

## Yoga training enhances auditory and visual reaction time in children with autism spectrum disorder: A case - control study

Ramanathan M<sup>1,\*</sup>, Eswari R<sup>2</sup>, Bhavanani A.B<sup>1</sup>, Prathima G.S<sup>2</sup>, Sanguida A<sup>2</sup>

<sup>1</sup>Centre for Yoga Therapy  
Education and Research  
(CYTER),

<sup>2</sup>Department of Paedodontics  
and Preventive Dentistry,  
Indira Gandhi Institute of Dental  
Sciences  
Sri Balaji Vidyapeeth,  
(Deemed to be University),  
Pillaiyarkuppam,  
Puducherry-607402.

### For Correspondence

\*Ramanathan M,

Email: [yoga@mgmcri.ac.in](mailto:yoga@mgmcri.ac.in)

Date of

Submission: 01-02-2019

Acceptance: 17-02-2019

Access this article online

Quick Response Code



<https://www.jbcahs.org>

E-ISSN: 2581-6039

### ABSTRACT

**Background and Objective:** Autism is a neuro-developmental disorder leading to multiple problems including academic difficulties and impaired skills. Information processing is abnormal in children with Autism Spectrum Disorder (ASD) and their central nervous system (CNS) is either over or under aroused. Reaction time (RT) is a useful marker to study the ability of CNS. This study planned to investigate the changes in RT before and after 12 weeks of yoga training

**Material and Methods:** 72 ASD children were divided equally into control group (Group I) who did not undergo yoga training and yoga group (Group II) who received 60 minutes' yoga training, five days a week, for 12 weeks. Components of yoga protocol included *jathis, kriyas, asanas, pranayamas* and yogic relaxation. Auditory RT (ART) and Visual RT (VRT) were recorded before and after 12 weeks' yoga training using RT apparatus. Data was assessed for normality using GraphPad InStat version 3.06 for Windows 95. Wilcoxon matched-pairs signed-ranks test was used for intragroup comparison and Mann-Whitney test for intergroup comparison.  $P < 0.05$  was accepted as indicating significance.

**Results:** Intra-group comparisons showed a highly significant increase in ART in group I ( $p < 0.001$ ) whereas both ART and VRT decreased significantly in group II ( $p < 0.001$ ) with yoga training. Intergroup comparisons showed highly significant differences in ART and VRT values ( $P < 0.0001$ ). Delta % changes were also highly significant for both ART and VRT ( $P < 0.0001$ ).

**Conclusion:** Yoga training may be utilized to reduce dependency on others and enhance learning capabilities and social skills in ASD children.

### Keywords:

Reaction time, central neuronal processing, social skills, quality of life

### INTRODUCTION

Autism is a neuro-developmental disorder associated with stereotyped repetitive activities, difficulty in forming relationships and understanding the world around them. Attention deficit and hyperactivity are additional factors leading to academic difficulties and impaired skills. Autism spectrum disorder (ASD) is characterized by abnormal or impaired development in social interaction and communication. <sup>1</sup> ASD varies in severity from individual to individual, ranging from those with no speech and severe learning disabilities to people with intelligence

quotients in an average range and who can hold a job or start a family. <sup>2</sup>

Parents of children with ASD turn to Complementary and Alternative Medicine (CAM) since no single intervention has proved effective in alleviating ASD's core symptoms. Reports exist of significant recovery using various combinations of mainstream and alternate medicine. <sup>3</sup> Medications help in symptomatic management but certainly have other negative side-effects such as sleep disturbances, reduced appetite, mood disorders etc. Treatment options that

**How to Cite:** Ramanathan M, Eswari R, Bhavanani AB, Prathima GS, Sanguida A.

Yoga training enhances auditory and visual reaction time in children with autism spectrum disorder: A case - control study. J Basic Clin Appl Health Sci. 2019;2:8-13.

are evidence-based are limited and hence application of CAM seems to be a boon for many.<sup>4</sup> Yoga has been found to be a blessing for children with emotional and behavioural disorders and is extremely effective in improving low attention span and adaptive skills.<sup>5</sup> Yoga practice help individuals to master different breathing patterns and postures consciously and willingly, promoting self-control, attention and body awareness.<sup>6</sup>

Children with ASD have learning delays due to their hyperactivity and distractibility. They develop more resilience through the ability to self-regulate, reduce stress and anxiety; balance themselves and learn how to relax, release tension and frustration through various techniques of yoga. Previous studies have also reported beneficial effects such as decreased anxiety, and improved relationship, quality and sleep patterns and a variety of social, emotional, behavioural, and cognitive ailments.<sup>7</sup>

Reaction time (RT) is one of the easiest methods of assessing the sensory and motor performance of an individual. RT is the time interval between onset of stimulus and the beginning of response to stimuli and is a useful index to study the ability of central nervous system. Most commonly used tests are auditory reaction time (ART) and visual reaction time (VRT) and it has been proven that yoga training enhances both ART and VRT.<sup>8</sup>

Bhavanani et al reported decreased RT in mentally challenged adolescents by performance of *mukha bhastrika*, a yogic technique. Reduced RT signifies improved central neuronal processing ability and/or ability to ignore or inhibit extraneous stimuli. It was suggested that yogic breathing techniques may be used as an effective means of improving neuromuscular abilities in special children.<sup>9</sup>

Due to the information being processed abnormally in ASD children, their central nervous system is either over or under aroused. Previous studies have suggested that repetitive stereotyped behaviour may calm over aroused nervous systems and alert under aroused ones promoting balance.<sup>10,11</sup> Literature on ASD suggests a wide variety of cognitive, social and behavioural deficiencies that could be correlated to RT which is a significant underlying mechanism combining cognitive abilities and functions together.<sup>12</sup>

Many studies have been done on RT in normal population comprising different age groups and

different conditions, whereas only a few studies focused on RT in special children, especially those with ASD. Hence, we planned to explore the lacunae by analysing changes in RT before and after 12 weeks of yoga training through this study.

## MATERIAL AND METHODS

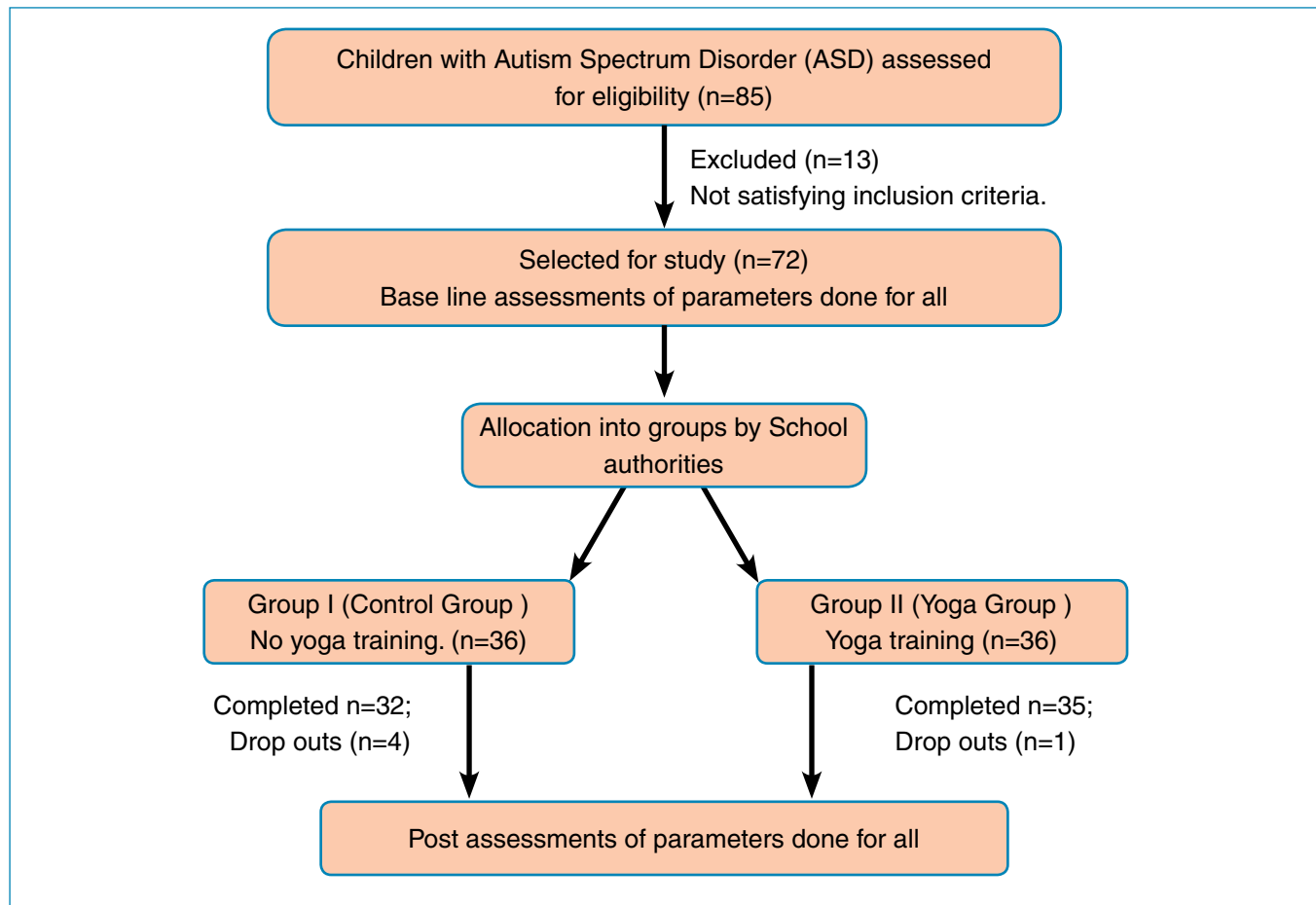
The present study was undertaken as an interdisciplinary collaborative work between the Centre for Yoga Therapy Education and Research (CYTER) of Sri Balaji Vidyapeeth (SBV) and Department of Paedodontics and Preventive Dentistry of Indira Gandhi Institute of Dental Sciences (IGIDS) also of SBV. The study was approved by the Institutional Review Board & Institutional Ethical Committee. Informed consent was obtained from both parents and school authorities of the Carunai School for children with special needs at Pondicherry.

Convenient sampling method was used. The inclusion criteria are children between the ages 7 and 15yrs, able to understand visual or simple verbal instructions and cues and those whose parents agreed to let their children undergo yoga training. Children unable to either perform yoga techniques or understand the procedure for testing RT and with co-morbidities like epilepsy were excluded from the study.

Eighty-five children with ASD were assessed for eligibility out of which 72 children satisfied the inclusion criteria and were selected to participate in this study. They were then divided into two equal groups, a control group (Group I) and a yoga group (Group II), by the school authorities based on the perceptive ability of the children, thus allotting 36 in each group. Children who could respond to verbal cues and understand instructions were allotted to Group II and received 60 minutes' yoga training per day, for five days, (Monday to Friday) for 12 weeks. The others were allotted to group I who did not undergo yoga training. Children in both groups participated in the regular activities of the school. Four participants from group I and one from group II discontinued the study as they left the school within the 12 weeks' study period and were considered as drop outs (Figure 1).

Yoga sessions were conducted at Carunai school, Pondicherry and the components of yoga protocol (Table 1) included simple *jathbis*, the warm-up practices [toe touching, hip rotation, shaking the hands and throwing out with a whoosh sound and boating

Figure 1: Flow chart of methodology of the study



movements done as in *nava asana*, the boat posture]; *kriyas*, the breath-body coordinated harmonising practices [*tala kriya* (stretching up on toes), *chatushpada kriya* (crawling movements), *malla kriya* (squatting movements with breath) and *bhujangini mudra* (hissing up like a cobra)]; *asanas*, the postures held steady and with ease [*meru asana* (mountain posture), *ardhakati chakrasana* (lateral bending posture), *dharmikasana* (posture of devotion), and *pavanamuktasana* (wind-releasing posture)] and *pranayamas*, techniques manipulating breath and altering breathing patterns consciously, [*mukha bhastrika* (bellows breath), *om pranayama*, (chanting of *om*) and *pranava pranayama* (chanting of *aaa*, *uuu*, *mmm* separately and finally bringing all of them together as *aaa...uuu...mmm* with a specific hand-*mudra*/gesture used with each sound)] and finished the session with yogic relaxation.

Reaction time (RT) apparatus manufactured by Anand Agencies, Pune, was used for the study. The instrument has a built in 4 digit chronoscope with a display accuracy of 1 ms. It features four stimuli, two response keys and a ready signal. Switches for selecting

right or left response key for any stimulus is provided. In the present study simple auditory RT (ART) was recorded for auditory beep sound stimulus and simple visual RT (VRT) for red light stimulus. The subjects were instructed to release the response key as soon as they perceived the stimulus. The signals were given from the front of the subjects to avoid the effect of lateralized stimulus and they used their dominant hand while responding to the signal. All subjects were given adequate exposure to the procedure and equipment on 2 different occasions to familiarize them with the methodology of RT measurement.<sup>9</sup>

Children were made to sit comfortably in a chair and were motivated to better their results as much as possible, with 5 practice trials (not included for analysis) for each of the RT tests followed by the actual data acquisition trials. Data was collected very patiently, encouraging and cheering up each of the child verbally so that they were as relaxed as possible. More than ten trials were recorded and the mean of three similar observations was taken as a single value for purpose of statistical analysis.

**Table 1.:** Yoga techniques for children with ASD in group II

<i>Jathis</i> (10 min)	<i>Kriyas</i> (10 min)	<i>Asanas</i> (10 min)	<i>Pranayamas</i> (15 min)
Toe touching	<i>tala kriya</i>	<i>meru asana</i>	<i>mukha bhastrika</i>
Hip rotation	<i>chatuspada kriya</i>	<i>ardhakati chakrasana</i>	<i>om pranayama</i>
Shake and throw	<i>malla kriya</i>	<i>dharmikasana</i>	<i>pranava pranayama</i>
Boating movement	<i>bhujangini mudra</i>	<i>pavanamuktasana</i>	relaxation (15 min)
Total duration : 60 minutes			

Statistical analysis: Data entry was done and assessed for normality using GraphPad InStat version 3.06 for Windows 95 (GraphPad Software, San Diego California USA, www.graphpad.com). As data did not pass normality, Wilcoxon matched-pairs signed-ranks test was used for intragroup comparison and Mann-Whitney test for intergroup comparison. Values are given as Median (Range). P value less than 0.05 was considered as significant. Actual p values are given for the intergroup comparisons by Mann Whitney test.

## RESULTS

Effect of 12 weeks of yoga training on ART and VRT in 67 children with ASD before and after study period has been tabulated in Table 2.

Intra-group comparisons showed a highly significant prolongation of ART in group I ( $p < 0.001$ ) whereas both ART and VRT shortened significantly in group II ( $p < 0.001$ ) following yoga training.

Intergroup comparisons show highly significant differences in both ART and VRT values ( $P < 0.0001$ ). Delta % changes were also highly significant for both ART and VRT ( $P < 0.0001$ ).

## DISCUSSION

This study was planned to explore the effect of yoga on RT in ASD children before and after 12 weeks of yoga training. RT is one of the established diagnostic methods used in psychology to find the time interval between a stimulus and its response. This sensitive cognitive test also evaluates quality and speed of information processing in individuals which includes sensory neural code traversing in central and peripheral pathways, cognitive and perceptive processing, motor signal traversing both peripheral and central neuronal structures and eventually the muscle activation.<sup>13</sup>

Stress retards neuron growth in the hippocampus, associated with memory, helping explain why anxious ASD children have difficulty learning.<sup>14</sup> However yoga practices results in decreased sympathetic activation and improved parasympathetic tone, promotes body- mind equilibrium and enhances emotional self-regulation<sup>15</sup> Hence it is extremely useful for the ASD children to enhance their overall personality, health and wellbeing evidenced by significantly decreased RT.

Significant shortening in ART and VRT have been found in this study which signifies faster reactivity and this is in agreement with previous studies done on RT, where a significant reduction of ART and VRT have

**Table 2:** Effect of 12 weeks of Yoga training on auditory reaction time (ART) and visual reaction time (VRT) in 67 children with autism spectrum disorder (ASD) before and after study period.

Parameters	Group 1 (Control) (n=32)			Group 2 (Yoga) (n=35)			Comparison (P values)		
	Before	After	Delta %	Before	After	Delta %	Before	After	Delta %
<b>ART (ms)</b>	660.00 (349 to 1210)	761.00 (390 to 1299) ***	5.83 (-10.80 to 44.04)	743.00 (222 to 1210)	376.00 (228 to 674) ***	- 46.11 (-69.07 to 21.17)	0.950	< 0.0001	< 0.0001
<b>VRT (ms)</b>	784.50 (459 to 1451)	858.50 (384 to 1438)	-0.28 (-21.99 to 92.96)	817 (268 to 1451)	421.00 (272 to 1278) ***	- 44.55 (-69.38 to 18.28)	0.589	< 0.0001	< 0.0001

been reported.<sup>16-20</sup> Decrease in RT may be attributed to greater arousal and faster rate of information processing along with improved concentration. RT is fastest with an intermediate level of arousal and deteriorates when subjects are either too relaxed or too tensed.

Yogic techniques improve RT and moderate muscular tension shortens pre-contraction RT while isometric contraction allows the brain to work faster.<sup>21</sup> Increased concentration, focus, organization, and relaxation have been reported after yoga practice. Through the positive influence of such techniques, it is possible to bring about progress in their behaviour.<sup>3</sup>

Penn reported increased neurotransmitter production and activity of serotonin in autistic children following short term yoga intervention. He also confirmed previous reports of qualitative behaviour changes along with increased tolerance and subsequent socialization.<sup>22</sup> Increased slow-frequency brain wave activity has been reported along with significant decrease of cortisol and increase in brain-derived neurotropic factor (BDNF), serotonin, and dopamine.<sup>23,24</sup>

RT is a simple measure that contributes to the understanding of organizing, planning and preparing the performance of motor skills. Ferraro concluded after a meta-analysis that although many cognitive and information processing domains are altered in ASD, RT is relatively unaffected in ASD individuals.<sup>12</sup> It forms the basis of many cognitive tasks, given that individuals with ASD do not always show evidence of information processing impairments on some processes that involve RT, further investigation of the role RT in individuals with ASD seems important.<sup>25</sup>

ASD children have frontal lobe deficits involving cortical and subcortical regions, as suggested by ASD's pervasive nature. Working to improve brain function directly through yoga, rather than focusing on the problem, helps improve their behaviour. Improvements in sensory integration, attention and increased verbal receptivity for commands have been reported. Yoga techniques enable the children to relax completely and focus on breathing, resulting in a calm and relaxed nervous system and state of mind.<sup>3</sup>

Ability to understand spatial commands like right, left, front, back, up and down improved with yoga as the children watch the instructor or therapist

demonstrate and then listen to the command to perform the same. Thus they get both audio and visual aid possibly due to the kinaesthetic/tactile stimulation given during asanas. The imitation skills get enhanced as they replicate the therapist during each yoga posture progressing gradually to a stage of being able to relate and interact with others as normal people.<sup>26</sup>

## LIMITATIONS

As a case-control study on the effect of adjuvant yoga therapy on children with ASD, this study has some limitations. The sample size was relatively small, which could have caused some non-significant results with large effect sizes. In addition, all participants in the present study belonged only to one school in Pondicherry. Whether similar effect can be obtained on other cohorts of different cultures and backgrounds remains unknown. Further studies are needed to validate the present findings.

## CONCLUSION

The present study provides evidence that yoga training can enhance RT in children with ASD. Both ART and VRT shortened and these changes may be attributed to enhanced central neuronal processing resulting in better sense of alertness, sensitivity and awareness after yoga practice. Children with ASD more often than not are very routine-oriented. They are stressed if their set routine is changed. They feel comfortable with structured yoga sessions and procedures. Hence we suggest that yoga be made a part of everyday schedule in the schools for children with special needs as it can enhance quality of life and improve overall health among this population. Yoga training may be utilized to reduce dependency on others and enhance learning capabilities and social skills in ASD children.

## ACKNOWLEDGMENTS

Heartfelt gratitude is offered to Ammaji Yogacharini Meenakshi Devi Bhavanani, Director ICYER, Prof Dr Madanmohan, Director, Centre for Yogic Sciences, AVMC, and Dr. G. Ezhumalai, Senior statistician & Research consultant, SBV for their professional advice. We thank the authorities, staff, children and parents of Carunai School for children with special needs, Pondicherry for their involvement and assistance during the period of the study.

## References

- American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR). 4<sup>th</sup> ed. Text revision. Washington, D.C.: American Psychiatric Association; 2000. p.78
- Ramanathan M, Bhavanani AB. Addressing autism spectrum disorder through yoga as a complementary therapy. *J Basic Clin Appl Health Sci*. 2018;2:3-7.
- Radhakrishna S, Nagarathna R, Nagendra HR. Integrated approach to yoga therapy and autism spectrum disorders. *J Ayurveda Integ Med*. 2010;1:120-4.
- Barnes PM, Bloom B, Nahin RL. Complementary and alternative medicine use among adults and children: United States, 2007. *Natl Health Stat Report*. 2008;12:1-23.
- Steiner NJ, Sidhu TK, Pop PG, Frenette EC, Perrin EC. Yoga in an urban school for children with emotional and behavioral disorders: a feasibility study. *J Child Fam Stud* 2013; 22:815- 26.
- Kimbrough S, Balkin R, Rancich A. The effect of inverted yoga positions on short- term memory. *The Online Journal of Sport Psychology* 2007;9:34-42.
- Diamond A, Lee K. Interventions shown to aid executive function development in children 4-12 years Old. *Science* 2011;19:959 – 64.
- Hanji CV, Venkatesh G. To study the effect of Yoga Training on auditory and visual reaction time. *J Int Med Dent* 2014;1:90-92.
- Bhavanani AB, Ramanathan M, Harichandrakumar KT. Immediate effect of mukha bhasrika (a bellows type pranayama) on reaction time in mentally challenged adolescents. *Indian J Physiol Pharmacol* 2012;56:174-80.
- Guess D, Carr E. Emergence and maintenance of stereotypy and self-injury. *Am J Ment Retard*. 1991;96:299-319; discussion 321-44.
- Schneck CM. The efficacy of a sensorimotor treatment approach by occupational therapists. *Autism: A sensorimotor approach to management*. In: Huebner RA, editor. Austin: PRO-ED INC; 2000. p.139-78.
- Ferraro FR. No evidence of reaction time slowing in autism spectrum disorder. *Autism*. 2016;20:116-22.
- Moradi A, Esmailzadeh S. Simple reaction time and obesity in children: whether there is a relationship? *Environ Health Prev Med*. 2017;22:2
- Goldeberg L. Creative relaxation a yoga based program for regular and exceptional student education. *Int J Yoga Ther*. 2004;14:67-78.
- Streeter CC, Gerbarg PL, Saper RB, Ciraulo DA, Brown RP. Effects of yoga on the autonomic nervous system, gamma-aminobutyric-acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. *Med Hypotheses*. 2012;78:571-9.
- Bhavanani AB, Ramanathan M, Balaji R, Pushpa D. Immediate effects of Suryanamaskar on reaction time and heart rate in female volunteers. *Indian J Physiol Pharmacol*. 2013;57:199-204.
- Bhavanani AB, Ramanathan M, Balaji R, Pushpa D. Differential effects of uninostril and alternate nostril pranayamas on cardiovascular parameters and reaction time. *Int J Yoga*. 2014;7:60-5.
- Bhavanani AB, Ramanathan M, Madanmohan. Immediate effect of alternate nostril breathing on cardiovascular parameters and reaction time. *Int Interdisciplinary Res J*. 2014; 4; (Special Issue): 297-302.
- Ramanathan M, Bhavanani AB. Immediate effect of chandra and suryanadi pranayamas on cardiovascular parameters and reaction time in a geriatric population. *Int J Physiol*.2014;2:59-63.
- Bhavanani AB, Ramanathan M, Dayanidy G, Madanmohan Trakroo, Renuka K. A comparative study of the differential effects of short term asana and pranayama training on reaction time. *Ann Med Health Sci Res*. 2017;7:80-3.
- Etnyre B, Kinugasa T. Post-contraction influences on reaction time (motor control and learning). *Res Q Exerc Sport* 2002;73:271– 81.
- Penn HE. Neurobiological correlates of autism: a review of recent research. *Child Neuropsychol*. 2006;12:57-79.
- Arambula P, Peper E, Kawakami M, Gibney KH. The physiological correlates of Kundalini Yoga meditation: a study of a yoga master. *Appl Psychophysiol Biofeedback*. 2001;26:147-53.
- Pal R, Singh SN, Chatterjee A, Saha M. Age-related changes in cardiovascular system, autonomic functions, and levels of BDNF of healthy active males: role of yogic practice. *Age (Dordr)*. 2014;36:9683.
- Herrero D, Crocetta TB, Massetti T, de Moraes IAP, Trevizan IL, Guarnieri R, et al. Total reaction time performance of individuals with autism after a virtual reality task. *Int J Neurorehabil*. 2015; 2:189.
- Gepner B, Féron F. Autism: a world changing too fast for a mis-wired brain? *Neurosci Biobehav Rev*. 2009;33:1227-42.