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is consistently documented lower than their sighted counterparts.<sup>11,13-16</sup> Furthermore, in minimum muscles fitness tests, 54% of children with visual impairment failed compared to 5% of normal sighted ones.<sup>17</sup> Another study demonstrated that those with visual impairment are deficient in strength and power compared to sighted individuals.<sup>11</sup> These draw attention to need for a set of minimal standards of strength and flexibility needed for daily living.

Physical activities in early stages of life can enhance fitness levels in children.<sup>18</sup> Dale *et al.*,<sup>19</sup> reported that early intervention may prevent or minimize the risk factors and developmental difficulties in children.

Yoga, the ancient Indian health promoting procedure, includes well known physical and breathing techniques which can help achieve recommended levels of fitness at physical, mental and emotional levels.<sup>20</sup> It has received much attention from the scientific communities over the last 20 years due to its effectiveness in enhancing muscular strength, endurance, body flexibility,<sup>21</sup> generating balanced energy, vitality,<sup>22</sup> and cultivating calmness in the mind.<sup>23</sup> Also, Yoga has been observed to have good benefits on health related fitness in sighted school children's muscles strength,<sup>24-26</sup> endurance,<sup>24,25</sup> flexibility,<sup>24</sup> and cardiovascular endurance.<sup>24</sup> Its positive effects in children with visual impairment are also well-documented, including autonomic arousal,<sup>27</sup> balance,<sup>28</sup> and proprioception.<sup>29</sup>

Lieberman,<sup>30</sup> describes yoga as an inexpensive way to improve fitness, and to gain relaxation. In the present study a yoga intervention was administered to children with visual impairment to improve muscular fitness as measured by the Kraus-Weber test, a battery of six muscular strength tests.<sup>31</sup> The test was selected for children with visual impairment due to the advantages that it offers such as simplicity of administration, low risk, minimal use of equipment, and because it permits quick testing of each participant.<sup>32</sup> Earlier studies

have shown the test to be effective especially in children.<sup>32-34</sup>

However, it can also be used as an indicator of overall health in similar age groups. Benefits of other physical activities for fitness in visually impaired people have been previously investigated.<sup>35-38</sup> However, potential beneficial effects of yoga practice on minimum muscle fitness in children with visual impairment have not been documented. This study hypothesized that 16 weeks of yoga intervention would improve participants' muscles fitness.

## Materials and methods

A total of 83 students from the "Shree Ramana Maharishi Academy for the blind", a residential school (Bangalore, South India) volunteered to participate in the study: 41 in yoga group and 42 control group. All were active and proficient in their ability to move about within their environment by themselves to carry out their regular activities, and all passed a medical examination prior to the study. None had any other identifiable disability, neurological, or other disorder.

This was a wait-list controlled design with pre-post single blind study. Participants volunteered to join the study. Children in the yoga group were not involved in any other vocational training program; controls continued to participate in normal professional training.

Inclusion criteria were; (a) children aged between 9 to 16 years, (b) with various degrees of visual impairment since birth, (c) healthy in the sense of having no overt disease conditions, (d) able to understand both English and their regional language (Kannada), (e) either had no earlier exposure to yoga, or had not attended any yoga classes in the last 3 years, and (f) willing to provide written informed consent prior to the study.

Students who had; (a) late onset visual impairment, (b) multiple impairments, (c) any recent injury restricting their practice of yoga, (d) deficits in other sensory systems,

or (e) other physical disabilities were excluded from study.

The study protocol was approved by the Institutional Ethical Committee of SVYASA Yoga University, and followed the tenets of the declaration of Helsinki research ethics and reviewed by Institutional Review Board. Signed informed consent was obtained from the school authorities, and from one parent. Written informed consent was also collected from all participants after explaining the study to them in detail.

#### Blinding and masking

Participants' data was presented for analysis using numerical identifiers, ensuring that the statistician was blind to the source of the data. Masking participants to a yoga intervention is not possible; however the trained research assistants were masked to participants' group assignment during data collection and analysis.

Selected yoga practices consisted of breathing exercises, loosening practices, yoga-asanas, pranayama, relaxation and meditation (Table 1). The yoga group received intervention for 60 minutes, 5 days per week for 16 weeks by the first author, a trained yoga instructor already having experience with children who are visually impaired. Two other trained instructors were also present to assist or guide participants. For convenience of learning, the yoga group was divided into four subgroups, each containing 10-11 students. Individual care was taken so that they could understand, feel and perform the chosen practices accurately. Each practice (especially the asanas) was taught in five steps:

1. Verbal guidance: Clear, concise, direct, simple and complete oral instructions were given in the student's local language.
2. Tactile modelling with verbal guidance: Thick paper cut-out model of each asana was prepared and distributed among the participants and were instructed to touch and feel the model until they thought they really understood the body position.

3. Step by step teaching: Each practice was divided into sub steps so that each step can be taught successively.

4. Learning in a group: All participants were divided into small groups and made them to stand in circles with a demonstrator in the center. Next, the demonstrator student performed each posture, while instructions were given by the yoga instructor. Others in the group were encouraged to touch feel the demonstrator's limbs and body position.

5. Physical assistance with verbal guidance: While performing the practices, the yoga assistances corrected their postures individually by guiding their limbs into better positions. Complete class attendance was achieved by all participants. Yoga classes were conducted on the premises of the school where the children with visual impairment were studying to make the yoga classes more accessible. After the yoga group had completed the training and assessments had been collected, the wait-list control group were invited to participate in the yoga program; all accepted.

All participants completed Kraus-Weber test assessments before, mid and after the intervention i.e. at 0, 8 and 16 weeks respectively. To allow the tests for participants with visual impairment, each test-item was demonstrated to them and they were instructed to touch the demonstrator's limbs and body position before performing the test. Also tactile models were used for their better understanding. In all other respects, the test was administered according to the standard procedure with no warming-up period prior to taking the test.<sup>31,39</sup>

The Kraus-Weber test is a reliable and easy exercise test<sup>39</sup> which includes six specific tests to measure strength and flexibility of various different muscle groups, e.g. a test of "abdominal with psoas muscles", "upper abdominal without psoas muscles", "lower abdominal with psoas muscle", "upper back muscles", "lower back muscles" and "back and hamstrings". It is a pass or fail test with one 'fail' on any

of its six test items considering a whole-test failure. Those who fail the test appear to be unhealthy, emotionally imbalanced and or exhibiting strain constantly.<sup>40</sup>

The Kraus-Weber test was conducted as follows:

Test 1: the participants were instructed to lie flat on the back with hands behind the neck. The feet were held by the examiner to keep them on the ground. Then they were asked to roll up into a sitting position.

Test 2: the body position for this test remained same and knees were bent. The feet were held. They were asked to follow the same procedure as test 1.

Test 3: position of the body remained same with legs extended. Students were instructed to lift the feet above the ground, 25 cm (10 inches) and maintained for ten seconds.

Test 4: the participants were instructed to lie on their stomach with a pillow under the lower abdomen and the hands behind the neck. The examiner held down the feet and asked the students to lift up the chest, head and shoulders and remained in this position for ten seconds.

Test 5: the position remained the same as test 4. Here the examiner held the chest down and asked the students to lift the legs up without bending at the knees and to maintain this position for ten seconds.

Test 6: the participants were instructed to stand erect with hands by the sides and feet together. They were asked to lean down slowly to touch the floor with the fingertips. The knees were kept straight and then leaning down position was maintained for ten seconds.

Statistical analysis was performed using SPSS (version 13.0. Chicago, SPSS Inc.) for statistical analysis. Since all variables were categorical and nominal levels of measurement, no assumptions for parametric test were checked. Chi-square test was performed to examine the frequency and percentage to compare successes and failures in Kraus-Weber test items in each group and McNemar test was used to determine group differences.

## Results

A total of eighty three students were enrolled for the study. Finally, eighty students (39 control and 41 yoga) completed the pre, mid and post tests. Three participants dropped out in control group who were not available for mid testing. Demographic variables (gender, and degree of blindness) showed no significant differences between two groups (Table 2). The mean age was 11.85 (2.17) years in the yoga group and 12.51 (2.47) years in the control group ( $P = 0.208$ , independent t-test).

Table 3 presents the number of children passing the Kraus-Weber test. Before starting the yoga intervention only 5 (12.2%) children in the yoga group and 9 (23.1%) children in the control group passed the test. Baseline scores were not significantly different between the two groups ( $P = 0.200$ ). At mid assessment the number of students who passed the test were increased from 5 to 18 (43.9%) in yoga group and from 9 to 12 (30.8%) in control group. In post-test assessment, yoga group showed a continuous improvement in muscles fitness performance in which 28 students (68.3%) passed the test successfully, whereas in control group the number of passed students remained 12 (30.8%), same as the result of the mid test.

Between group comparison failed to reach significance at mid-test, but achieved good significance ( $P = 0.001$ ) for the post test.

An exact McNemar test showed that there was a statistically significant difference in the proportion of successful students in yoga group pre versus mid,  $P < 0.001$  and pre versus post,  $P < 0.001$ .

Further details on individual test items at baseline: the largest numbers of failures were on the strength and flexibility of lower abdomen subtest (Test 3), (31 out of the 41 (75.6%) yoga group, and 20 of the 39 (51.3%) failed in control group). At 16 weeks, failure percentage in the yoga group dropped to 2.4%, whereas the control group only reduced to 35.9%, a very large difference.

## Discussion

The result of the present study indicates that 16 weeks of yoga training can increase minimum muscular fitness in children with visual impairment, rejecting the null hypothesis. This is consistent with the previous finding on normal school children where yoga practice achieved a significant improvement on minimum muscular fitness measured by Kraus-Weber test.<sup>41</sup> Prior studies reported statistically significant increases in muscle strength, endurance and body flexibility through the practice of yoga in both upper extremities, evaluated by hand grip strength<sup>42-44</sup> and lower extremities; evaluated by chair stand test.<sup>45</sup>

Tran et al.,<sup>46</sup> observed significant increase in isokinetic muscle strength and isometric muscular endurance following eight weeks hatha yoga practice. During loosening practices the entire body experience alternating stretch and relaxation in different groups of muscles, major and minor; also they impart strength, flexibility and bring nourishment. Yogic postures is known to increase skeletal muscle strength,<sup>47</sup> since they involve isometric contraction of many muscle groups throughout the body, similar to resistance training.<sup>48</sup> These are the probable reasons for improvements observed in this study.

Previous studies have shown positive effects on muscle strength due to practice of surya namaskar,<sup>49</sup> pranayama.<sup>50</sup> This study included the above mentioned practices and also bhujangasana, shalabhasana, and dhanurasana involving sustained isometric contraction of the abdomen, chest, arm and back muscles. Consequent improvement in the strength and endurance of these muscles explains the significant increase in muscle fitness in the various muscle groups involved in the Kraus-Weber test.

The eight week assessment aimed to determine whether yoga can bring positive changes in children in the short term, as no

concrete guidelines exist regarding duration or frequency of practice to acquire optimal benefit. In the present study percent success rate observed was more in yoga group than control group after eight weeks training, demonstrates the beginning of a significant trend though the difference in post scores between the groups after 16 weeks reached statistical significance. However, our participants, being visually impaired and exposed to yoga practice for the first time, took much time to understand and learn the different yoga postures, still performed well. Ramani et al.,<sup>51</sup> have explained that visual impairment from birth or at an early age may cause slow learning. Despite this, our findings suggest that even eight weeks yoga intervention may be enough to promote children's fitness level to some extent.

Yoga may be considered as complementary therapy or alternative physical activity for students with visual impairment. In Yoga practice, duration and frequency should be personalized, as it tends to vary from person to person, requiring modification to meet individual needs, goals, and initial fitness level and health status.

No adverse events occurred during yoga classes in our study, consistent with yoga's known low rate of side effects, low risk of injury and no known interactions with prescribed medication.

Strength of the study: to our knowledge, this is the first study where muscle fitness in children with visual impairment has been evaluated as an objective outcome before and after yoga training. Results encourage us to undertake further study.

Limitations of the study: Some students did not participate in test to the best of their ability. Despite specific criteria to minimize heterogeneity in our visual impairment population, it is likely that individual differences in visual function vary

**Table 1.** List of the practices

<b>Types of Practices (Duration)</b>	<b>Name of the Practices</b>	<b>Target Symptoms</b>
<b>Breathing Practices (5 mins)</b>	Hands in and out breathing	High breath rate
	Ankle stretch breathing	Impaired sense of balance
	Sasankasana breathing	Restless mind
	Tiger breathing	Low ventilatory capacity, Stiffness in different groups of muscles
<b>Loosening Practices (10 mins)</b>	Jogging and Jumping	Lethargy and tardiness
	Mukha dhouti	Strain of exercise
	Forward & backward bending	Stiffness of trunk muscles
	Twisting	Stiffness of waist
	Surya Namaskar (12 rounds)	Low stamina and immunity, Imbalance of body and mind
<b>Yoga-Asanas (20 mins)</b>		
<b>Standing-Asana</b>	Ardha Cakrasana	Stiffness of the dorsal spine
	Padahastasana	Weakness in the back, hip and calf muscles stiffness of spinal and hip joints
	Trikonasana	Lack of stamina in limb and trunk muscles
	Parivritta Trikonasana	Stiffness of spinal joints and muscles
<b>Sitting-Asana</b>	Vajrasana	Indigestion, Constipation, menstrual disorders
	Paschimottanasana	Stiffness of spinal joints and muscles constipation, poor appetite
	Ustrasana	Poor lung capacity, laziness
	Vakrasana	Stiffness of Shoulder neck and dorsal spine
<b>Prone- Asana</b>	Bhujangasana	Back problems, low mood, constipation, weight gain/loss
	Salabhasana	Low backache, pelvic problems, poor appetite
	Dhanurasana	Gastrointestinal disorders, menstrual disorders
	Makarasana	Problems related to back and respiratory system
<b>Supine-Asana</b>	Sarvangasana	Problems of thyroid gland, mental and emotional stress and various psychological disturbances
	Halasana	Digestive disorders, constipation and dyspepsia
	Matsyasana	Complimentary to previous two asanas. Poor flexibility and respiratory stamina
<b>Pranayama (15 mins)</b>	Kapalabhati	Decreased concentration or thinking or memory, low mood, speed of mind, drowsiness
	Vibhagiya pranayama	poor awareness, fatigue, tired, angry
	Nadisuddhi pranayama	Stress and anxiety, low concentration, imbalance of body and mind
	Bhramari pranayama	Stress, tension, anger, anxiety and insomnia, low memory and lack of concentration
<b>Relaxation/Meditation (15 mins)</b>	Instant, quick and deep relaxation technique/ Nadaanusandhana,	Tiredness and fatigue; low mood Poor in concentration, memory, and Co-ordination
	A+U+M Chanting	Lack of internal and self awareness
	(each 9 rounds)	Lack of confidence
	<b>Total 60 mins</b>	

**Table 2.** Baseline comparison on gender and blindness

Group	Control N=39 (%)	Yoga N=41(%)	Statistical indicators
<b>Gender</b>			
Female	10 (25.6)	15 (36.6)	$\chi^2=1.114, P=0.291$
Male	29 (74.4)	26 (63.4)	
<b>Types of Blindness</b>			
Partial Blind	9 (23.1)	9 (22.0)	$\chi^2=0.015, P=0.904$
Total Blind	30 (76.9)	32 (78.0)	

**Table 3.** Kraus-Weber test scores of minimum muscular fitness level

Group	Control	Yoga	Statistical indicators
<b>Pre test</b>			$\chi^2=1.63, P=0.20$
<b>Fail</b>			
Count	30	36	
Expected count	32.2	33.8	
% within group	76.9	87.8	
<b>Pass</b>			
Count	9	5	
Expected Count	6.8	7.2	
% within Group	23.1	12.2	
<b>Mid test</b>			$\chi^2=1.47, P=0.22$
<b>Fail</b>			
Count	27	23	
Expected count	24.4	25.6	
% within group	69.2	56.1	
<b>Pass</b>			
Count	12	18	
Expected count	14.6	15.4	
% within group	30.8	43.9	
<b>Post test</b>			$\chi^2=11.25, P=0.001$
<b>Fail</b>			
Count	27	13	
Expected count	19.5	20.5	
% within group	69.2	31.7	
<b>Pass</b>			
Count	12	28	
Expected count	19.5	20.5	
% within group	30.8	68.3	

according to severity, duration and types of visual impairment and may limit the generalization of results. Applications of the study: Based on evidence from this study Suggestions for future research: a similar, more comprehensive study including children from other states with larger sample size is recommended. Also, a multicenter RCT can be recommended to confirm the results of this study.

## Conclusion

In the present study, yoga practice for 16 weeks in children with visual impairment demonstrated significant improvement in muscle strength. Hence it may be concluded that yoga, a moderate-intensity form of exercise may enhance their physical fitness and health status to optimum level as their sighted peers.

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## Ethical issues

None to be declared.

## Conflict of interest

The authors declare no conflict of interest in this study.

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