapeutic interventions, such as behavioural therapy, occupational therapy,

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speech therapy, and medication are beneficial in meeting the respective functional objectives. The complexity of managing co-occurring conditions like ASD and with ID intensifies these challenges. This study is an attempt to supplement the existing therapies with yoga intervention to see if there are any improvement in psychological areas like cognitive, behavioural, and emotional domains.

Yoga, an ancient mind-body practice, has increasingly been recognized for its potential therapeutic benefits across various populations. *Yoga* based interventions on normal preschool children shows significant improvement in their motor abilities like balance, strength, and flexibility[5,6]. In few other studies *yoga* interventions like *asana* (postures), *pranayama* (breath regulation), *dharana* (concentration), *dhyana* (meditation) appears to be an effective modality for helping normal children to cope with the stress, anxiety and improvement in self-regulation and emotional regulation[7,8]. Among children with ASD with interventions like IYAT (Integrated Approach to Yoga Therapy) and movement based *yoga* has shown significant improvement in their motor skills, while few study involving mindfulness based practices such as MBSR (Mindfulness Based Stress Reduction), MBPBS (Mindfulness Based Positive Behaviour Support) shows improvement in behavioural skills among adults with ID[9–12]. However, the body of research is still nascent on *yoga* interventions for multiple disabilities having combination of more than one developmental disorder, often marked by methodological limitations and non-scientific case studies.

Yoga intervention for children with ASD and ID necessitates modification in *yoga* teaching methodology customized to the individual level and capacity. The *yoga* course plan is designed based on the fundamental principles of *yoga* as rooted in classical text of *Patanjali Yogasutra* (PYS). The aphorism, *sukham sthiram asanam* (PYS, Chap. 2, Verse 46) means quality of *asana* (practice) should meet the criteria of *sukham* (comfort) and *sthiram* (stability) of the practitioner. Another aphorism, *tasya bhumisu viniyoga* (PYS, Chap. 3, Verse 6) means the practice is always unique and specific to the individuals' capacity and comfort. A common misconception among people around *yoga* is to attain only certain form classically. This might lead to compromising *sukham* and *sthiram*. All the tools of *yoga* like *asana* (physical postures or form), *pranayama* (breath regulation), and *dhyana* (meditation) were designed to serve certain functional benefits. This purpose can also be achieved through adaptations. Another important reason for practicing *asana* variations is to encourage attentiveness. The design of a right course plan serves this purpose, yet that is personalised, meets the criteria of function over form and safe, while maintaining the *sukham* and *sthiram* for a practitioner. A course plan also evolves as the practitioner establishes themselves in the practice gradually. *Yoga* practices performed with coordination of movement and breath with awareness offers a pathway to better sensory integration and subsequently improve psychological areas such as cognitive, behavioural, and emotional domains[13].

The participation of caregiver in the session along with *yoga* teacher is an important dimension. This helps the participants to build a psychologically safe environment. The caregiver also helps in patterning the movements along with the *yoga* teacher. The design also involves extended intervention in home setting without *yoga* teacher, where the participant continues the practice along with the caregiver during follow-up phase and later.

Children with special needs require personalized intervention. Every child has unique needs and capacity. A traditional group design and aggregate analysts like RCT may not be appropriate for the study of intervention impact on psychological areas. A Single Case Experimental Design (SCED) empirically establishes both internal and external validity even with smaller sample size where the participant serves as their own control. The data generated by continuous assessments across phases contribute to establish the significance of the impact. The baseline phase compared to intervention phases shows the functional relationship[14,15]. The SCED established functional relationships between the intervention (or independent variable) and the outcomes observed in autistic children or youth[16]. The significance of impact can be established by replication of study across participants, psychological domains, and settings.

This study was first of its kind to apply *yoga* intervention on children with multiple disabilities on their psychological skills. The study was a multi-stakeholder study with involvement of experts from field of multiple disabilities, clinical psychology, and *yoga*. The genesis of this experiment was a joint effort to test and see any possibilities of benefit that can be derived from *yoga* for children with special needs with multiple developmental disorders. From clinical psychology experts' point of view, the scope of the study was kept simple, limited to the children having ASD and with ID, with mild level of severity and assess the impact on psychological areas using standardized tools - ISAA and BASIC(MR) across sub-domains that do not conflict cross functionally, i.e., cognitive, behavioural and emotional. From *yoga* experts' point of view, the scope was to design an adaptive *yoga* module and an intuitive teaching methodology that suits the capacity of individual participants with such conditions, keeping the foundational principles of *yoga* intact and simplifying the practice to the level of participants and their caregivers, to ensure continuity of practice in post research context. The anticipated indicators of improvement in cognitive domain were for the participants to be able to follow basic *yoga* instructions, under behavioural domain were to have reduced hyper activity, cooperate to complete daily practice and under emotional domain the indicators were improvement in demonstrating certain level of expression and regulation of emotions. We wanted to make this study as a robust experiment, empirically establishing any outcome as it comes. Thus, used SECD with continuous assessments to generate adequate data to support our outcome. Both psychological assessments and *yoga* intervention happened in parallel and the respective observations were blinded from each other till the experiment was over. The empirical significance and the subjective observations to these psychological domains are provided in this article.

This research work aims to prove existence of a functional relationship and efficacy of tailored made *yoga* intervention for children with ASD and with ID on improving their psychological health in cognitive, behavioural, and emotional domains by employing a rigorous scientific framework, a well-crafted adaptive course plan and teaching methodology. The purpose is also to involve caregivers that ensures continuity of the practice if there are carry forward benefits in home condition.

Method

Participants

Six children participated along with their caregivers (mothers), recruited from NIEPMD—National Institute for Empowerment of Persons with Multiple Disabilities (Divyangjan), Chennai, Tamil Nadu, India, Under Department of Empowerment of Persons with Disabilities (Divyangjan), Ministry of Social Justice & Empowerment, Govt. of India. The participants are residents and day boarders availing therapeutic services from the institute. Two of the participants attend special model school run by the institute and four attend other schools outside the institute admitted based on special status. The mothers with limited educational background could communicate only in vernacular (Tamil) language and children could follow their mothers. For children, two were non-verbal and other four however verbal, had minimal communication. Mostly caregivers understood them better and helped bridging the communication gaps during the intervention.

The two participants from the institute were introduced to basic yoga postures as part of school curricula in form of a group practice and not formally as a regular therapeutic one-to-one intervention. Other four participants had no prior exposure to *yoga*. The common therapeutic services like occupational therapy, speech therapy, behavioural therapy and special education were attended time to time by all the participants in the institute.

All the participants are certified by the institute under Department of Empowerment of Persons with Disability (DEPD) gazette guidelines for multiple disability certification on ASD and with ID. As per the guidelines, INCLEN Diagnostic tool for Autism Spectrum Disorder (INDT-ASD) is used by the institute for ASD diagnosis followed by Indian Scale for Assessment of Autism (ISAA) to assess the severity of the condition. The Binet-Kamat Test of Intelligence (BKT) and Malins Intelligence Scale for Indian Children (MISIC) are used to confirm the ID diagnosis and Vineland Social Maturity Scale (VSMS) tool is used assess the severity of the diagnosis.

The inclusion criteria for the study included children those were certified by the institution as multiple disabled having ASD and with ID, chronological age between 7 and 12 years having mild severity level and the caregiver agreed to participate throughout the study. Children having other disabilities, beyond the age criteria, having moderate, severe to profound conditions in ASD and ID were excluded. Demographic details are represented in Table 1. Prior to the participation the informed consent was obtained from parents and/or legal guardians.

The six assessors recruited were practicing clinical psychologists facilitated by the institute. One assessor was mapped to one participant. The trained *yoga* teacher was the researcher of this study to execute the intervention.

Design

A multiple baseline single case experimental design (AB1B2) was implemented for this study. Each participant went through three phases: (A) baseline phase without intervention, (B1) intervention phase in institute setting with *yoga* teacher and caregiver, and (B2) intervention phase in home setting with only caregiver. Continuous assessments were planned and administered for each participant at a frequency of every two weeks. The start of the intervention was stratified based on completion of four months of without any *yoga* practice and completion of associated baseline assessments for respective participants from the time of recruitment. This was planned to establish the existence of the problem related to the variables of interest before start of the intervention. Six months of intervention along with *yoga* interventionist and caregiver in institute setting followed by three months of *yoga* along with caregiver alone in home setting was planned. The duration of each intervention phase was decided based on number of intervention sessions as per the plan and that covers at least five counts of assessments for observable data representation for a phase analysis[15]. The multiple baselines were compared for each replication across six participants, twelve parameters distributed under three psychological domains and two settings. Replication added strength for external validity[17]. There was limited scope of randomization in this study. The continuous assessment outcomes were blinded for the interventionist and parents, also the assessors were blinded to the intervention procedure throughout the study. The study was conducted and reported as per the Single-Case Reporting Guidelines In Behavioural Interventions (SCRIBE) 2016 Statement[18].

The study was approved by Research Committee (RC) of the institution where the study was executed, Doctoral Committee (DC) and Institutional Ethics Committee (IEC) of affiliated University. This is to confirm that all the methods were performed in accordance with the relevant guidelines and regulations as per the Declaration of Helsinki. The study adhered to the approved protocol and consent process.

			Disability Severity		Caregiver	
Participant	Gender	Age	ASD	ID	Relation	Education
Participant#1	Male	9	Mild	Mild	Mother	Higher Secondary
Participant#2	Female	8	Mild	Mild	Mother	Higher Secondary
Participant#3	Female	12	Mild	Mild	Mother	Higher Secondary
Participant#4	Male	12	Mild	Mild	Mother	Under Graduate
Participant#5	Male	10	Mild	Mild	Mother	Higher Secondary
Participant#6	Male	9	Mild	Mild	Mother	Under Graduate

Table 1. Demographics. ASD: Autism Spectrum Disorder, ID: Intellectual Disability.

Intervention procedure

A caregiver orientation workshop was conducted before commencing the intervention to explain the purpose of study and the importance of their role during the intervention. The participants continued their respective regular therapies throughout the study. There were no conditional restrictions on other therapies along with *yoga* intervention. This also met the purpose of SCED where respective participants served as their own control and only change was additional *yoga* intervention to assess the impact.

The *yoga* sessions were administered for the participants as one-to-one intervention along with *yoga* teacher and caregiver. The intervention sessions started in institute setting along with *yoga* teacher and caregiver for 120 days, followed by 60 days in home setting along with only caregiver. Each intervention session duration was between 45 to 60 minutes administered every working day of the week excluding weekends and holidays. Before moving from institute setting to home setting, the ownership of intervention was handed over to the caregiver with documented course plan for continuity and smooth execution. A sample documented plan can be referenced in Appendix B.

During home setting phase, six sessions (once in a fortnight) over this period were conducted by the *yoga* teacher to re-establish the continuity and correct the course plan as applicable. The total days of intervention were adjusted to the planned number of days to compensate any longer absences (more than a week) against medical emergencies. Figure 1 represents the flow.

Course plan

A well-crafted course plan designed that was personalized, prioritized function over form, and was safe based on the fundamental principles of *yoga* as rooted in the scripture of *Patanjali Yogasutra*[13]. (1) Personalized – The practice was designed specific to the individual's capacity and comfort. The course plan was further modified to suite the physical and mental condition of the participant on a particular day. (2) Function over form – A well-structured yet flexible course plan was designed with appropriate sequences towards fulfilling the function rather than emphasis to achieve the form. (3) Transition of planes were carefully crafted keeping it smooth and in sequence for example from seated to standing to supine to prone to kneeling to seated. (4) For all *asanas* (physical postures) adequate counter postures were given. (5) Adequate rests were incorporated between *asanas* integrated with counting or chanting to sustain the participant's attention. Refer to a sample course plan in Appendix A.

In the initial phase, the sessions were simplified, preparatory, and executed depending on the interest and comfort of the participant on that day. Once the relationship was established (between the *yoga* teacher and the participant), the nuances were understood by the *yoga* teacher, the sessions were modified incrementally as per the course plan.

Teaching methodology

The fundamentals of *yoga*—movement, breath and awareness were achieved by incorporating following adaptation techniques in teaching.

Movement (1) The objective is to get into and come out of the posture with comfort. This sequence was simplified and broken into smaller steps. (2) Adaptations were seasoned by repetition. The approach was iterative and incremental, subject to the readiness of participant for next stage. (3) *asana* forms were established using patterning wherever applicable with support of caregiver. For example, in *dvipada pitham* (bridge pose), the hip movements were patterned by support of caregiver lifting the back of the participant.

Breath The breath was influenced in two ways. (1) Our body naturally inhales on expansion and exhales on contraction. Appropriate sequencing by alternating movements helped to achieve the right breathing. (2) Chanting happens on exhalation. Thus, chanting of any syllable of participants' choice was used in exhalation leading to an implicit inhalation. Length of the chant was moderated as per the participant's capacity.

Awareness Awareness was brought by maintaining the attention of the participants throughout the session. (1) Every session started by re-establishing a positive connect between *yoga* teacher, the participant, and the caregiver. (2) The sessions were then executed with continuous engagement in form of movements integrated with limited voice modulated short instructions, counting, chanting, demonstration, and patterning that was suitable for the participant for that session. (3) Every day the teacher assessed the readiness and responsiveness of the participants and accordingly customised the session to bring the best to meet the session objective. (4) The *yoga* teacher demonstrated and practiced along with the participants throughout the session for ease of imitation.

The visual cues (parallel demonstration), auditory cues (limited voice modulated short instructions), support (caregiver patterning), simple plan integrating movements with chanting or counting; all combined throughout the session helped in making the session mindful and accessible.

Assessments

Indian Scale for Assessment of Autism (ISAA) and Behavioural Assessment Scales for Indian Children with Mental Retardation (BASIC-MR) instruments were used to assess the desired cognitive, behavioural, and emotional parameters objectively.

ISAA is an objective assessment tool for persons with autism which uses observation, clinical evaluation of behaviour, testing by interaction with the subject and information supplemented by parents or caretakers. The ISAA questionnaire is divided under six domains: social relationship and reciprocity, emotional responsiveness, language and communication, behaviour pattern, sensory aspects, and cognitive component. These are further quantified by providing percentages to indicate the frequency, degree and intensity of behavioural characteristics that are observed. Lower the percentage indicates lesser problem and higher the score indicates severity. ISAA is a standardized, reliable, and valid tool for diagnosis and assessment of severity in autism among children[19].

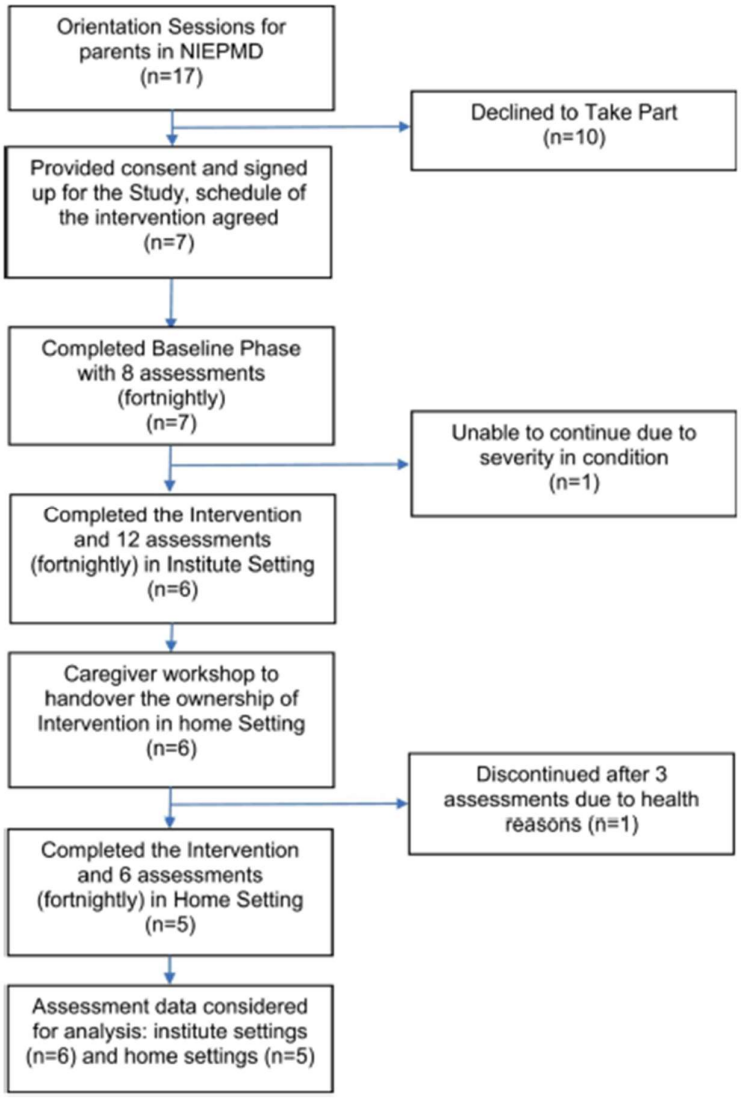

Fig. 1. Recruitment flowchart.

BASIC-MR is designed to elicit systematic information on the current level of behaviour in school going children with development disorders. It is developed in two parts. Part-A helps to assess the current level of skills behaviours in the child. Part-B helps to assess the current level of problem behaviours in the child. Part-A consists of seven domains: motor, activity of daily living (ADL), language, reading-writing, number-time, domestic-social, and prevocational-money. Part-B consists of ten domains: violent and destructive behaviour, temper tantrums, misbehaviour with others, self-injurious behaviours, repetitive behaviours, odd behaviours, hyperactive behaviours, rebellious behaviours, antisocial behaviours, and fears. For both Part-A and Part-B each

of the respective domains of interest can be consumed independently. The scores for each domain are calculated and converted into a percentage. For Part-A a higher score indicates better skill behaviours, while for Part-B a lower score indicates fewer behaviour problems[29].

Twelve domains as variables of interest were picked from ISAA and BASIC-MR (A&B) that was administered to generate percentage scores. The aggregate score of the child on each domain expressed as the raw score. This was converted into percentage for each domain by dividing the obtained raw score by maximum score for that domain and multiplied by 100. The percentage scores across phases were compared against the expected outcome of increasing or decreasing measure as prescribed in the tool. Table 2 describes the assessment parameters of interest, description of problems assessed in each domain, and expected outcome.

The study was conducted over three phases. The assessments were administered by assessors to collect cognitive, behavioural, and emotional data desired for the study every two weeks as per the plan. Total twenty-six (26) assessments were administered throughout the study with first eight during baseline phase (without intervention), followed by twelve during intervention phase in institute setting followed by six during intervention phase in home settings. The assessors were blinded to the intervention modifications. The *yoga* interventionist and caregivers were blinded to the assessment scores during the intervention phases. After all the assessments were completed and completion of intervention phases, the scores were revealed and consolidated for analysis.

Data analysis–collection, visual and empirical analysis

Overall, 1836 data points generated out of 153 assessments for six participants. The data points were aggregated and analysed for each participant, for each parameter within and across phases. A visual analysis tool was developed using MS Excel to consume the data collected and generate respective participant-parameter wise time sequence line graphs for visualization. Figure 2 represents the sample distribution of 26 data points representing the percentage score on 'Odd Behaviour' across three phases for Participant#1. Percentage scores of observable parameters are depicted along the ordinate axis, and the abscissa represents the baseline (B1-B8), intervention institute setting (II1-II12), and intervention home setting (IH1-IH6) assessments.

Visual analysis was used to determine the functional relationship between the intervention and observable parameters. A change in percentage score indicates the change in functional behaviour as observed during assessment. If the change is visible to be significant, consistent during visual analysis and aligned to the desired direction, was a clear indication of functional improvement. The visual analysis was further supplemented with quantitative analysis for evaluating the magnitude of impact using multiple non-overlapping indices for effect size and the statistical effect size was calculated using *Cohen's d* between baseline to intervention (institute settings) and baseline to intervention (home settings) respectively.

The visual analysis involved evaluating level, trend, and stability of data for within phase analysis. Further the immediacy-of-effect, consistency of data patterns, and non-overlap of data was compared between baseline and respective intervention phases. When the changes (and/or variability) in level, are in the desired direction, are immediate, perceptible, and maintained over time, it is concluded that the changes in behaviour across phases is a result of the intervention and are indicative of functional improvement. This analysis was repeated for all 12

Domain	Instrument	Parameter	Description	Expected Outcome
Cognitive	ISAA	Cognitive Component	Assess participants lack of attention and concentration. Their responses to the instructions are prompt or after a considerable delay.	Decrease
	BASIC-MR (A)	Language	Assess (A) Receptive language ability like pointing to a picture in a book, arranging pictures after listening to a story, etc. (B) Expressive Language like ability to use two phrases, name common objects in use, etc.	Increase
		Reading-Writing	Assess the reading ability of sight words, own name, scribbling with pencil or chalk, writing own name, address, etc.	Increase
		Number-Time	Assess abilities to rote counts till five, count five objects meaningfully, add single digit numbers, name, or identify numbers on the clock, name or identify day, date and months of the year, etc.	Increase
Behavioural	ISAA	Behavioural Pattern	Assess participants engagement in self-stimulatory behaviour in the form of flapping of hands or using an object for this purpose, insisting on following routines, resisting change, restlessness and exhibiting aggressive behaviour.	Decrease
	BASIC-MR (B)	Hyper Activity-Inattention	Assessed the ability to sit in one place for required time, completing task at hand, etc.	Decrease
		Repetitive Behaviour	Assess patterns like rocking the body, nodding head, shaking parts of the body repeatedly, etc.	Decrease
Emotional	ISAA	Emotional Responsiveness	Individuals with autism do not show the expected feelings in a social situation. Emotional reactions are unrelated to the situation and may show anxiety or fear which is excessive in nature without apparent reason. They may engage in self-talk that is inappropriate for their age and may lack fear of danger.	Decrease
	BASIC-MR (B)	Violent & Destructive Behaviour	Tears books, breaks things, throws objects, etc.	Decrease
		Temper Tantrums	Bangs head, scratches self, pulls own hair, bites self, peels skin/wound, etc.	Decrease
		Self-Injurious Behaviours	Rolls on the floor, screams, cries excessively, etc.	Decrease
		Odd Behaviours	Smiles, laughs, or talks to self without reason, collects rubbish, etc.	Decrease

Table 2. Variables of Interest: Domain, source, parameter, description and expected outcome. ISAA: Indian Scale for Assessment of Autism, BASIC–MR: Behavioural Assessment Scales for Indian Children with Mental Retardation.

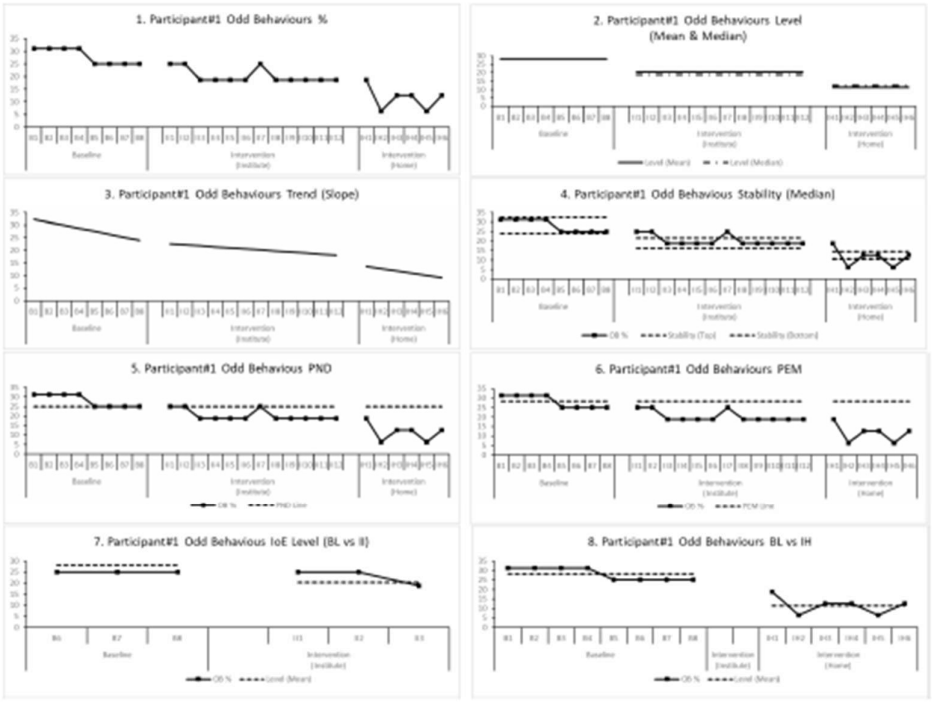

Fig. 2. Sample graphs generated for visual analysis for Participant#1 for "odd behaviours" parameter. Description of graphs in order (1) Overall 26 data points across baseline, intervention(institute), intervention(home). (2) Levels represented by Mean and Median Lines. (3) Phase wise trend line. (4) Stability of data between Median range of (+/-) 15%. (5) The Percentage of Non-overlapping data (PND) using min (or max) baseline data point. (6) Percentage of data exceeding median line (PEM). (7) Immediacy of effect comparing last three data points of baseline against first three data points of intervention phase. (8) The level mean comparison between baseline phase and intervention in home setting.

parameters for each participant and across all participants. At least three such demonstration of an intervention effect during visual analysis was necessary for establishing a functional relationship[14].

Level, trend, and stability of the data within each phase was evaluated. Mean and median of percentage scores was used to report the level. An increasing or decreasing trend was observed. Within phase stability was evaluated.

by calculating the percentage of data points within 15% of the phase median. The stability criteria are satisfied if about 85% (80-90%) of the data in a phase fall within a 15% range of the median of all data points for that phase.

Between the phase analysis included observing shift in level, change in stability of data distribution, immediacy of effect, and non-overlap of data between phase. The immediacy of effect is observed by change in level, trend or variability comparing the last three data points of baseline compared with first three data points of intervention phase. Immediacy of effect is not considered between baseline and second intervention phase in home settings.

Non overlapping indices were used to calculate the magnitude of effect and quantify the proportion of measurements in the intervention phase not overlapping with the baseline measurements. Non-overlapping of All Pairs (NAP), Percentage of Non-overlapping Data (PND), Percentage of Data Exceeding the Median (PEM) were used to quantify the magnitude of effect to supplement the visual analysis[21]. This paper depicts the NAP as a parameter to show the magnitude effect. The significance associated with the magnitude of effect was classified as greater than 0.90 are indicative of significant impact, 0.89 to 0.70 represent moderately significant and 0.69 to 0.50 are less significant and score less than 0.50 are considered insignificant[21].

The *Cohen's d* was used to generate the effect size between baseline and intervention phases (first and second) respectively[15]. A score greater than 0.80 was considered significant, 0.79 to 0.50 represents moderately significant,

Parameter	Level/Trend/Stability	Participant#1			Participant#2			Participant#3			Participant#4			Participant#5			Participant#6		
		BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH*
Cognitive Component	Mean	35.00	33.33	28.33	52.50	46.25	30.00	23.13	19.17	22.50	35.00	34.58	35.00	33.13	35.00	32.50	35.00	32.92	45.00
	Slope	0.00	-0.45	-0.29	1.90	-2.01	-2.86	-0.89	0.14	1.29	2.26	0.12	0.00	0.77	-0.31	-1.29	0.00	-0.37	0.00
	Stability	100	100	83.33	50.00	41.67	83.33	62.50	83.33	100	62.50	91.67	100	87.50	58.33	100	100	91.67	50.00
Language	Mean	67.50	76.04	84.40	35.88	36.92	38.00	67.06	67.67	69.25	45.94	46.00	46.50	11.31	11.00	14.00	42.00	51.17	50.50
	Slope	0.00	1.40	0.51	-0.05	0.12	0.00	0.04	-0.07	0.73	0.04	0.00	0.09	-0.70	-0.19	0.26	0.00	-0.11	0.00
	Stability	100	100	100	100	100	100	100	100	100	100	100	100	87.5	100	100	100	100	50.00
Reading-Writing	Mean	47.00	61.79	67.50	14.19	15.67	16.00	56.00	57.46	59.33	25.81	26.00	26.00	8.88	8.29	8.25	41.50	16.83	30.00
	Slope	1.40	0.66	0.00	-0.12	-0.02	0.00	0.00	0.31	-0.46	0.09	0.00	0.00	0.39	0.02	0.39	0.00	2.13	0.00
	Stability	87.50	100	100	100	100	100	100	100	100	100	100	100	87.50	100	100	100	66.67	50.00
Number -Time	Mean	31.00	33.08	30.00	10.25	11.96	14.50	52.81	53.92	57.63	8.63	9.67	10.00	3.63	3.75	5.50	30.50	22.83	24.50
	Slope	0.00	-0.97	0.04	0.11	0.17	0.00	-0.13	0.14	0.54	0.07	0.11	0.00	0.36	0.09	0.00	0.00	0.28	0.00
	Stability	100	66.67	100	100	100	100	100	100	100	100	100	100	62.50	75.00	100	100	100	50.00

Table 3. Cognitive metrics supporting visual analysis within phase: level (Mean), trend (Slope), stability (% of data between 15% range of Median). BL – Baseline; II – Intervention (Institute); IH – Intervention (Home). BL Baseline; II Intervention (Institute); IH Intervention (Home). *Represents aggregate of only three data points.

Parameter	Level/Trend/Stability	Participant#1			Participant#2			Participant#3			Participant#4			Participant#5			Participant#6		
		BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH*
Behaviour Patterns	Mean	36.07	32.86	30.48	41.43	34.52	35.43	43.57	22.86	20.95	46.43	39.76	31.43	48.93	44.29	46.19	30.36	32.86	48.57
	Slope	-0.17	-0.32	-0.33	0.41	-0.81	-2.45	0.07	-0.74	0.65	1.29	-1.57	0.00	1.53	-1.26	-4.82	-0.71	0.38	0.00
	Stability	87.50	75.00	100	100	66.67	83.33	100	58.33	100	62.50	75.00	100	75.00	75.00	33.33	87.50	91.67	50.00
Hyperactivity-Inattention	Mean	52.08	29.17	16.67	72.92	29.17	50.00	6.25	-	-	68.75	47.22	33.33	64.58	47.22	55.56	66.67	40.28	50.00
	Slope	-1.39	-0.29	0.00	-6.15	-0.29	0.00	-	-	-	-8.13	-2.45	0.00	-2.58	-3.50	-7.62	0.00	-1.69	0.00
	Stability	87.50	0.00	100	75.00	41.67	100	-	-	-	62.50	50.00	100	62.50	33.33	66.67	100	50.00	50.00
Repetitive Behaviour	Mean	17.97	9.38	6.25	17.19	3.13	0.00	2.34	-	-	32.03	20.31	17.71	19.53	23.44	16.67	33.59	13.02	12.50
	Slope	-0.52	-0.87	0.00	-2.38	-1.01	0.00	-	-	-	-3.35	-0.85	-0.18	-0.37	0.55	1.79	-1.71	-0.59	0.00
	Stability	87.50	58.33	100	0.00	0.00	0.00	-	-	-	62.50	75.00	66.67	87.50	58.33	0.00	62.50	25.00	50.00

Table 4. Behavioural metrics supporting visual analysis within phase: level (Mean), trend (Slope), stability (% of data between 15% range of Median). BL – Baseline; II – Intervention (Institute); IH – Intervention (Home). BL Baseline; II Intervention (Institute); IH Intervention (Home). *Represents aggregate of only three data points.

0.49 to 0.20 represent less significant and less than 0.2 is considered insignificant. The polarity of the *Cohen's d* represented the alignment to the expected result, negative for decreased effect and positive for increased effect[22].

Results

Preliminary analyses

The visual analysis of all baseline data across participants establishes the existence of the problem associated with the parameter as per the definition in Table 2. Quantifying the same, the minimum baseline mean (or median) > 10% is considered as problem for parameters where expected outcome is to decrease. The maximum baseline mean (or median) < 50% is considered as problem for parameters where expected outcome is to increase.

For Participant#1 and Participant#2, "self-injurious behaviour" and for Participant#3 "hyperactivity and inattention", "repetitive behaviour" and "temper tantrums" were not the observable problems during baseline phase and thus excluded from further analysis. Supplementing data points to visual analysis within phase of level (mean), trend (slope) and stability is represented in Tables 3, 4 and 5 for cognitive, behavioural, and emotional domains respectively.

Overall, all the participants recorded more than 90% of the attendance during the intervention phase (institute settings). Participant#6 dropped during the last phase of intervention in home settings resulted in only three recorded observations, the between phase comparison for baseline (BL) vs intervention home (IH) results are not conclusive for this participant.

Primary outcomes

The visual analysis done between the phases from baseline to intervention phase (institute setting) and baseline to intervention phase (home setting), establishes the functional dependency between *yoga* intervention and psychological skills. This is visible in at least one or more of the parameters under cognitive, behavioural, and emotional domains respectively across all the six participants. More than three instances of change in level,

Parameter	Level/Trend/Stability	Participant#1			Participant#2			Participant#3			Participant#4			Participant#5			Participant#6		
		BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH	BL	II	IH*
Emotional Responsiveness	Mean	44.50	37.67	36.00	42.50	31.00	21.60	36.00	32.33	80.00	35.00	39.00	42.00	30.00	49.00	45.33	53.00	44.00	40.00
	Slope	-0.90	-0.35	0.34	-0.05	-1.05	-2.97	-2.76	3.26	0.00	1.24	0.63	-1.03	-1.05	-0.32	-4.57	0.67	-1.15	0.00
	Stability	87.50	100	100	100	66.67	83.33	50.00	58.33	100	62.50	75.00	100	75.00	41.67	66.67	87.50	75.00	50.00
Violent and Destructive Behaviour	Mean	12.50	6.25	6.25	10.94	4.95	0.00	11.72	5.73	0.00	26.95	21.61	17.19	18.36	16.67	14.06	67.97	13.28	12.50
	Slope	0.00	0.00	-0.27	-0.52	-0.34	0.00	-0.60	-0.22	0.00	-1.23	-0.86	-0.63	0.48	-1.07	-1.88	0.52	-1.21	0.00
	Stability	100	100	83.33	100	58.33	0.00	62.50	83.33	0.00	75.00	75.00	100	25.00	41.67	0.00	100	33.33	50.00
Temper Tantrums	Mean	25.00	8.33	6.25	29.69	5.21	0.00	0.00	-	-	26.56	26.04	12.50	18.75	15.63	14.58	96.88	25.00	25.00
	Slope	0.00	-0.09	3.21	-8.18	0.66	0.00	-	-	-	0.45	0.04	-6.43	-1.19	-2.93	-6.79	1.49	-0.70	0.00
	Stability	100	66.67	0.00	0.00	0.00	0.00	-	-	-	87.50	91.67	0.00	0.00	33.33	0.00	87.50	58.33	50.00
Self-Injurious Behaviours	Mean	5.00	-	-	3.75	-	-	11.25	6.25	0.00	36.88	21.67	22.50	10.63	8.75	10.83	46.25	10.83	10.00
	Slope	-	-	-	-	-	-	0.24	-0.26	0.00	-4.82	-2.62	3.00	-0.18	-1.73	-2.71	-0.83	-1.08	0.00
	Stability	-	-	-	-	-	-	75.00	75.00	0.00	25.00	25.00	50.00	87.50	0.00	0.00	100	50.00	50.00
Odd Behaviours	Mean	28.13	20.31	11.46	21.88	13.02	0.00	17.19	9.90	6.25	17.97	14.58	8.33	24.22	19.79	22.92	68.75	34.38	31.25
	Slope	-1.19	-0.42	-0.89	-3.87	-1.73	0.00	-0.45	-0.33	0.00	-1.71	-0.44	-3.21	-2.01	-1.75	5.00	0.00	-1.97	0.00
	Stability	100	75.00	50.00	25.00	25.00	0.00	75.00	58.33	100	0.00	75.00	0.00	37.50	58.33	0.00	100	50.00	50.00

Table 5. Emotional metrics supporting visual analysis within phase: level (Mean), trend (Slope), stability (% of data between 15% range of Median). BL – Baseline; II – Intervention (Institute); IH – Intervention (Home). BL Baseline; II Intervention (Institute); IH Intervention (Home). *Represents aggregate of only three data points.

immediacy of effect and sustenance of change in measure is observed for each of the participants across all the observable parameters. The data supplementing this observation is represented in Tables 3, 4 and 5 depicting the level (mean), trend (slope) and stability (consistency of data around median) for cognitive, behavioural, and emotional domains respectively. The sample immediacy of effect can be observed from graphical analysis as shown in Fig. 2.

The visual analysis for respective participants has shown the following significant changes in functional behaviours. Under cognitive domain for 'language' skills Participant#1 and Participant#6 shown significant improvement. For 'reading-writing' skills only Participant#1 shown significant improvement. For rest of the cognitive parameters none of the participants have shown a visible improvement. For Participant#6 cognitive domain reflected opposite effect. Under behavioural domain for 'behaviour patterns' Participant#2 and Participant#3 demonstrated significant decrease in expected behaviour changes. All the five participants shown significant reduction in 'hyperactivity-inattention' behaviour with Participant#3 not having the problem at first place. Except Participant#5 all other participants have shown reduction in 'repetitive behaviour'. Under emotional domain, Participant#1, Participant#2 and Participant#6 have shown significant improvement in 'emotional responsiveness', while Participant#4 and Participant#5 have shown opposite effect. 'Violent and destructive behaviour' of Participant#6 have shown significant reduction. Participant#1, Participant#2, and Participant#6 have shown significant reduction in 'temper-tantrums'. The 'self-injurious behaviour' has significantly dropped for Participant#4 and Participant#6. The 'odd behaviour' of Participant#6 was significantly reduced (Tables 6, 7, 8).

The visual analysis is supplemented by the effect size calculation using non-overlap indices PND, PEM, NAP. This data is depicted in Tables 6 and 7 for respective domains and aggregated interpretation of NAP is depicted in Table 9. For this paper, the effect size calculation measure of NAP between baseline vs. intervention phase (institute settings) and baseline vs. intervention phase (home settings) is used for depiction of impact. NAP shows moderately significant to significant outcome for Participant#1, #2, #3, #4 and #6 for at least one parameter across cognitive, behavioural, and emotional domains respectively. For participant#5 it shows less significant impact.

The statistical effect size calculated using *Cohen's d* between baseline vs. intervention phase (institute settings) and baseline vs. intervention phase (home settings) shows the outcome is positive and significant for at least one parameter across cognitive, behavioural, and emotional domains for Participant#1, #2, #3 and #6. For Participant#4 the results are significant only in cognitive domain and in other domains it is insignificant. For Participant#5 the outcome is insignificant across domains. The supporting data is depicted in Table 8 for respective domains and aggregated interpretation of the same is presented in Table 10.

Comparing the statistical effect along the functional changes in participants shows mismatch in few instances. The observable significant change in behaviour was not always resulted in equivalent *Cohen's d* significance and/or NAP significance. For example, 'hyperactivity-inattention' was reduced significantly as behaviour for all participants, however, the magnitude of effect supplemented by *Cohen's d* did not reflect as significant as it was. Similarly, a significant *Cohen's d* and NAP score for a parameter did not reflect as actual behavioural improvement. For example, the 'language' skills show statistical significance for most of the participants however, it was only demonstrated by Participant#1 and Participant#6.

Parameter	Participant#1		Participant#2		Participant#3		Participant#4		Participant#5		Participant#6	
	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH
Cognitive Component	**0.67**	**0.92**	**0.71**	**0.94**	**0.84**	**0.56**	0.49	0.44	0.49	**0.63**	0.46	*
Language	**1.00**	**1.00**	**0.97**	**1.00**	**0.82**	**0.83**	**0.56**	**0.78**	**0.54**	**0.88**	**1.00**	*
Reading-Writing	**0.98**	**1.00**	**0.98**	**1.00**	**0.79**	**1.00**	**0.69**	**0.69**	0.32	0.31	0.00	*
Number -Time	**0.67**	0.00	**0.99**	**1.00**	**0.82**	**1.00**	**0.96**	**1.00**	0.47	**1.00**	0.00	*
Behaviour Patterns	**0.77**	**0.96**	**0.89**	**0.81**	**1.00**	**1.00**	**0.73**	**1.00**	**0.71**	**0.61**	0.16	*
Hyperactivity-Inattention	**0.89**	**1.00**	**0.93**	**0.81**	-	-	**0.78**	**1.00**	**0.77**	**0.63**	**0.96**	*
Repetitive Behaviour	**0.96**	**1.00**	**0.95**	**1.00**	-	-	**0.84**	**0.84**	0.22	**0.70**	**0.98**	*
Emotional Responsiveness	**0.86**	**0.95**	**0.98**	**0.89**	**0.78**	0.00	0.33	0.22	0.06	0.10	**0.88**	*
Violent and Destructive Behaviour	**1.00**	**1.00**	**0.98**	**1.00**	**0.95**	**1.00**	**0.85**	**1.00**	**0.64**	**0.74**	**1.00**	*
Temper Tantrums	**1.00**	**1.00**	**0.83**	**0.94**	-	-	**0.52**	**0.78**	**0.58**	**0.58**	**1.00**	*
Self-Injurious Behaviours	-	-	-	-	**0.91**	**1.00**	**0.85**	**0.81**	**0.65**	**0.52**	**1.00**	*
Odd Behaviours	**0.94**	**1.00**	**0.70**	**1.00**	**0.93**	**1.00**	**0.65**	**0.82**	**0.64**	**0.54**	**1.00**	*

Table 6. Metrics supporting visual analysts across phase BL vs II and BL vs IH: the non-overlap indices calculated using non-overlap of all pairs (NAP). Non-overlap >= 0.50 is marked as **significant**. BL – Baseline; II – Intervention (Institute); IH – Intervention (Home). * Insufficient data points to calculate this value.

Parameter	PND/PEM	Participant#1		Participant#2		Participant#3		Participant#4		Participant#5		Participant#6	
		BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH
Cognitive Component	PND	0.33	**0.83**	0.08	**0.83**	0.17	0.00	0.00	0.00	0.00	0.00	0.08	*
	PEM	0.33	**0.83**	**0.50**	**0.83**	**1.00**	**0.50**	0.25	0.00	**0.50**	**0.50**	0.08	*
Language	PND	**1.00**	**1.00**	**0.92**	**1.00**	**0.67**	**0.83**	0.00	**0.50**	0.00	0.00	**1.00**	*
	PEM	**1.00**	**1.00**	**0.92**	**1.00**	**0.83**	**0.83**	0.00	**0.50**	0.25	**1.00**	**1.00**	*
Reading-Writing	PND	**0.75**	**1.00**	**0.92**	**1.00**	**0.58**	**1.00**	0.00	0.00	0.00	0.00	0.00	*
	PEM	**1.00**	**1.00**	**1.00**	**1.00**	**0.58**	**1.00**	0.00	0.00	0.00	0.00	0.00	*
Number -Time	PND	**0.67**	0.00	**0.83**	**1.00**	**0.58**	**1.00**	**0.67**	**1.00**	0.00	**1.00**	0.00	*
	PEM	**0.67**	0.00	**1.00**	**1.00**	**0.58**	**1.00**	**1.00**	**1.00**	0.00	**1.00**	0.00	*
Behaviour Patterns	PND	0.17	0.33	**0.50**	**0.50**	**1.00**	**1.00**	0.25	**1.00**	0.17	0.33	0.00	*
	PEM	**0.75**	**1.00**	**1.00**	**0.83**	**1.00**	**1.00**	**0.58**	**1.00**	**0.75**	**0.67**	0.00	*
Hyperactivity-Inattention	PND	**0.75**	**1.00**	0.33	0.00	-	-	0.33	**1.00**	0.33	0.33	**0.92**	*
	PEM	**0.75**	**1.00**	**1.00**	**1.00**	-	-	**0.83**	**1.00**	**0.67**	0.33	**0.92**	*
Repetitive Behaviour	PND	0.42	**1.00**	**0.58**	**1.00**	-	-	**0.50**	**0.67**	0.00	**0.50**	**0.83**	*
	PEM	**1.00**	**1.00**	**1.00**	**1.00**	-	-	**0.50**	**0.67**	0.00	**0.50**	**1.00**	*
Emotional Responsiveness	PND	0.00	0.17	**0.92**	**0.83**	**0.58**	0.00	0.00	0.00	0.00	0.00	0.08	*
	PEM	**1.00**	**1.00**	**1.00**	**0.83**	**0.83**	0.00	0.00	0.00	0.00	0.00	**1.00**	*
Violent and Destructive Behaviour	PND	**1.00**	**1.00**	**0.92**	**1.00**	0.17	**1.00**	**0.50**	**1.00**	0.17	**0.50**	**1.00**	*
	PEM	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.83**	**1.00**	**0.58**	**0.83**	**1.00**	*
Temper Tantrums	PND	**1.00**	**1.00**	0.00	0.00	-	-	0.00	**0.50**	0.25	**0.50**	**1.00**	*
	PEM	**1.00**	**1.00**	**1.00**	**1.00**	-	-	0.00	**0.50**	**0.58**	**0.50**	**1.00**	*
Self-Injurious Behaviours	PND	-	-	-	-	**0.75**	**1.00**	**0.67**	0.33	**0.50**	**0.50**	**1.00**	*
	PEM	-	-	-	-	**0.75**	**1.00**	**0.83**	**0.83**	**0.50**	**0.50**	**1.00**	*
Odd Behaviours	PND	**0.75**	**1.00**	0.33	**1.00**	0.42	**1.00**	0.00	**0.50**	0.25	**0.50**	**1.00**	*
	PEM	**1.00**	**1.00**	**0.67**	**1.00**	**1.00**	**1.00**	**0.75**	**0.83**	0.42	**0.50**	**1.00**	*

Table 7. Metrics supporting visual analysts across phase BL vs II and BL vs IH: the non-overlap indices calculated using percentage of non-overlap (PND) and percentage of data exceeding median (PEM). Non-overlap >= 0.50 is marked as **significant**. BL Baseline; II Intervention (Institute); IH Intervention (Home). * Insufficient data point to calculate this value.

Overall outcome

The internal validity of effectiveness of adaptive *yoga* intervention is established based on visual analysts, the effectiveness is supplemented by non-overlap method NAP and statistical significance using *Cohen's d*. The impact of intervention shows effectiveness across all cognitive, behavioural, and emotional domains; and across participant replications. This establishes external validity of the impact.

Parameter	Participant#1		Participant#2		Participant#3		Participant#4		Participant#5		Participant#6	
	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH	BL vs. II	BL vs. IH
Cognitive Component	**-0.39**	**-0.57**	-0.10	**-0.38**	**-0.73**	-0.09	-0.01	0.00	***0.04***[b]	-0.02	-0.03	*
Language	**0.41**	**19.92**	**5.45**	**56.10**	**2.55**	**1.38**	**2.83**	**2.64**	***-0.09***[b]	**0.79**	**53.47**	*
Reading-Writing	**0.94**	**1.36**	**4.27**	**18.52**	**1.24**	**4.42**	**3.96**	**3.96**	***-0.65***[c]	***-0.62***[c]	***-0.39***[c]	*
Number -Time	0.16	**-33.94**[c]	**4.47**	**42.07**	**1.58**	**5.12**	**5.93**	**36.30**	0.19	**2.91**	***-7.15***[c]	*
Behaviour Patterns	**-0.34**	**-1.58**	**-0.30**	-0.19	**-2.78**	**-11.45**	-0.09	**-0.21**	-0.10	-0.04	***0.21***[b]	*
Hyperactivity-Inattention	-0.15	**-1.44**	-0.12	-0.08	-	-	-0.06	-0.10	-0.07	-0.04	-0.14	*
Repetitive Behaviour	**-0.66**	**-3.39**	**-0.36**	**-0.46**	-	-	-0.17	-0.17	***0.34***[b]	-0.15	**-0.47**	*
Emotional Responsiveness	**-0.33**	**-0.41**	**-0.72**	**-0.34**	-0.01	***1.05***[c]	***0.11***[b]	***0.22***[c]	***0.25***[c]	***0.19***[b]	**-0.27**	*
Violent and Destructive Behaviour	'	**-5.43**	**-1.01**	**-5.54**	**-1.08**	**-2.16**	**-0.40**	**-0.98**	-0.05	-0.14	**-1.54**	*
Temper Tantrums	**-0.62**	**-0.57**	-0.07	-0.09	-	-	-0.03	-0.11	-0.03	-0.02	**-0.74**	*
Self-Injurious Behaviours	-		-		**-0.95**	**-2.97**	-0.12	-0.10	-0.06	***0.01***[b]	**-1.71**	*
Odd Behaviours	**-0.80**	**-0.95**	-0.06	**-0.28**	**-0.77**	**-1.85**	-0.11	-0.20	-0.10	-0.01	**-0.51**	*

Table 8. Effect size across phases - *Cohen's d*. **Significant** values are marked as **bold** and *underlined*. BL Baseline; II Intervention (Institute); IH Intervention (Home). ***b*: *Opposite effect insignificant***. ***c*: *Opposite effect significant***. *Insufficient data point. 'Inconclusive.

Description	Overall		Cognitive		Behavioural		Emotional	
	#	%	#	%	#	%	#	%
Absence of behaviour	10	7%	0	0%	4	11%	6	10%
Insufficient data point	12	8%	4	8%	3	8%	5	8%
Insignificant	17	14%	10	23%	2	7%	5	10%
Less Significant	21	17%	8	18%	3	10%	10	20%
Moderately Significant	30	25%	8	18%	11	38%	11	22%
Significant	54	44%	18	41%	13	45%	23	47%

Table 9. Impact summary in percentages based on non-overlap effect size (NAP) for overall study. # Count of observations; % percentage of observations.

Description	Overall		Cognitive		Behavioural		Emotional	
	#	%	#	%	#	%	#	%
Absence of behaviour	10	7%	0	0%	4	11%	6	10%
Insufficient data point	13	9%	4	8%	3	8%	6	10%
Opposite Effect	15	12%	7	16%	2	7%	6	13%
Insignificant	40	33%	8	18%	15	52%	17	35%
Less Significant	15	12%	3	7%	6	21%	6	13%
Moderately Significant	10	8%	3	7%	1	3%	6	13%
Significant	41	34%	23	52%	5	17%	13	27%

Table 10. Impact summary in percentages based on *Cohen's d* effect size for overall study. #Count of observations; % percentage of observations.

Effect size using non overlap method shows for the 122 observable parameters across baseline vs. intervention phases (institute and home settings) having 17% as less significant, 25% as moderately significant, 44% as significant and 14% as insignificant. Similarly, effect size using *Cohen's d* shows 34% of data has significant effect, 8% of data shows moderately significant and 12% of data shows less significance. 33% of data shows the intervention impact is positive, however, insignificant and 12% of data shows opposite effect. Tables 9 and 10 represents the impact summary for NAP and *Cohens' d* respectively.

Observed changes of clinical significance

There were changes observed by interventionist during the sessions and by caregivers beyond sessions. All the improvements were not consistent across all participants, and impact varied for participants from mild to moderate to significant and at an early, middle or later stage of the intervention. Few indicators and observations with examples are as follows.

Cognitive All the participants' quality of participation and cooperation to follow the practice like, imitating the postures, following the instructions and reduced dependency on caregiver for patterning improved over time. Except Participant#2 and #5, all other participants towards end started to practice independently along with *yoga* interventionist in presence of caregiver as an observer. Participant#2 and Participant#4 were able to repeat the instructions at home for other family members as feedback shared by their respective caregivers.

Behavioural Repetitive behaviour for Participant#1 and Participant#6 were reduced. For example, Participant#1 used to pinch people around him that got reduced and Participant#6 used to be aggressive and hit people at times, got moderately reduced. Hyper-activity reduced gradually among all the participants. Fiddling during rest or practice reduced over time for all. Later stages they were more stable and calmer during the sessions. Participant#2 and Participant#4 could able to chant comfortably for even 5–10 min without distraction towards the end of the intervention. As shared by the caregiver, Participant#4 even continued chanting during his day-to-day activities while taking bath, and sometimes even during sleep.

Emotional Participant#6 used to demonstrate aggression which reduced over time during sessions. Also, the caregiver testified the participant had reduced temper tantrums at home.

Discussions

To the best of our knowledge, this is the first study to design and develop an integrated yoga module within a single-case experimental design to evaluate its effectiveness on the psychological health of children with multiple disabilities, specifically those having ASD and with ID, using a long-term intervention, and multi-time point approach. A distinctive feature of this study is the inclusion of caregivers and psychologists who are emotionally involved with the children and can assess them more effectively.

Considering the current condition of ASD and with ID, each child was unique and had respective ways to adapt with a stranger. Involving caregivers and being present in each of the sessions helped significantly to establish the initial connect before start of the intervention making the child feel secured and comfortable. Every day 5–10 min of the session was consumed to understand the readiness of the participant based on cues, like smile when greeted, energy level before the session, hyper activity level etc. The time it took to establish the first connect varied from participant to participant and gradually they got used to the instructor. A flexible, simplified approach made all the difference to establishing the comfort and safety of the participant. As we progress with time the participants start experiencing the comfort and safety and get along cooperating with the teacher. The duration may vary for individual participant. So, based on the readiness for each session only that portions they were comfortable were covered. The use of yoga components like movement, chanting, rest were customised to a day keeping function over form. There were few days, where depending on their readiness sessions were also cancelled as required.

The strength of the study lies in its methodological rigor, enhanced by the single-case, multiple-baseline design, and the objective assessments of psychological parameters. The long-term intervention allows for detailed insights into individual responses and trajectories of change over time. As a single-case experimental design (SCED), this study addresses the need for individualized interventions, which are crucial for mitigating the influence of time-varying social and psychological factors, and thus cannot rely on group statistical inferences. Generalizing group estimates to individuals can be, at best, ineffective and, at worst, potentially harmful[23].

The participants continued with their other regular therapies served as a control environment. This adaptive yoga intervention was only additional change for the participants, strengthens the hypothesis of functional improvement of the behaviours in psychological domains. The possibility of a cross functional effects among interventions was kept out of scope for this study.

The qualitative feedback as observed and shared by the caregivers (mothers) were subjective and experiential. Few caregivers found the *yoga* intervention made a lot of difference in reducing hyper activity, improved quality of sleep, and eye contact during the intervention. One of the participants had shown significant improvement in verbal skills. Even post intervention the mothers were in touch with the interventionist sharing feedback over long term. Few repetitive behaviours in participants while reduced significantly during and post intervention, however, observed to be reversed due to discontinuity in practice later. The caregiver's involvement and dedication as one of the predictors was not taken into consideration for this study, would be an interesting dimension to research in future.

There was no clear evidence for attendance of practice in home settings. Thus, the results obtained in home settings could be a carry forward effect from institute intervention or due to continued practice. This was inconclusive. There is a scope to consider the factor of change from one setting to another setting and validate the effect in future. The comparative data between institute and home settings using *Cohen's d* can be referenced in Appendix C.

This study now establishes the change in functional behaviour across cognitive, behavioural, and emotional domains for children with ASD and with ID along with empirical evidence. This study now is subject to further research by replications across increased number of participants, on other psychological parameters, geographical conditions, varied severity levels with similar combinations of multiple disability, longitudinal study etc. In future, cross functional effectiveness of other therapies practiced along with *yoga* intervention as a complementary therapy can be researched.

Conclusion

This is a single case experimental design to study the impact of adaptive *yoga* intervention on the children with multiple disabilities with ASD and ID. The result suggests that a long term, consistent one-to-one adaptive *yoga* intervention can effectively improve the cognitive, behavioural, and emotional conditions of children having ASD and with ID. The results are observed to be satisfactory and shows mild to moderate change in each of

the psychological areas for all six participants. This study establishes the potential of *yoga* interventions in the field of multiple disabilities. The study will unlock the perspectives of caregivers, assessing the feasibility and acceptability of *yoga* practices in the context of their daily routines and overall care strategies.

Data availability

The aggregate summary and analysis outcome of data are included in this published article.

Received: 11 September 2024; Accepted: 13 May 2025
Published online: 26 May 2025

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Acknowledgements

I thank the Department of Clinical Psychology, NIEPMD(D), Chennai, India in supporting this research by helping with identifying participants, assessors, and providing space to conduct the study. I thank the participants, caregivers, assessors, department staff, head of the department and the institute. My sincere thanks for the support by Mr. Sumit Bose who provided technical support, ran the analyses, was the scribe and assisted in writing the paper.

Author contributions

J.M. designed and executed the study, performed data analyses, and wrote the paper. S.M. & K.S. were involved in planning, guiding the study, reviewing the manuscript.

Funding

No funds, grants, or other support was received.

Declarations

Competing interests

The authors declare no competing interests.

Conflict of interest

Authors and co-authors have no conflict of interest in publishing this work.

Ethical approval

The study was approved by Research Committee (RC) of the National Institute for Empowerment of Persons with Multiple Disabilities (Divyangjan) (NIEPMD), Doctoral Committee (DC) and Institutional Ethics Committee (IEC) of Swami Vivekananda Yoga Anusandhana Samsthana (Deemed to-be University), Bengaluru, India. The study adhered to the approved protocol and consent process.

Informed consent

Informed consent was obtained from parents and/or legal guardians.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-02368-2.

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