

CHAPTER 7

RESULTS

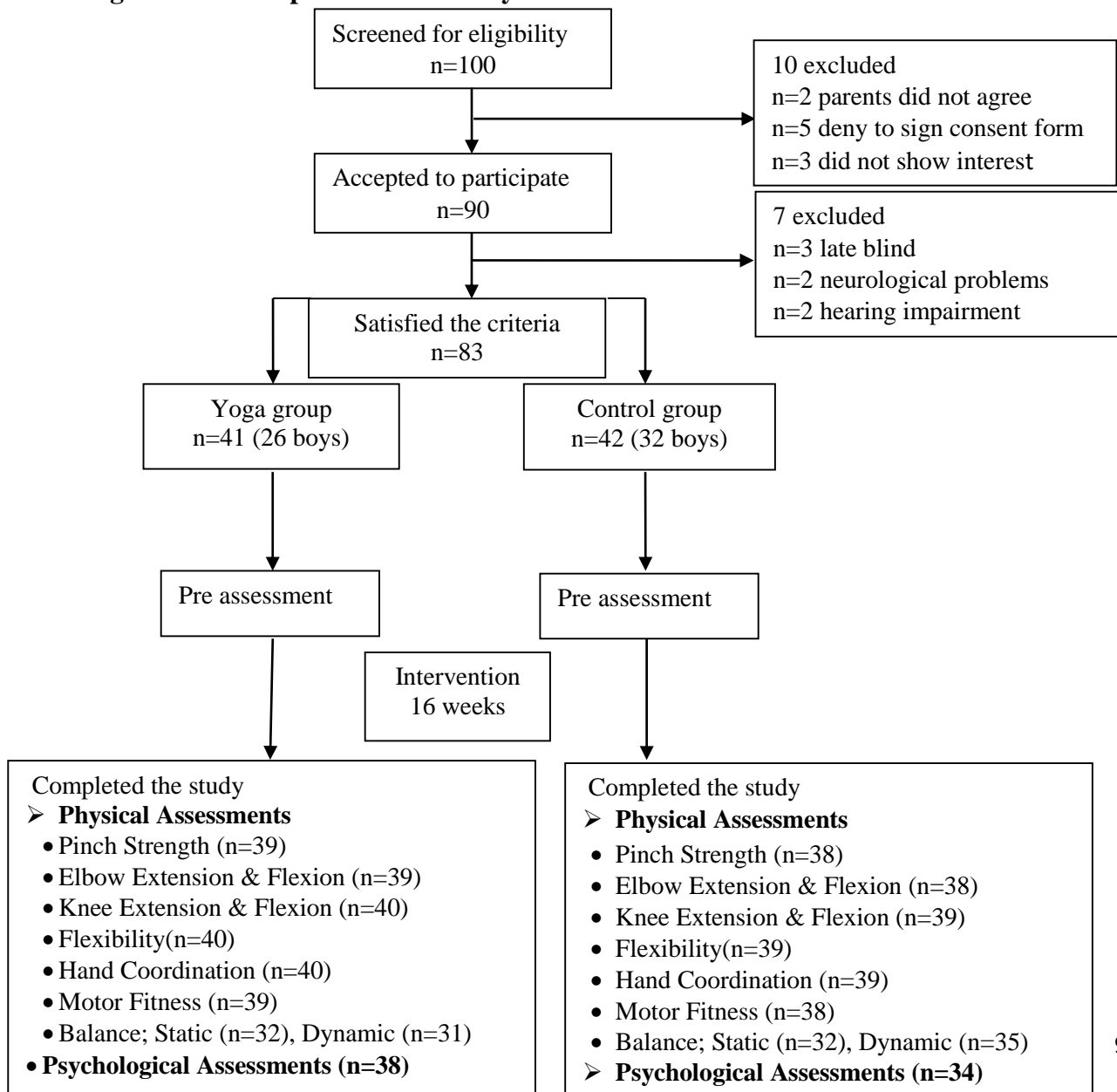
Key Messages

- Of 100 children, 83 satisfied the inclusion criteria of the study and based on their interest assigned to yoga group (n=41) and control group (n=42).
- Both yoga and control groups were matched on all the socio-demographic characteristics.
- Baseline values of the yoga and control groups matched on all physical variables ($p > 0.05$).
- Within group analysis found significant improvements ($p < 0.001$) for the yoga group in all physical variables except static balance at 20 secs.
- Control group showed marginally significance in left Hand Grip Strength ($p = 0.043$) and PEFR ($p = 0.047$), although a significant positive result occurred in motor coordination for both hands ($p = 0.005$).
- For psychological variables; no differences between groups at baseline, within group comparisons showed significant improvements in yoga group scores for all variables; whereas controls showed marginally significant changes in scores of STAI-C ($p = 0.043$) and CDI ($p = 0.008$).

7.0 RESULTS

Of the 100 children screened, 90 satisfied the selection criteria, and 83 of them were included in the study after medical examination. The students who were not engaged in any other vocational training program formed the yoga group (n=41), while the others formed the control group (n=42), and continued following their regular activities. Pre-intervention all subjects were tested, but post intervention numbers of participants completing each test were lower for various reasons: ill health, visiting home, questionnaires not completed etc. Their data on that test was excluded from subsequent analysis.

Figure 7.0: Trial profile of the study



7.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS

Demographic characteristics, anthropometric variables, autonomic parameters, and socio economic status (Verma, Saxena & Mishra, 2008) of the two groups are presented in Table 7.1.

Baseline values of all variables matched between the yoga group and controls ($p > 0.05$; Independent sample t test and Chi-square tests) On the average heights were near 0.05.

Table 7.1: Socio-Demographic Data				
Variables		Yoga (n=41)	Control (n=42)	p-value
Gender*	Male	26(63.4)	32(76.2)	0.205
	Female	15(36.6)	10(23.8)	
Degree of blindness*	Total blind	32(78.0)	30(71.4)	0.488
	LP	9(22.0)	12(28.6)	
Anthropometric*	Age (years)	12.00±2.03	12.74±2.32	0.127
	Height (cm)	141.51±13.71	147.60±16.08	0.068
	Weight (kg)	33.58±12.27	38.19±15.00	0.129
	BMI (kg/m ²)	16.61±3.44	16.82±4.07	0.799
	Fat (%)	21.74±5.66	19.94±6.27	0.173
Autonomic*	SBP (mmHg)	104.54±12.85	108.50±9.94	0.120
	DBP (mmHg)	66.88±9.08	67.36±9.17	0.812
	PR (bpm)	83.56±14.65	81.12±13.14	0.426
	SpO2 (%)	95.78±8.16	96.60±4.22	0.568
Socio Economic Status*	Average	5(12.2)	3(7.1)	0.473
	Low	11(26.8)	16(38.1)	
	Very low	25(61.0)	23(54.8)	
Family History of blindness*	Present	16(39.0)	23(54.8)	0.284
	Absent	9(22.0)	5(11.9)	
	Unknown	16(39.0)	14(33.3)	
Students staying in*	Residential hostel	34(82.9)	30(71.4)	0.213
	Home	7(17.1)	12(28.6)	

*n (%), Chi square test and **Mean ± SD, Independent t' test
Abbreviations: LP- Light Perception, BMI- Body Mass Index, PR-Pulse Rate, SpO2- Blood Oxygen Saturation, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, bpm – (Breath per minute) **Legends:** No significant difference between groups in all variables.

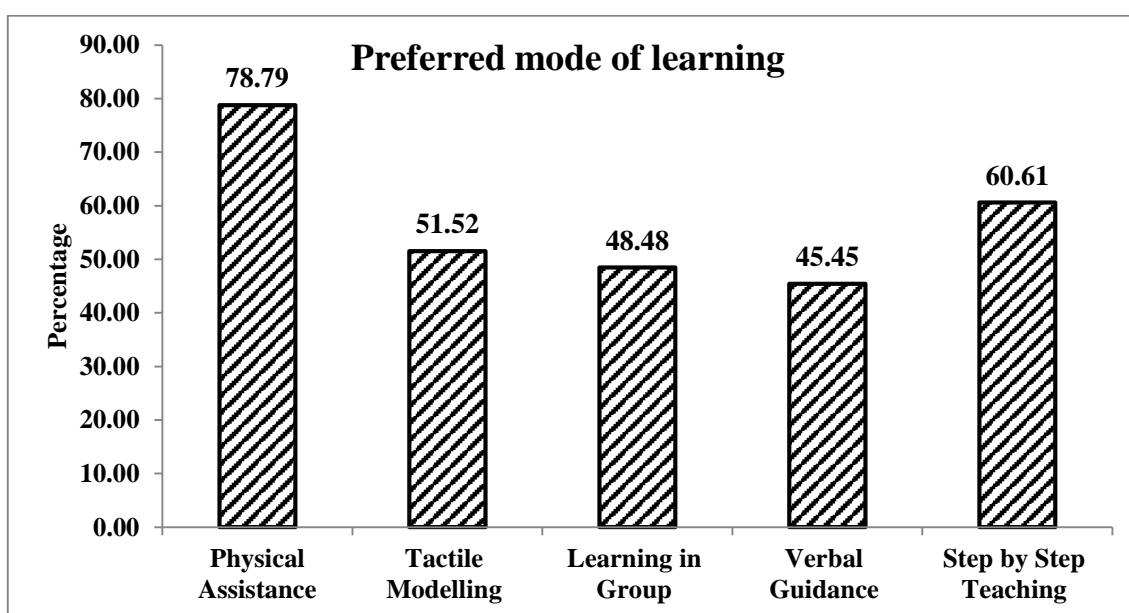
7.2 PREFERRED MODE OF LEARNING

Participants responded individually concerning their preferred learning method, i.e., which strategy they preferred. Each student told the interviewer their order of preference for the five steps. A total of 41 participants were interviewed, 33 (27 were totally blind and six had only light perception), aged 11.97 ± 1.94 , 18 males and 15 female responded for their order of preference for the five steps of learning yoga. Eight failed to provide satisfactory data, mostly because they could not name their order of preference.

Table 7.2 shows that the most popular method of learning was physical guidance by the instructor (Step 5), 26 of the 33 students (78.79%) chose this. As their second preference, 17 (51.51%) participants chose Step 2; while the third preference was Step 4, with 16 (48.48%) students; fourth preference was Step 1, selected by 15 (45.45%) students, and Step 3 was least preferred, with 20 (60.61%) students opting for this as their fifth choice.

Order of Preference	Name of Step	Result (total 33 students) No. of students (%)
1 st	Physical Assistance	26 (78.79%)
2 nd	Tactile Modelling	17 (51%)
3 rd	Learning in Group	16 (48%)
4 th	Verbal Guidance	15 (45%)
5 th	Step by Step Teaching	20 (60%)

Figure 7.2: Percentage of Students' preferred instructional strategies



7.3 VALIDATION OF THE YOGA MODULE

Of the 25 experts; 19 experts were from the field of yoga (14 males, 5 female): 9 had PhDs in yoga, 8 had Masters degrees in yoga and had been practicing it for over three decades, while 2 were medical graduates (MBBS) who had received formal training in yoga. Their ages ranged from 36 to 72 years. Experience in yoga since completing formal training ranged from 12 to 35 years. Of the 6 physical trainers (4 males, 2 female), ages ranged from 30 to 55 years; their experience in teaching children with VI was 10 to 30 years.

During the first phase of the validation by 12 experts, two practices, cleansing through a single mouth blast breath (*Mukha Dhauti*), and Tree posture (*Vrikshasana*), were excluded from the list as less than 50% (5) of the experts supported them. *Mukha Dhauti* can be used to relieve strain caused by other practices, but its absence can be compensated by simple relaxation practices such as Corpse pose (*Savasana*) or standing relaxation technique (*Sithila tadasana*). 75% of the experts stated that, although *Tree posture* is an important practice to improve balance, it is not suitable for children with VI, as there is a chance of falling. 60% of the experts

opined that yoga practice with conscious awareness of body position and extremity movements can improve joint proprioception, a necessary factor in balance ability (Guo et al., 2014) which it should help improve. The revised list was prepared and scored by 13 different experts. In this phase, only one practice; half waist sliding pose (*Ardhakati chakrasana*), was deleted from the list, because its CVR was less than the required minimum of 0.37. Most experts agreed with a 1hr yoga session, but suggested that one month duration would be too short and should be increased, so that the children could memorise and perfect the practices, and then practice yoga independently at home on a regular basis. Experts in both phases were in favour of adding yogic counselling to the schedule. The final module, modified according to experts' suggestions, is presented in Table 5.4.2.

7.3.1 Feasibility of the Yoga Module

7.3.1.1 Participants

20 children enrolled in this preliminary feasibility study, but only 9 passed both inclusion and exclusion criteria. Of these, 7 were totally blind, while 2 had only light perception; 6 had family histories of blindness.

7.3.1.2 Outcome measures

All 9 children completed the pilot study. The Shapiro-Wilk test showed baseline scores of Tennis Ball Throw and Standing Vertical Jump (SVJ) not to be normal ($p < 0.05$), so the non-parametric Wilcoxon test was used to analyse within group differences. However, 3 were absent due to severe weather during SVJ test post data extraction, and were listed as drop outs on that test. TBT mean scores increased significantly ($p = 0.011$) from 6.37 to 6.42, but changes on the SVJ test from 24.75 to 25.47 were not significant ($p = 0.585$).

7.3.1.3 Exit survey results

All 9 participants took the post-program exit survey. 5 reported being extremely satisfied, and 3 mostly satisfied with the program. All stated that the program was well received, with 7 accepting that yoga is helpful for health. All participants expressed an interest in participating in future yoga programs, and stated that they would recommend them to friends and family. All said that they really liked the instructors, and the setting and environment of the program. 6 were able to complete over 60% of the practices from the yoga module, but only 4 could remember and complete all steps of each yogic practice by themselves. Both the students and the yoga instructor thought that providing participants with personal audio CDs of the yoga program would help them continue their practice at home or at school. Positive exit survey responses (all subjects were extremely satisfied, wanted to continue the yoga practice, and were interested in recommending it to their friends) and excellent participation rate (90% attendance) supported the feasibility of the yoga module.

7.4 OUTCOME MEASURES

7.4.1 PHYSICAL FITNESS

The ANOVA values of the within subjects factors (time) and interaction between the group and time (time x group) for the different variables of physical fitness; (i) muscle strength, (ii) muscle endurance, (iii) flexibility, (iv) coordination, (v) motor speed, (vi) balance, and (vii) Peak expiratory flow rate, were evaluated. Group means and SDs are presented, together with graphical representations of results.

7.4.1.1 MUSCLE STRENGTH

7.4.1.1.1 Upper extremity muscle strength

At base line there was no significant difference between groups for the following variables; Hand Grip Strength Right Hand (HGS_RH) ($p = 0.110$), Hand Grip Strength Left Hand

(HGS_LH) ($p = 0.60$), Pinch Strength Left Hand (PS_LH) ($p = 0.236$), Elbow Flexion Right Hand (EF_RH) ($p = 0.269$) and Elbow Flexion Left Hand (EF_LH) ($p = 0.589$); but groups differed in Elbow Extension Right Hand (EE_RH) ($p = 0.045$), Elbow Extension Left Hand (EE_LH) ($p = 0.004$) and Pinch Strength Right Hand (PS_RH) ($p = 0.031$), Table 7.4.1.2.

An analysis of covariance (ANOCOVA) controlling for baseline differences found significant differences between groups on all three post scores: EE_RH, [$F(1, 74) = 19.90, p < 0.001$], EE_LH, [$F(1, 74) = 9.633, p = 0.003$], and PS_RH [$F(1, 74) = 50.7, p < 0.001$].

Repeated measures ANOVA difference between pre-post scores, and group-time interaction scores for upper extremity muscle strength variables as follows:

HGS_RH showed a difference between times [$F(1,81) = 349.48, p < 0.001$] and a group-time interaction [$F(1,81) = 268.60, p < 0.001$]. HGS_LH showed a difference between times [$F(1,81) = 20.65, p < 0.001$] but no significant change in group-time interaction ($p = 0.102$).

PS_RH showed a difference between times [$F(1,75) = 46.57, p < 0.001$] and a group-time interaction [$F(1,75) = 60.21, p < 0.001$]. PS_LH also showed a difference between times [$F(1,81) = 19.41, p < 0.001$] and a group-time interaction [$F(1,81) = 10.04, p = 0.002$].

Results of elbow extension showed a difference between times for both right hand [$F(1,75) = 54.00, p < 0.001$], and left hand [$F(1,75) = 48.17, p < 0.001$], and group-time interactions of [$F(1,75) = 23.79, p < 0.001$] for right, and [$F(1,75) = 17.17, p < 0.001$] for left.

In EF_RH, no significant changes were observed between times [$F(1,75) = 1.38, p = 0.244$] but group-time interaction was significant [$F(1,75) = 13.91, p < 0.001$]. In contrast, EF_LH showed both a difference between times [$F(1,75) = 19.90, p < 0.001$] and a group-time interaction [$F(1,75) = 10.70, p = 0.002$].

Significant pre-post improvements were seen in the yoga group in the variables HGS_RH ($p < 0.001$), HGS_LH ($p < 0.001$), PS_RH ($p < 0.001$), PS_LH ($p < 0.001$), EE_RH ($p < 0.001$), EE_LH ($p < 0.001$), EF_RH ($p = 0.001$) and EF_LH ($p < 0.001$) (see Table 7.4.1.1.1). Controls showed within group improvement in HGS_LH ($p = 0.043$), marginally significant.

Table 7.4.1.1.1: Result of upper extremity muscle strength						
Variables	Group	Pre M \pmSD	Post M \pmSD	% change	Diff	Group* Time
HGS_RH (Kg)	Y (n=41)	11.12 \pm 3.39	14.93 \pm 3.46****a	34.26	3.81	< 0.001
	C (n=42)	12.65 \pm 5.06	12.90 \pm 5.07	1.98	0.25	
HGS_LH (Kg)	Y (n=41)	10.62 \pm 3.21	11.44 \pm 3.10****	7.72	0.82	0.102
	C (n=42)	12.50 \pm 5.44	12.88 \pm 5.26*	3.04	0.38	
PS_RH (Kg)	Y (n=39)	2.62 \pm 1.00	3.64 \pm 1.01****a	38.93	1.02	< 0.001
	C (n=38)	3.17 \pm 1.09	3.11 \pm 1.16	1.89	-0.06	
PS_LH (Kg)	Y (n=39)	2.44 \pm 1.10	3.00 \pm 1.03****	22.95	0.56	0.002
	C (n=38)	2.92 \pm 1.12	3.01 \pm 1.13	7.32	-0.21	
EE_RH (Kg)	Y (n=39)	4.94 \pm 0.94	5.95 \pm 0.77****	20.45	1.01	< 0.001
	C (n=38)	5.41 \pm 1.13	5.62 \pm 0.88	3.88	0.21	
EE_LH (Kg)	Y (n=39)	4.64 \pm 0.95	5.75 \pm 0.80****	23.92	1.11	< 0.001
	C (n=38)	5.31 \pm 1.31	5.59 \pm 0.89	5.27	0.28	
EF_RH (Kg)	Y (n=39)	6.08 \pm 0.77	6.43 \pm 0.53****b	5.76	0.35	0.001
	C (n=38)	6.26 \pm 0.76	6.08 \pm 0.51	2.88	-0.18	
EF_LH (Kg)	Y (n=39)	6.00 \pm 0.68	6.36 \pm 0.54****	6.00	0.36	0.002
	C (n=38)	6.07 \pm 0.83	6.13 \pm 0.59	0.99	0.06	

Abbreviations: Hand Grip Strength Right Hand (HGS_RH), Hand Grip Strength Left Hand (HGS_LH), Pinch Strength Right Hand (PS_RH), Pinch Strength Left Hand (PS_LH), Elbow Extension Right Hand (EE_RH), Elbow Extension Left Hand (EE_LH), Elbow Flexion Right Hand (EF_RH) and Elbow Flexion Left Hand (EF_LH)
* $p < 0.05$, **** $p < 0.001$ (Within group comparisons) and ^a $p < 0.05$, ^b $p < 0.01$ (Between group post-post comparisons)
Legend: Yoga group showed significant improvement in all the tests of upper extremity muscle strength.

Figure 7.4.1.1.A: Pre-Post Changes in Hand Grip Strength Scores

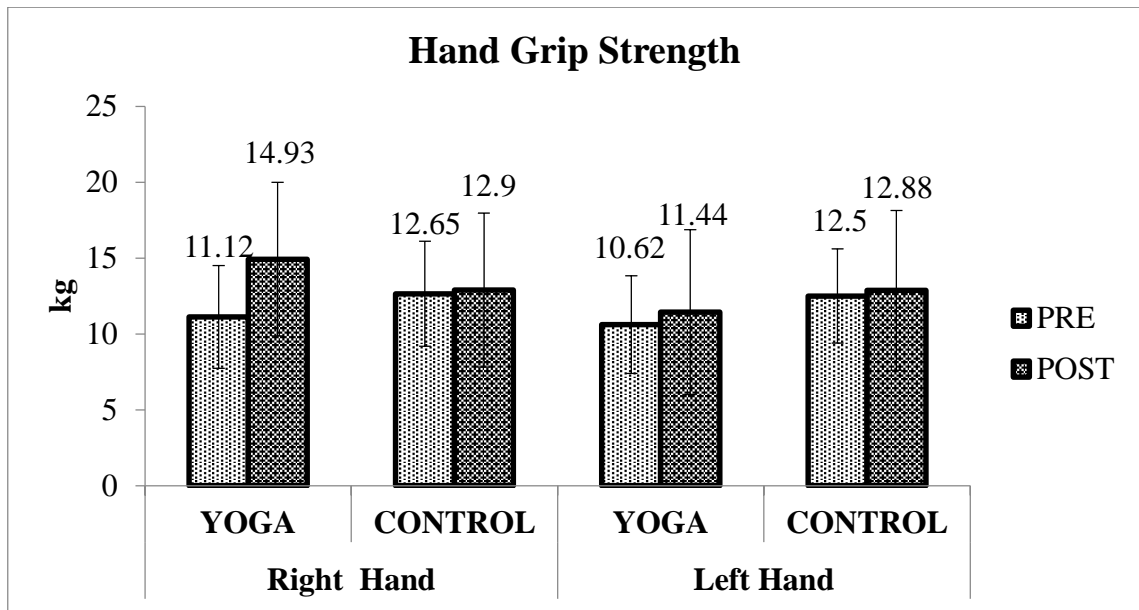


Figure 7.4.1.1.B: Pre-Post Changes in Pinch Strength Scores

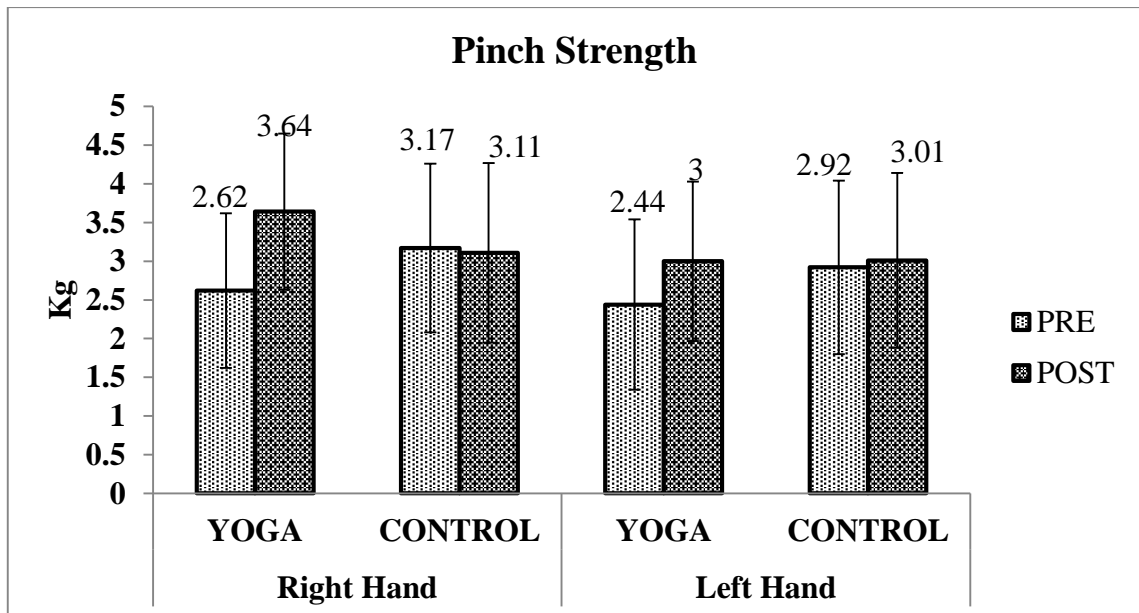


Figure 7.4.1.1.1C: Pre-Post Changes in Elbow Extension Scores

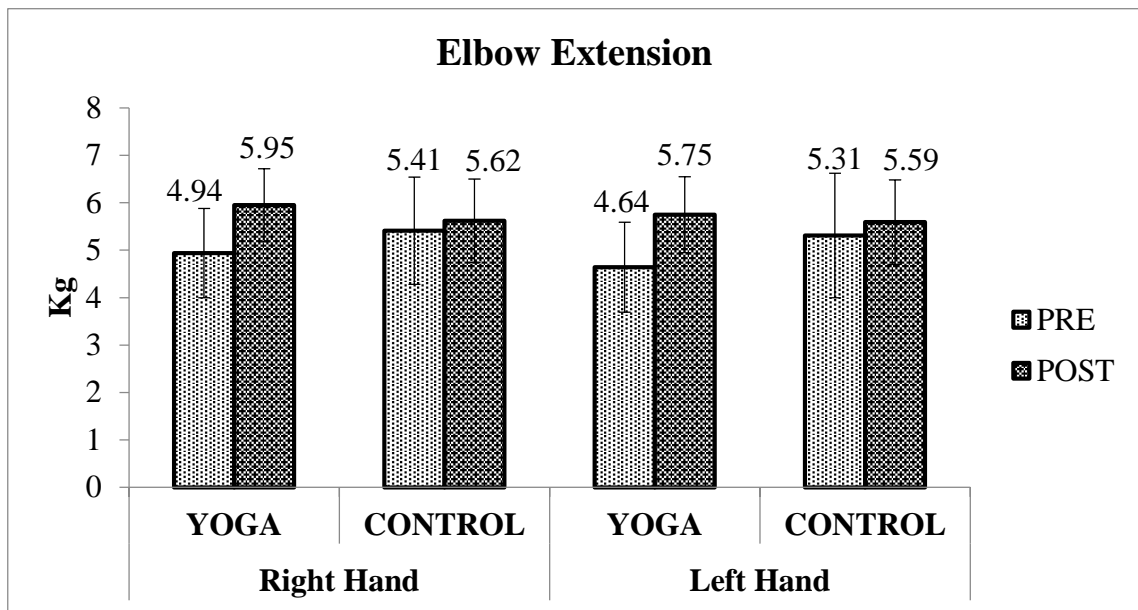
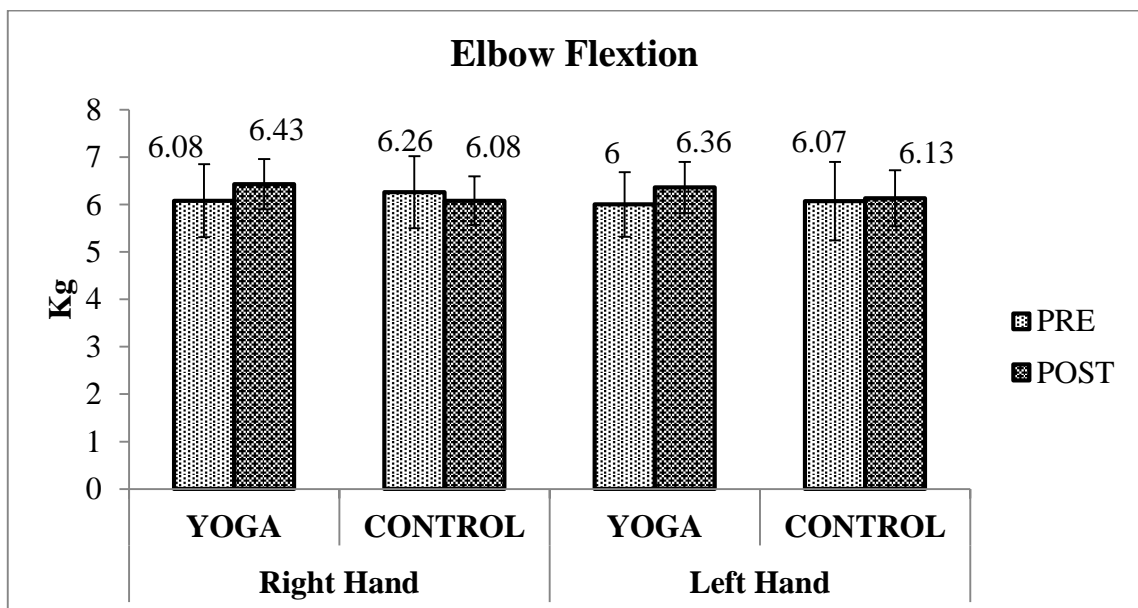


Figure 7.4.1.1.1D: Pre-Post Changes in Elbow Flexion Scores



7.4.1.1.2 Lower Extremity Muscle Strength

Difference between the groups at base line were not significant for Knee Extension Right Leg (KE_RL) ($p = 0.793$), Knee Extension Left Leg (KE_LL) ($p = 0.099$), Knee Flexion Right Leg (KF_RL) ($p = 0.060$), or Knee Flexion Left Leg (KF_LL) ($p = 0.070$).

Repeated measures ANOVA found significant difference between pre-post scores for KELL [$F(1,77) = 5.22, p = 0.025$], but not KERL [$F(1,77) = 0.086, p = 0.770$]. Group-time interaction improvements occurred in both RL [$F(1,77) = 6.66, p = 0.012$] and LL [$F(1,77) = 23.30, p < 0.001$]. Mean KF interval showed a significant difference between times for both KF_RL [$F(1,77) = 29.96, p < 0.001$] and KF_LL [$F(1,77) = 33.99, p < 0.001$], and group-time interactions RL [$F(1,77) = 15.31, p < 0.001$] and LL [$F(1,77) = 11.16, p = 0.001$].

Significant pre-post within group improvement was seen for the yoga group in the variables KE_RL ($p = 0.044$) KE_LL ($p < 0.001$), KF_RL ($p < 0.001$) and KF_LL ($p < 0.001$). In contrast, the controls showed no significant within group improvement. (Table 7.4.1.1.2)

Table 7.4.1.1.2: Results of Knee Strength						
Variables	Group	Pre M± SD	Post M± SD	% Change	Diff	Group* Time
KE_RL (Kg)	Y (n=40)	6.23 ±1.00	6.57 ±0.32* ^c	5.46	0.34	0.012
	C (n=39)	6.29 ±1.02	6.03 ±0.59	4.13	-0.27	
KE_LL (Kg)	Y (n=40)	6.22 ±0.93	6.72 ±0.37**** ^a	8.04	0.50	< 0.001
	C (n=39)	6.59 ±1.00	6.41 ±0.72	2.73	-0.18	
KF_RL (Kg)	Y (n=40)	5.09 ±0.83	6.11 ±0.55*** ^c	20.04	1.02	< 0.001
	C (n=39)	5.44 ±0.80	5.61 ±0.68	3.13	0.17	
KF_LL (Kg)	Y (n=40)	5.18 ±0.92	6.24 ±0.61**** ^a	20.46	1.07	0.001
	C (n=39)	5.55 ±0.91	5.84 ±0.74	5.23	0.29	
<p>Abbreviations: Knee Extension Right Leg (KE_RL), Knee Extension Left Leg (KE_LL), Knee Flexion Right Leg (KF_RL) and Knee Flexion Left Leg (KF_LL). *$p < 0.05$, *** $p < 0.001$ (Within group comparisons) ^a $p < 0.05$, ^c $p < 0.001$ (Between group post-post comparisons) Legend: Yoga group shows significant improvement in the score for all different groups of lower extremity.</p>						

Figure 7.2.1.1.2A: Pre-Post Changes in Knee Extension Scores

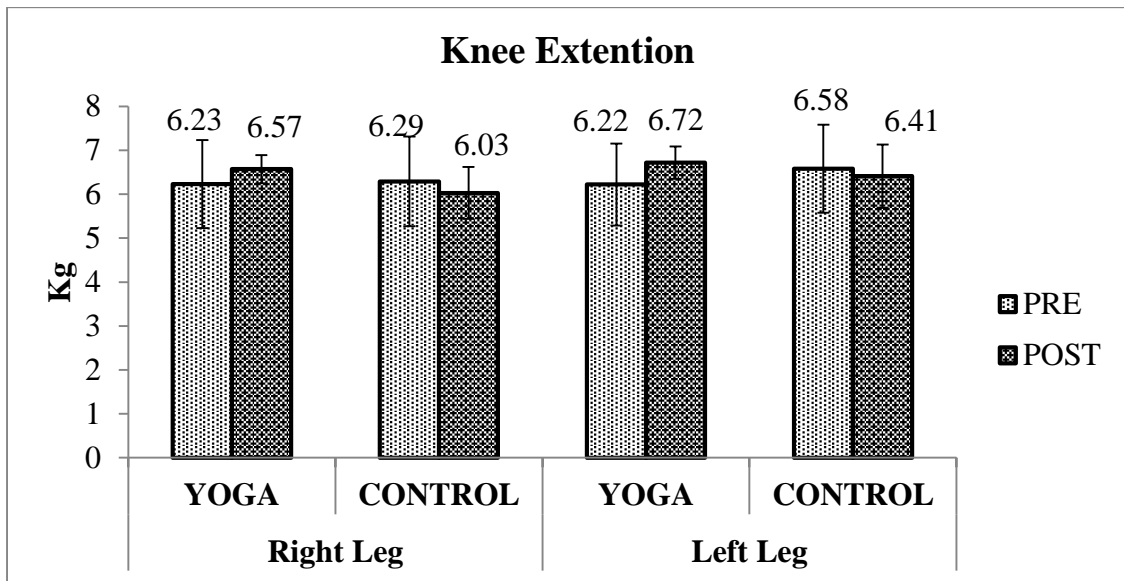
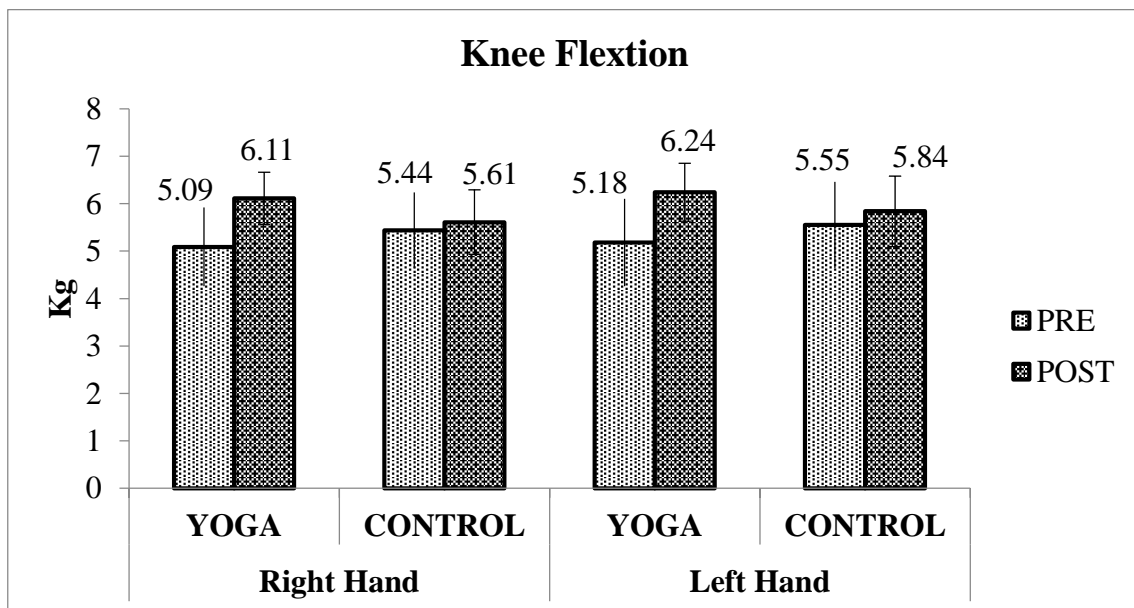


Figure 7.4.1.1.2B: Pre-Post Changes in Knee Flexion Scores



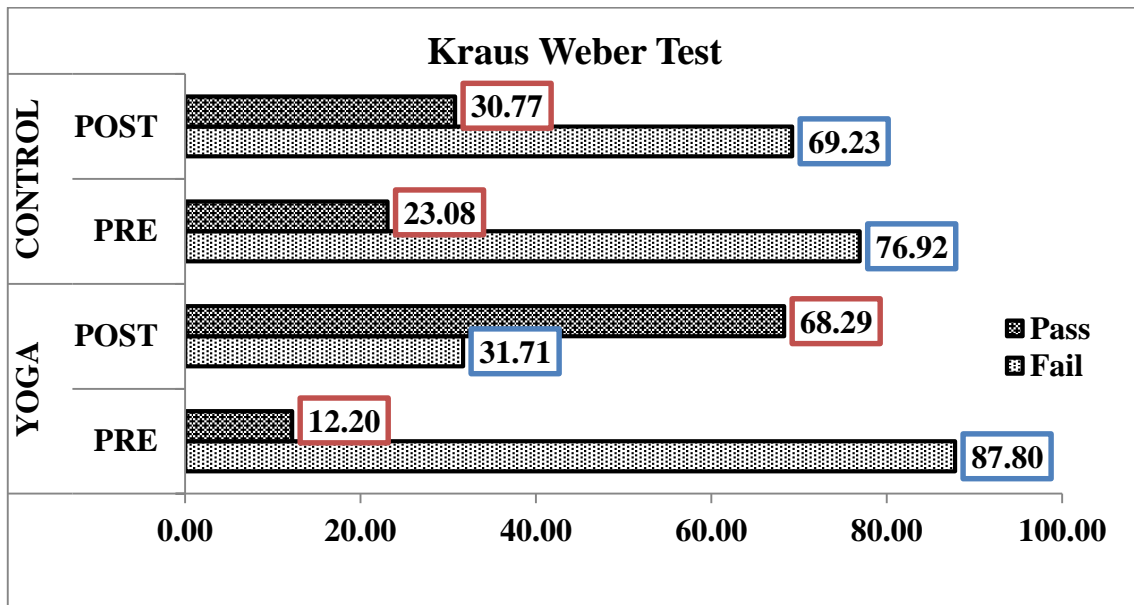
7.4.1.1.3 MINIMUM MUSCULAR FITNESS TEST

Baseline scores between groups were not significantly different ($p = 0.200$). Pre test 5 in the yoga group (12.2%), and 9 in the control group (23.1%) passed the test. Post-intervention, 28 yoga group students (68.3%) passed the test, whereas only 12 control group students (30.8%) passed. An exact McNemar test showed a statistically significance difference, $p < 0.001$, for

this result. Further details on individual test items at baseline: the largest numbers of failures were on strength and flexibility in the 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 in yoga group dropped to 2.4%, whereas controls reduced to 35.9%, a large difference.

Table 7.4.1.1.3 Results of Kraus-Weber test					
Test	Result		Group		χ^2 (p-values)
			Control	Yoga	
Pre test	Fail	Count	30	36	1.639 (0.200)
		Expected Count	32.2	33.8	
		% within GROUP	76.9%	87.8%	
	Pass	Count	9	5	
		Expected Count	6.8	7.2	
		% within GROUP	23.1%	12.2%	
Post test	Fail	Count	27	13	11.257 (0.001)
		Expected Count	19.5	20.5	
		% within GROUP	69.2%	31.7%	
	Pass	Count	12	28	
		Expected Count	19.5	20.5	
		% within GROUP	30.8%	68.3%	

Figure 7.4.1.1.3: Pre-Post Changes in the Krauss-Weber Test



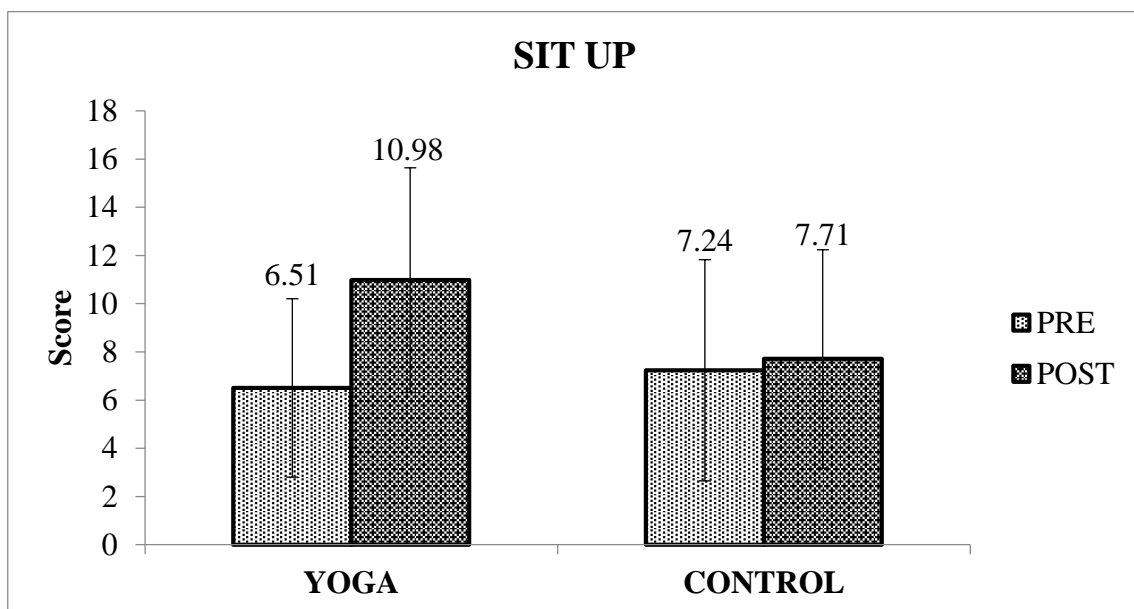
7.4.1.2 MUSCLE ENDURANCE

Baseline difference between groups ($p = 0.431$) was not significant. Repeated measures ANOVA showed significant difference between times Sit-Up [$F(1,81) = 112.44, p < 0.001$], and a group-time interaction difference [$F(1,81) = 73.26, p < 0.001$]. Pre-post improvement within the yoga group was significant (Table 7.4.1.2) ($p < 0.001$), whereas within group changes for the control group were not significant ($p = 0.150$).

Table 7.4.1.2: Results of Muscle Endurance Test						
Variables	Group	Pre M \pm SD	Post M \pm SD	% change	Diff	Group* Time
SIT-UP	Y (n=41)	6.51 \pm 3.7	10.98 \pm 4.66*** b	68.7	4.47	< 0.001
	C (n=42)	7.24 \pm 4.6	7.71 \pm 4.53	6.49	0.48	

Legend: Yoga group shows significant improvement in the score of Sit Up.
 *** $p < 0.001$ within group comparisons.
^b $p < 0.01$ between group post-post comparisons.

Figure 7.4.1.2: Pre-Post Changes on the Sit-Up Test



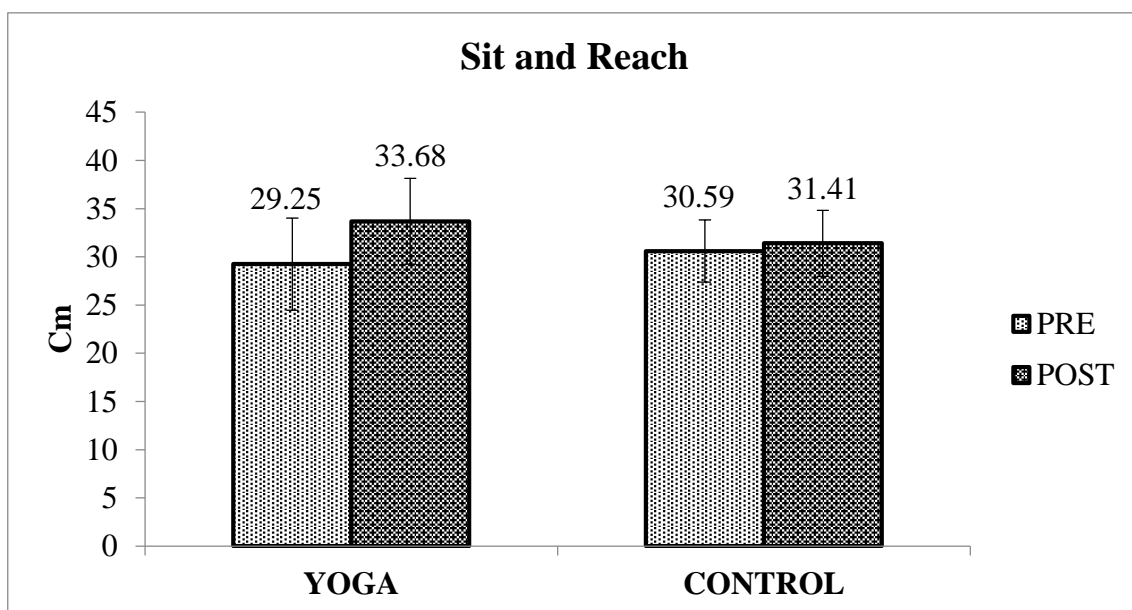
7.4.1.3 FLEXIBILITY

Baseline difference between groups ($p = 0.150$) was not significant. Repeated measures ANOVA showed significant difference between times (pre-post) scores for the mean Sit & Reach score [$F(1,77) = 54.80, p < 0.001$] and a group-time interaction [$F(1,79) = 25.87, p < 0.001$]. Significant improvement was shown within the yoga group pre-post intervention (Table 7.2.1.3) ($p < 0.001$) whereas the control group did not demonstrate any significant within group changes ($p = 0.108$)

Table 7.4.1.3: Results of Flexibility Test						
Variables	Group	Pre M \pm SD	Post M \pm SD	% change	Diff	Group* Time
SIT & REACH (cm)	Y (n=40)	29.25 \pm 4.79	33.68 \pm 4.45*** ^a	15.15	4.43	< 0.001
	C (n=39)	30.59 \pm 3.22	31.41 \pm 3.42	2.68	-0.82	

Legend: Yoga group shows significant improvement in the score of sit and reach
 *** $p < 0.001$ within group comparison.
^a $p < 0.05$ between group post-post comparison.

Figure 7.4.1.3: Pre-Post Changes in Flexibility



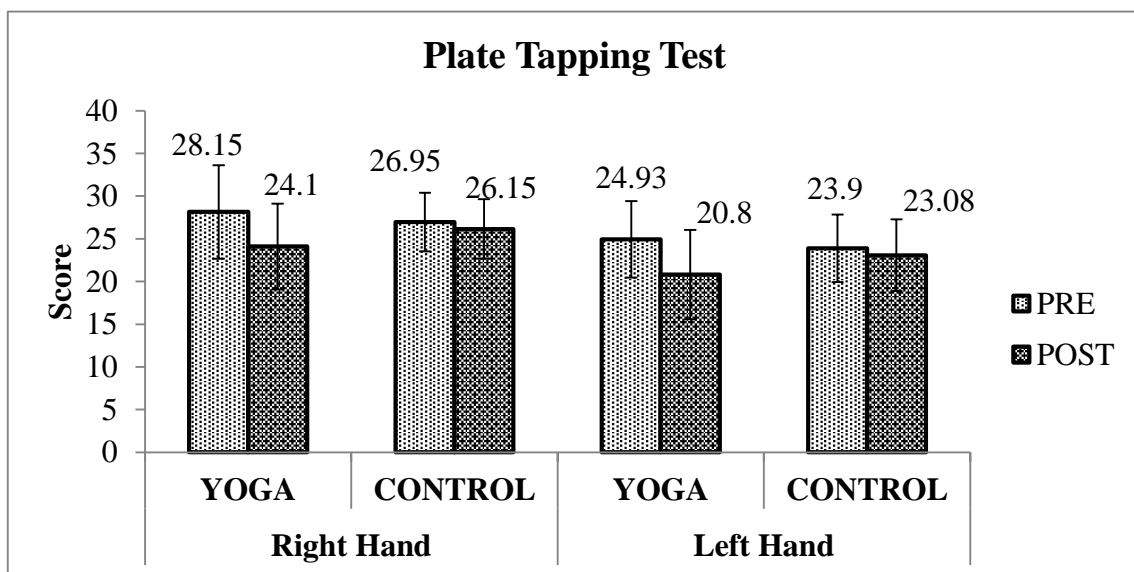
7.4.1.4 HAND COORDINATION

Baseline difference between groups was not significant for either plate-tapping test, Right Hand ($p = 0.247$) or Left Hand (PTT_LH) ($p = 0.283$). Repeated measures ANOVA showed significant difference between times (pre-post) scores for both right hand [$F(1,77) = 156.18, p < 0.001$], and left hand [$F(1,77) = 160.58, p < 0.001$]. Right hand group-time interaction was [$F(1,77) = 69.73, p < 0.001$], and for the left hand [$F(1,77) = 72.49, p < 0.001$]. As shown in (Table 7.4.1.4), significant improvement occurred in both groups, $p < 0.001$ for yoga group, and $p = 0.005$, less significant, for controls both hands.

Table 7.4.1.4: Results of Hand Coordination						
Variables	Group	Pre M ±SD	Post M±SD	% change	Diff	Group* Time
PLT_RH	Y (n=40)	24.93 ±4.47	20.80 ±5.23****a	-16.57	4.13	< 0.001
	C (n=39)	23.90 ±3.95	23.08 ±4.19*	-3.43	0.82	
PLT_LH	Y (n=40)	28.15 ±5.48	24.10 ±5.03****a	-14.39	4.05	< 0.001
	C (n=39)	26.95 ±3.43	26.15 ±3.48*	-2.97	0.80	

Abbreviations: Plate Tapping Test Right Hand (PTT_RH) & Plate Tapping Test Left Hand (PTT_LH), **Legend:** Yoga group shows significant improvement in the scores of both right and left hand coordination. * $p < 0.05$, *** $p < 0.001$ within group comparisons, ^a $p < 0.05$ between group post-post comparisons.

Figure 7.4.1.4: Pre-Post Changes in Hand Coordination

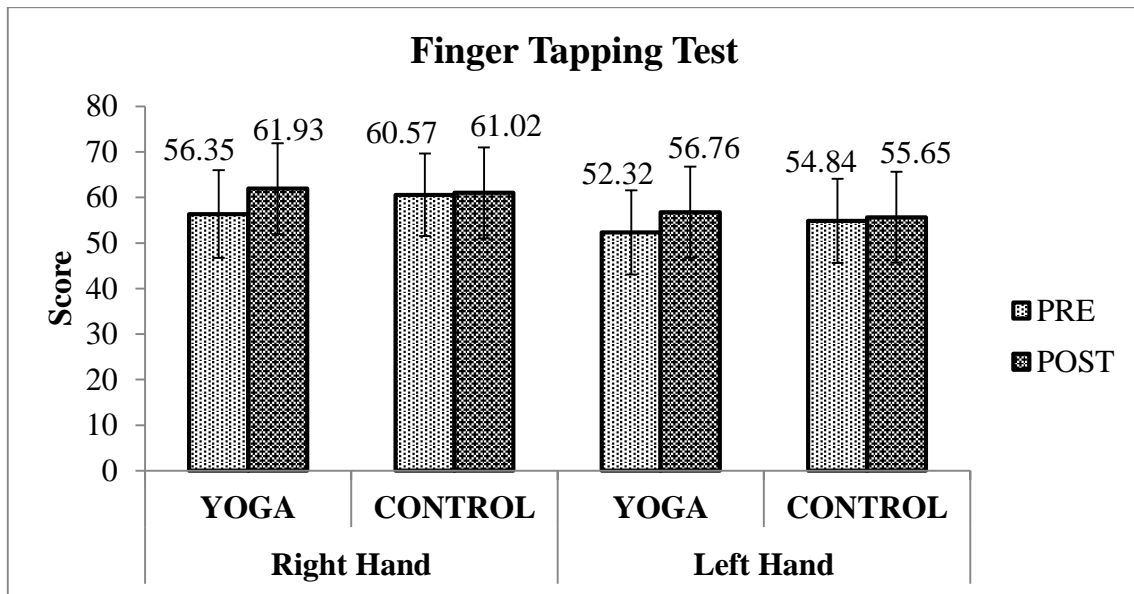


7.4.1.5 MOTOR FITNESS

Baseline difference between groups was not significant for either Finger Tapping Test Right Hand (FTT_RH) ($p = 0.054$), or the Finger Tapping Test Left Hand (FTT_LH) ($p = 0.233$). Repeated measures ANOVA showed significant difference between times for both right and left hand Finger Tapping Test [$F(1,75) = 11.64, p = 0.001$] and [$F(1,75) = 9.81, p = 0.002$], respectively, and group-time interactions of [$F(1,75) = 8.74, p = 0.004$] and [$F(1,75) = 4.82, p = 0.031$] respectively. As shown in Table 7.4.1.5, the yoga group showed significant within group improvements in both hands; FTT_RH ($p < 0.001$) and FTT_LH ($p < 0.001$), whereas the control group showed no significant within group changes.

Table 7.4.1.5: Results of Finger Tapping Test						
Variables	Group	Pre M±SD	Post M±SD	% change	Diff	Group* Time
FTT_RH	Y (n=39)	56.35 ±9.63	61.93 ±6.55***	9.90	5.58	0.004
	C (n=38)	60.57 ±9.06	61.02 ±6.64	0.74	0.45	
FTT_LH	Y (n=39)	52.32 ±9.22	56.76 ±5.73	8.49	4.44	0.035
	C (n=38)	54.84 ±9.25	55.65 ±6.71	1.48	0.81	
<p>Abbreviations: finger tapping test right hand (FTT_RH) and finger tapping test left hand (FTT_LH) Legend: Yoga group showed significant improvement in the score of FTT. *** $p < 0.001$ within group comparisons.</p>						

Figure 7.4.1.5: Pre-Post Changes in Finger Tapping Test



7.4.1.6 BALANCE

Static and Dynamic Balance were assessed. Results were as follows:

7.4.1.6.1 Static Balance

When the stability platform was centred, baseline differences between groups were not significant for Static Balance at 20 secs ($p = 0.257$), 30 secs ($p = 0.601$) or 40 secs ($p = 0.778$).

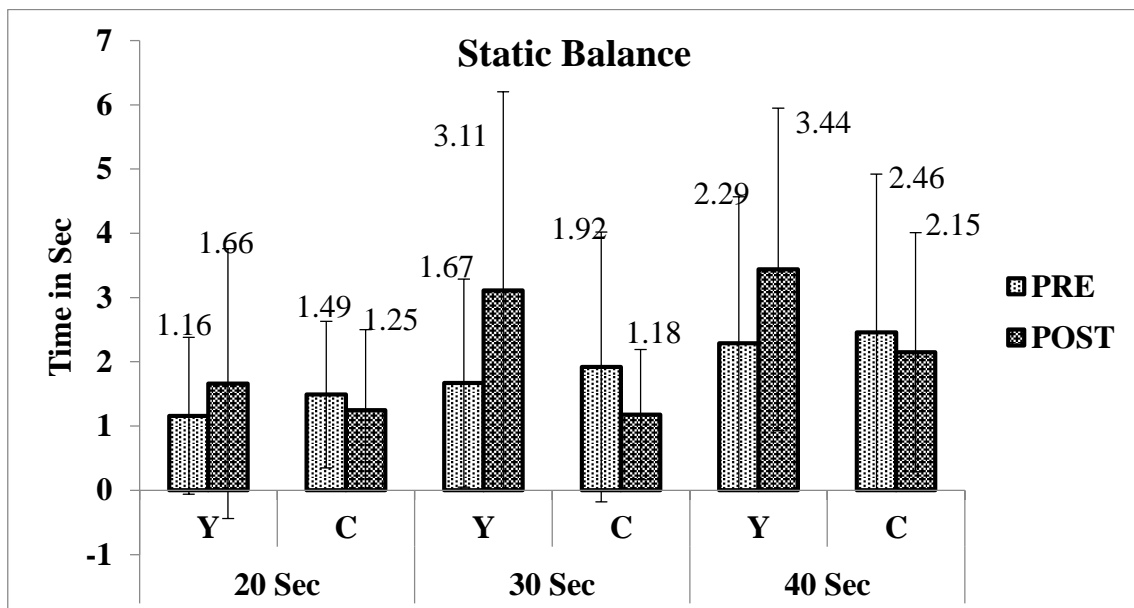
For Static Balance, within group comparison (ANOVA) show no significant difference for trials at (i) 20 secs [$F(1,62) = 0.312, p = 0.578$], (ii) 30 secs [$F(1,62) = 0.872, p = 0.354$] and (iv) 40 secs [$F(1,62) = 1.538, p = 0.220$]. Group-time interaction (ANOVA) found significant difference at 30 secs [$F(1,62) = 8.348, p = 0.005$] and 40 secs [$F(1,62) = 4.767, p = 0.033$] whereas the trend in the 20 secs trial [$F(1,62) = 2.639, p = 0.109$], did not reach significance.

Significant within group improvement in the yoga group was seen in trials at 30 secs ($p = 0.009$) and 40 secs ($p = 0.018$) but not 20 secs ($p = 0.128$). The control group showed no significant within group changes in any of the three trials: 20 secs ($p = 0.454$), 30 secs ($p = 0.172$) and 40 secs ($p = 0.507$) [Table 7.4.1.6.1].

Table 7.4.1.6.1: Result of Static Balance							
Variables		Group	Pre M ± SD	Post M±SD	% change	Diff	Group* Time
Static Balance (time in second)	Centre 20 sec	Y (n=31)	1.16 ±1.22	1.66 ±2.10	-43.10	0.50	0.109
		C (n=35)	1.49 ±1.14	1.25 ±1.25	16.11	-0.24	
	Centre 30 sec	Y (n=31)	1.67 ±1.62	3.11 ±3.09** ^c	-86.23	1.44	0.005
		C (n=35)	1.92 ±2.10	1.18 ±1.01	38.54	-0.74	
	Centre 40 sec	Y (n=31)	2.29 ±2.28	3.44 ±2.51* ^a	-50.22	1.14	0.033
		C (n=35)	2.46 ±2.46	2.15 ±1.86	12.60	-0.32	

Abbreviations: Y- yoga, C-control
Legend: Yoga group shows significant improvement in the scores of 30 secs and 40 secs but not for 20 secs.
^{*}*p*<0.05, ^{**}*p*<0.01 within group comparisons.
^a*p*<0.05, ^c*p*<0.001 between group post-post comparisons.

7.4.1.6.1: Pre-Post Changes in Static Balance



7.4.1.6.2 Dynamic Balance

Maximum number of lateral movements, individually and jointly, and maximum time spent on left and right regions, separately and jointly, were assessed. Baseline differences between groups were not significant ($p > 0.05$) for all dynamic balance comparisons. Between times (pre-post) values of ANOVA scores and group-time interaction scores on two different comparisons of the balance test; maximum movements (Test 1) and duration of time spent (Test 2) in left and right regions, separately and jointly, are shown in Table 7.4.1.6.2.

In Test 1, (i) Movements towards the left region showed significant between time differences, [$F(1,64) = 30.381, p = 0.005$] and a group-time interaction [$F(1,64) = 8.743, p < 0.001$]; (ii) Also showed significant between time differences [$F(1,64) = 24.802, p < 0.001$] and a group-time interaction [$F(1,64) = 8.878, p = 0.004$] in movements towards the right region; (iii) When the movements towards left and right region were analyzed together, significant between time difference was observed [$F(1,64) = 28.486, p < 0.001$] and a group-time interaction of [$F(1,64) = 9.132, p = 0.004$].

In Test 2, (i) Time spent towards the left region showed significant between time differences [$F(1,64) = 5.101, p = 0.027$] but not for group-time interaction [$F(1,64) = 0.041, p = 0.840$]; (ii) Time spent towards the right region did not show any significant between time differences [$F(1,64) = 0.171, p = 0.680$] or in group-time interaction [$F(1,64) = 0.932, p = 0.338$]; (iii) Time spent in the centre showed significant between time differences [$F(1,64) = 15.624, p < 0.001$] and a group-time interaction [$F(1,64) = 4.912, p = 0.030$]; (iv) When the time spent towards left and right region was analyzed together, significant between time differences were observed [$F(1,64) = 22.472, p < 0.001$] and a group-time interaction of [$F(1,64) = 4.322, p = 0.042$].

Analysis showed significant within group pre to post improvements ($p < 0.001$) for the yoga group for all comparisons of Test 1; the movements towards left region, right region and both

region together. Test 2 showed significant ($p < 0.001$) improvement in the time spent towards left and right region together, and significant ($p < 0.001$) reduction in the time spent in centre whereas the time spent in left ($p = 0.096$) and right ($p = 0.347$) region did not show any significant improvement within the yoga group [Table 7.4.6.1.2]. The control group showed no significant within group improvement for any dynamic balance test comparison ($p > 0.05$).

Table 7.4.1.6.2: Result of Dynamic Balance							
	Variables	Group	Pre M ± SD	Post M± SD	% change	Diff	Group* Time
MAXIMUM MOVEMENTS	LR	Y (n=31)	41.46 ±14.83	51.28 ±10.93***	-23.69	-9.187	0.004
		C (n=35)	42.53 ±16.88	45.50 ±14.73	-6.98	-2.962	
	RR	Y (n=31)	41.11 ±14.83	50.58 ±10.74***	-23.04	-9.473	0.004
		C (n=35)	41.90 ±16.32	44.28 ±15.33	-5.68	-2.381	
	LR+RR	Y (n=31)	82.57 ±29.40	101.86 ±21.60***	-23.36	-19.290	0.004
		C (n=35)	84.43 ±33.14	89.77 ±29.95	-6.36	-5.343	
MAXIMUM TIME SPEND	LR	Y (n=31)	13.23 ±2.58	14.23 ±3.12	-7.56	-1.003	0.840
		C (n=35)	13.37 ±2.56	14.20 ±2.55	-6.21	-0.838	
	RR	Y (n=31)	12.25 ±2.66	12.82 ±3.08***	-4.57	-0.565	0.030
		C (n=35)	12.76 ±2.20	12.53 ±3.10	1.80	0.226	
	CR	Y (n=31)	4.52 ±2.11	2.95 ±1.64	34.73	1.568	0.338
		C (n=31)	3.88 ±2.64	3.43 ±2.38	11.60	0.441	
	LR+RR	Y (n=31)	25.48 ±2.11	27.05 ±1.64***	-6.16	-1.569	0.042
		C (n=35)	26.12 ±2.46	26.73 ±2.04	-2.34	0.612	
Abbreviations: Y- yoga, C-control, LR- Left Region, RR- Right Region, CR- Central Region, LR+RR- Left and Right Region. Legend: Yoga group shows significant improvement in all scores of lateral movements and the time spent in both left and right region together has increased significantly whereas time spent in centre region has decreased significantly. *** $p < 0.001$ within group comparisons.							

Figure 7.4.1.6.2A: Pre-Post Changes in Lateral Movements

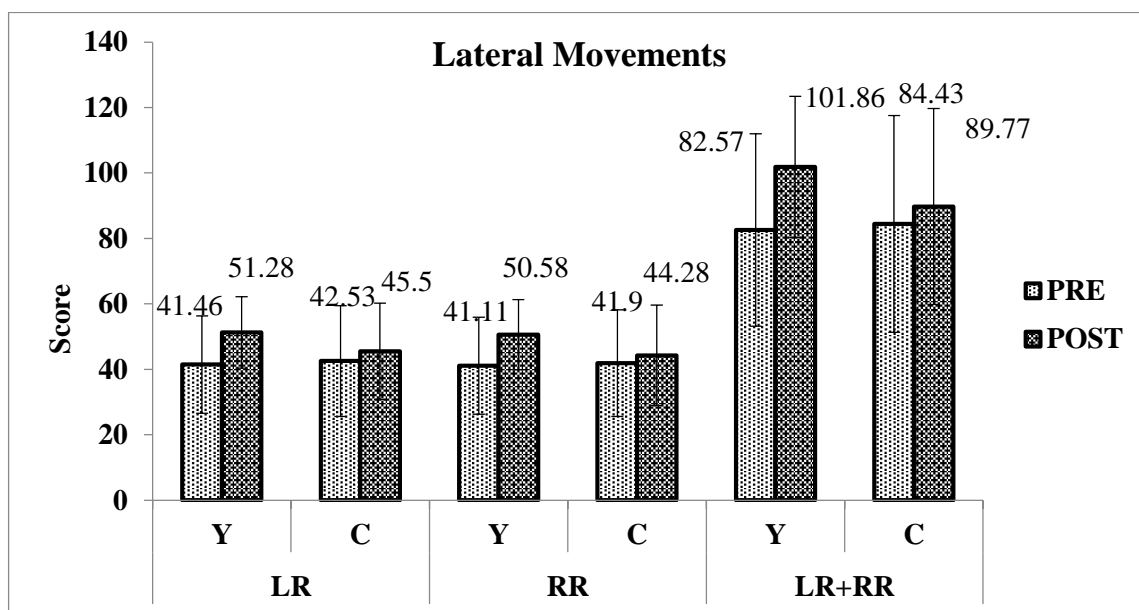
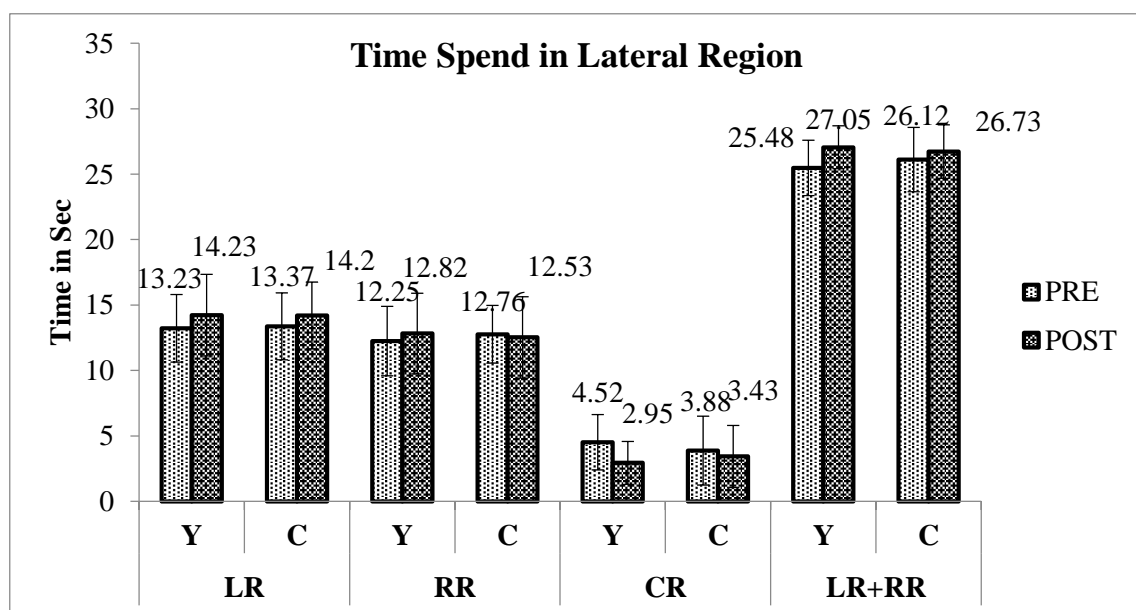


Figure 7.4.1.6.2B: Pre-Post Changes in Lateral Regions



Abbreviations: Y- yoga, C-control, LR- Left Region, RR- Right Region, CR- Central Region, LR+RR- Left and Right Region.

7.4.2 PSYCHOLOGICAL MEASURES

Repeated measures ANOVA was performed to evaluate Within-Subjects factors (times), Between-Subjects factors (groups) and group-time interaction for the different parameters of psychological wellbeing; (i) Depression, (ii) Anxiety, (iii) Self-esteem, (iv) Working memory and (v) Mental wellbeing. Group means and SDs for all variables are given below together with their graphical representations.

7.4.2.1 Depression

Total scores of CDI-2, sub-scale scores and scores of each domain were analyzed separately to determine the current depression status of participants. Baselines matched on total score of CDI-2 ($p = 0.125$), sub-scale; functional problems ($p = 0.404$) and domains; ineffectiveness ($p = 0.799$) and interpersonal problems ($p = 0.111$). In contrast, groups differed on emotional problems ($p = 0.002$) sub-scale and mood/physical symptoms ($p = 0.041$) and negative self-esteem ($p = 0.046$) domain.

After controlling for baseline effects, Analysis of Covariance (ANOCOVA) found significant between groups difference on emotional problems [$F(1, 69) = 10.77, p=0.002$], mood/physical symptoms score [$F(1, 69) = 6.88, p=0.011$], negative self-esteem [$F(1, 69) = 21.36, p < 0.001$]. Repeated measures ANOVA showed significant difference in times (pre-post) scores for T_CDI [$F(1,70) = 169.93, p < 0.001$]; sub scales: EP [$F(1,70) = 52.44, p < 0.001$]; FP [$F(1,70) = 30.34, p < 0.001$]; domains: M/PS [$F(1,70) = 10.59, p = 0.002$]; NSE [$F(1,70) = 45.78, p < 0.001$]; IE [$F(1, 70) = 41.56, p < 0.001$] and group-time interaction showed significant improvement for the same variables; T_CDI [$F(1,70) = 82.37, p < 0.001$]; sub scales: EP [$F(1,70) = 34.20, p < 0.001$]; FP [$F(1,70) = 9.16, p = 0.003$]; domains: M/PS [$F(1,70) = 15.93, p < 0.001$]; NSE [$F(1,70) = 11.35, p = 0.001$]; IE [$F(1,70) = 6.0, p = 0.017$]. No significant between group differences were observed, nor for group-time interactions in IP,

domain four. Within the yoga group; significant improvements were observed in; Total CDI-2 score ($p < 0.001$), sub scales: EP ($p < 0.001$) and FP ($p < 0.001$), Domains: M/PS ($p < 0.001$), NSE ($p < 0.001$) and IE ($p < 0.001$) but a trend was observed in the domain IP ($p = 0.053$).

Within control group; significant improvements were observed in; Total CDI-2 scores ($p = 0.008$), Domains: NSE ($p = 0.022$) and IE ($p = 0.008$).

Table 7.4.2.1: Result of total, sub-scale and each domain of CDI							
Variables		Group	Pre M ±SD	Post M±SD	% change	Diff	Group* Time
Total score	T_CDI	Y (n=38)	27.95 ± 3.18	19.74 ±2.61***	29.37	-8.21	< 0.001
		C (n=34)	26.68 ±3.76	25.21 ±4.71	5.51	-1.47	
Sub Scales	EP	Y (n=38)	15.45 ±2.42	10.47 ±3.00***	32.23	-4.97	< 0.001
		C (n=34)	13.74 ±2.15	13.21 ±3.10	3.86	-0.53	
	FP	Y (n=38)	12.50 ±2.06	9.26 ±2.73*** ^c	25.92	-3.24	0.003
		C (n=34)	12.94 ±2.40	12.00 ±3.02	7.26	-0.94	
Each Domain	M/PS	Y (n=38)	8.87 ±2.02	6.26 ±2.70*** ^b	29.43	-2.61	< 0.001
		C (n=34)	7.82 ±2.25	8.09 ±2.61	3.45	0.27	
	NSE	Y (n=38)	6.58 ±1.57	4.21 ±1.68***	36.02	-2.37	0.001
		C (n=34)	5.91 ±1.16	5.12 ±1.85* ^a	13.37	-0.79	
	IE	Y (n=38)	8.39 ±1.67	5.84 ±2.03***	30.39	-2.55	0.017
		C (n=34)	8.29 ±1.66	7.15 ±2.15*** ^a	13.75	-1.15	
	IP	Y (n=38)	4.11 ±1.48	3.42 ±1.93 ^b	16.79	-0.69	0.083
		C (n=34)	4.65 ±1.35	4.85 ±2.03	4.3	0.21	

Abbreviations: T-CDI- Total of Children Depression Inventory, EP- Emotional Problems, FP- Functional Problems, M/PS- Physical Symptoms, NSE- Negative Self-Esteem, IE- Ineffectiveness and IP-interpersonal problems, **Legend:** Yoga group shows significant improvement in all the comparisons of CDI. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (Within group comparisons) ^a $p < 0.05$, ^b $p < 0.01$, ^c $p < 0.001$ (Between group post-post comparisons)

Figure 7.4.2.1A: Pre-Post Changes in Total CDI Score

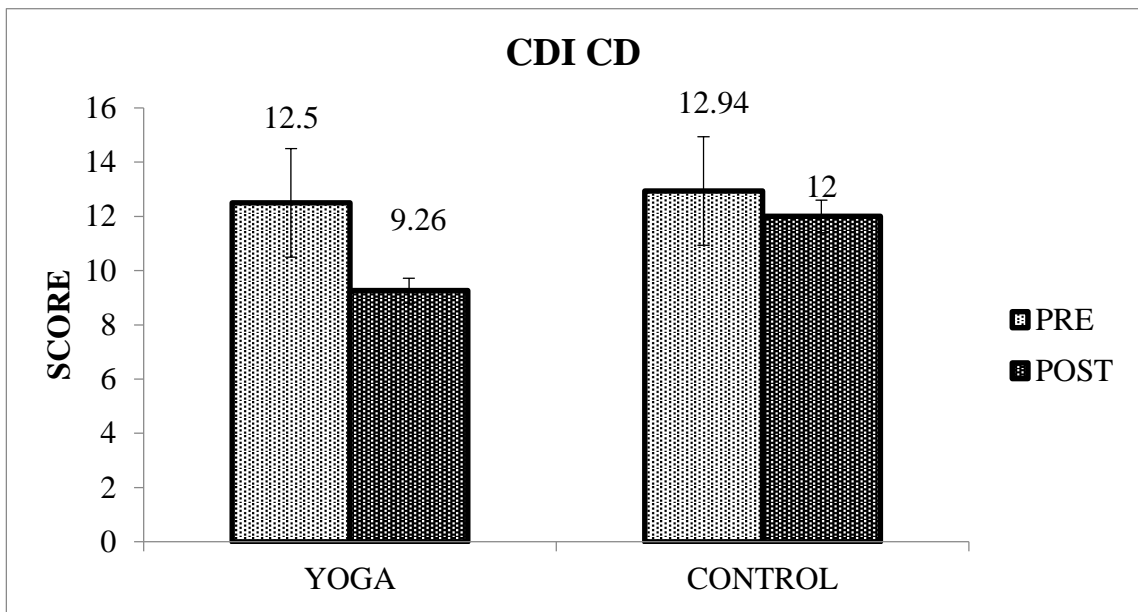
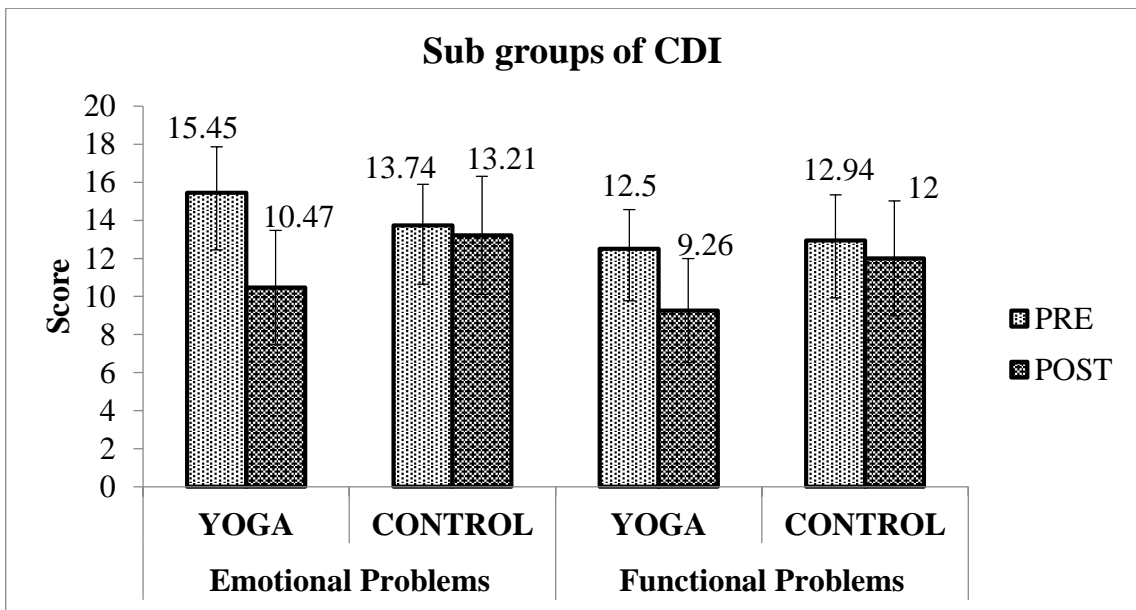


Figure 7.4.2.1B: Pre-Post Changes in CDI Sub Group Scores



7.4.2.2 Anxiety

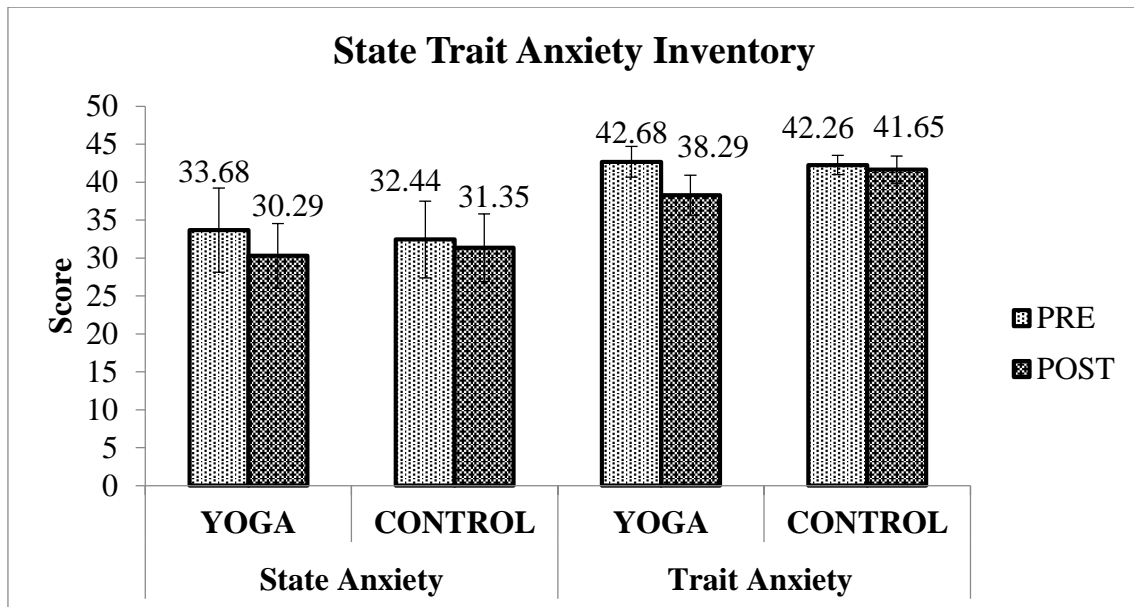
Both subscales of the State Trait Anxiety Inventory (STAI), State Anxiety Scale (STAI-S) and Trait Anxiety Scale (STAI-T) were evaluated to measure participants' current state of anxiety and anxiety proneness respectively.

Baseline data matched between groups on both subscales; STAI-S ($p = 0.326$) and STAI-T ($p = 0.305$). Repeated measures ANOVA showed significant difference between pre and post (times) scores for STAI-T [$F(1,70) = 148.09, p < 0.001$] and a group-time interaction [$F(1,70) = 84.09, p < 0.001$], while the STAI-S showed significant differences between pre and post (times) scores [$F(1,70) = 10.17, p = 0.002$]. No significant group-time interactions were observed for STAI-S scores.

Within group changes; the yoga group showed significant improvements in both subscales. STAI-S ($p < 0.001$) and STAI-T ($p < 0.001$). In contrast, the control group only showed a significant trend on the T-Anxiety subscale, $p = 0.043$ was much less significant.

Table 7.4.2.2: Results of State Trait Anxiety Inventory						
Variables	Group	Pre M ±SD	Post M±SD	% change	Diff	Group* Time
STAI_S	Y (n=38)	33.68 ±5.55	30.29 ±4.27***	10.07	-3.40	0.105
	C (n=34)	32.44 ±5.05	31.35 ±4.46	3.36	-1.09	
STAI_T	Y (n=38)	42.68 ±2.04	38.29 ±2.64*** ^c	14.39	-4.40	< 0.001
	C (n=34)	42.26 ±1.26	41.65 ±1.79*	2.97	-0.62	
Abbreviations: State Anxiety Scale (STAI-S) and Trait Anxiety Scale (STAI-T) Legend: Yoga group shows significant improvement in both the sub scales of STAI. [*] $p < 0.05$, ^{**} $p < 0.01$, ^{***} $p < 0.001$ (within group comparisons) ^c $p < 0.001$ (between group post-post comparisons)						

Figure 7.4.2.2: Pre-Post Changes in STAI Scores



7.4.2.3 Self-Esteem

Baseline differences between groups were not significant ($p = 0.739$).

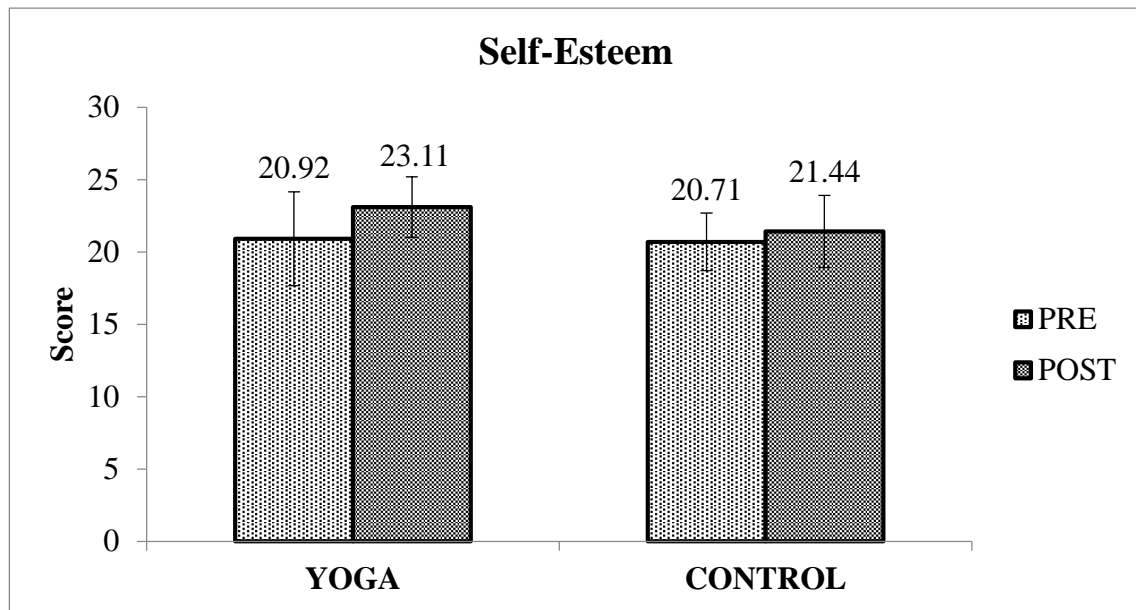
Repeated measures ANOVA showed significant differences between pre and post (times) scores for mean interval of self-esteem [$F(1, 70) = 15.20, p < 0.001$]. Group-time interaction differences showed a strong trend [$F(1, 70) = 3.74, p = 0.057$].

Pre-post intervention within group improvement was significant ($p < 0.001$) for the yoga group (Table 7.3.1.3), but within group changes were not significant for controls ($p = 0.181$).

Variables	Group	Pre M ± SD	Post M±SD	% change	Diff	Group* Time
Self-Esteem	Y (n=38)	20.92 ±3.24	23.11 ±2.09*** ^b	10.47	2.18	0.057
	C (n=34)	20.71 ±1.99	21.44 ±2.49	3.52	0.74	

Legends: Yoga group shows significant improvement in the score of Self-Esteem
 *** $p < 0.001$ within group comparisons.
^b $p < 0.01$ between group post-post comparisons.

Figure 7.4.2.3: Pre-Post Changes in Self-Esteem Scores



7.4.2.4 Working Memory

Four different N back test scores; N back test1 hit score (NBT1-H), N back test1 missed score (NBT1-M), N back test2 hit score (NBT2-H), N back test2 missed score (NBT2-M) were evaluated to measure participants working memory. (Table 7.4.2.4.1)

Baseline data matched for the two groups on all measurements; NBT1-H ($p = 0.052$), NBT1-M ($p = 0.768$), NBT2-H ($p = 0.114$) and NBT2-M ($p = 0.114$).

Repeated measures ANOVA showed significant differences on pre and post (times) scores for NBT1-H [$F(1,70) = 16.72, p < 0.001$] and NBT1-M [$F(1,70) = 10.67, p = 0.002$], but no significant differences were observed for NBT2-H [$F(1,70) = 1.80, p = 0.184$] or NBT2-M [$F(1,70) = 1.80, p = 0.184$]. Group-time interaction showed significant improvement for NBT1-H [$F(1,70) = 12.28, p = 0.001$], NBT2-H [$F(1,70) = 12.61, p = 0.001$] and NBT2-M [$F(1,70) = 12.61, p = 0.001$], but no significant differences were observed for NBT1-M [$F(1,70) = 1.44, p = 0.234$].

Significant within group improvements were observed for the yoga group in all comparisons of NBT; NBT1-H ($p < 0.001$), NBT1-M ($p = 0.001$), NBT2-H ($p < 0.001$) and NBT2-M ($p < 0.001$). In contrast, control group did not exhibit significant improvement on any.

Table 7.4.2.4: Result of N Back Test						
Variables	Group	Pre M ± SD	Post M± SD	% change	Diff	Group* Time
NBT1-H	Y (n=38)	8.08 ±0.82	8.84 ±0.37*** ^a	0.71	0.76	0.001
	C (n=34)	8.47 ±0.86	8.53 ±0.71	82.61	0.06	
NBT1-M	Y (n=38)	0.92 ±0.82	0.16 ±0.37** ^a	42.68	-0.76	0.234
	C (n=34)	0.82 ±1.83	0.47 ±0.71	14.18	-0.35	
NBT2-H	Y (n=38)	9.66 ±2.65	11.03 ±2.30*** ^a	5.9	1.37	0.001
	C (n=34)	10.50 ±1.62	9.88 ±1.98	16.43	-0.62	
NBT2-M	Y (n=38)	8.34 ±2.65	6.97 ±2.30*** ^a	8.27	-1.37	0.001
	C (n=34)	7.50 ±1.62	8.12 ±1.98	0.71	0.62	
<p>Abbreviations: N back test1 hit score (NBT1-H), N back test1 missed score (NBT1-M), N back test2 hit score (NBT2-H), N back test2 missed score (NBT2-M)</p> <p>Legend: Yoga group shows significant improvement in all test of N Back test</p> <p>** $p < 0.01$, *** $p < 0.001$ within group comparisons.</p> <p>^a $p < 0.05$ between group post-post comparisons.</p>						

Figure 7.4.2.4A: Pre-Post Changes in N Back-Hit Scores

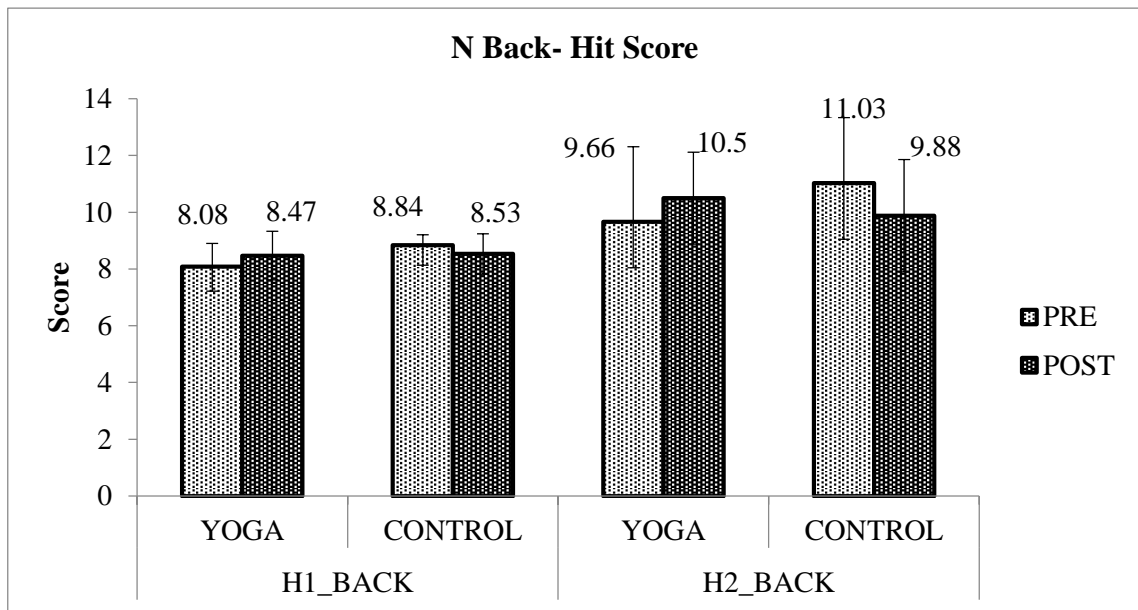
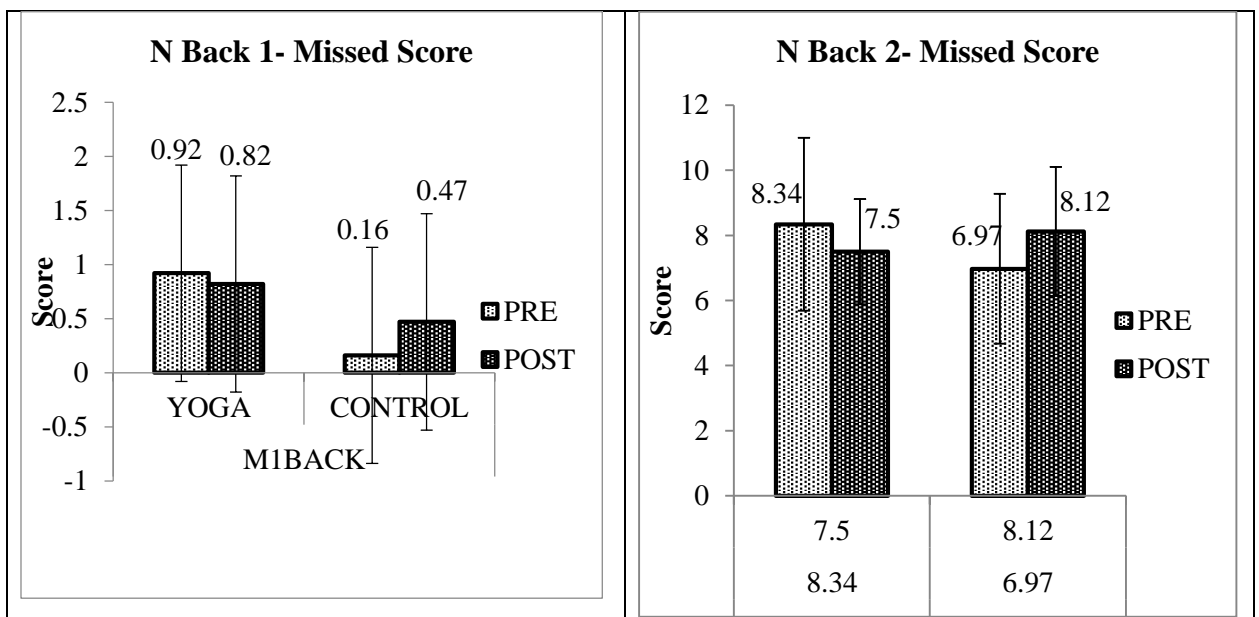


Figure 7.4.2.4B: Pre-Post Changes in N Back-Missed Scores



7.4.2.5 Mental Wellbeing

Total scores and all GHQ sub-scale scores were analyzed to assess participants' mental wellbeing. (Table 7.4.2.5.1)

Baseline data matched for the two groups on all measurements; total score of GHQ ($p = 0.275$), sub scale; SS ($p = 0.524$); AI ($p = 0.334$); SDF ($p = 0.627$) and SP ($p = 0.118$). Repeated

measures ANOVA showed significant differences between pre and post (times) scores for T_CDI [$F(1,70) = 39.17, p < 0.001$]; sub scales: SS [$F(1, 70) = 14.17, p < 0.001$]; SDF [$F(1,70) = 21.82, p < 0.001$] and SP [$F(1,70) = 5.72, p = 0.020$], but no significant difference was observed for subscale AI [$F(1,70) = 5.72, p = 0.276$]. Group-time interaction showed significant differences for the variables; T_CDI [$F(1,70) = 18.68, p < 0.001$]; and subscales: SS [$F(1,70) = 6.10, p = 0.016$]; AI [$F(1,70) = 5.34, p = 0.024$]; SDF [$F(1,70) = 4.56, p = 0.036$], but no significant difference was observed on subscale SP [$F(1,70) = 1.46, p = 0.231$]. Significant within group improvements were seen for the yoga group in all GHQ scales; T_GHQ ($p < 0.001$), and subscales: SS ($p < 0.001$), AI ($p < 0.015$), SDF ($p < 0.001$) and SP ($p < 0.010$). In contrast, the control group showed none.

Table 7.4.2.5: Results of General Health Questionnaire								
Variables		Group	Pre M± SD	Post M± SD	% change	Diff	Group* Time	
Total score	GHQ	Y (n=38)	9.82 ±3.92	6.76 ±2.52*** ^b	31.16	-3.05	< 0.001	
		C (n=34)	8.97 ±2.29	8.41 ±2.48	6.24	-0.56		
Sub Scales	SS	Y (n=38)	1.63 ±1.22	0.79 ±0.87* ^a	51.53	-0.84	0.016	
		C (n=34)	1.47 ±0.86	1.29 ±0.97	12.24	-0.18		
	AI	Y (n=38)	1.26 ±1.69	0.68 ±0.90***	46.03	-0.58	0.024	
		C (n=34)	0.91 ±1.33	1.12 ±1.01	23.08	0.21		
	SDF	Y (n=38)	5.68 ±1.04	4.50 ±1.33* ^b	20.77	-1.18	0.036	
		C (n=34)	5.79 ±0.84	5.35 ±1.20	7.6	-0.44		
	SP	Y (n=38)	1.24 ±1.36	0.79 ±0.91***	36.29	-0.45	0.231	
		C (n=34)	0.79 ±0.95	0.65 ±0.95	17.72	-0.15		
	Abbreviations: GHQ- General Health Questionnaire, SS- Somatic Symptoms, AI- Anxiety and Insomnia, SDF- Social Dysfunction, SP- Severe Depression Legend: Yoga group shows significant improvement in the score of GHQ * $p < 0.05$, *** $p < 0.001$ within group comparisons. ^a $p < 0.05$, ^b $p < 0.01$ between group post-post comparisons.							

Figure 7.4.2.5A: Pre-Post Changes in General Health Questionnaire score

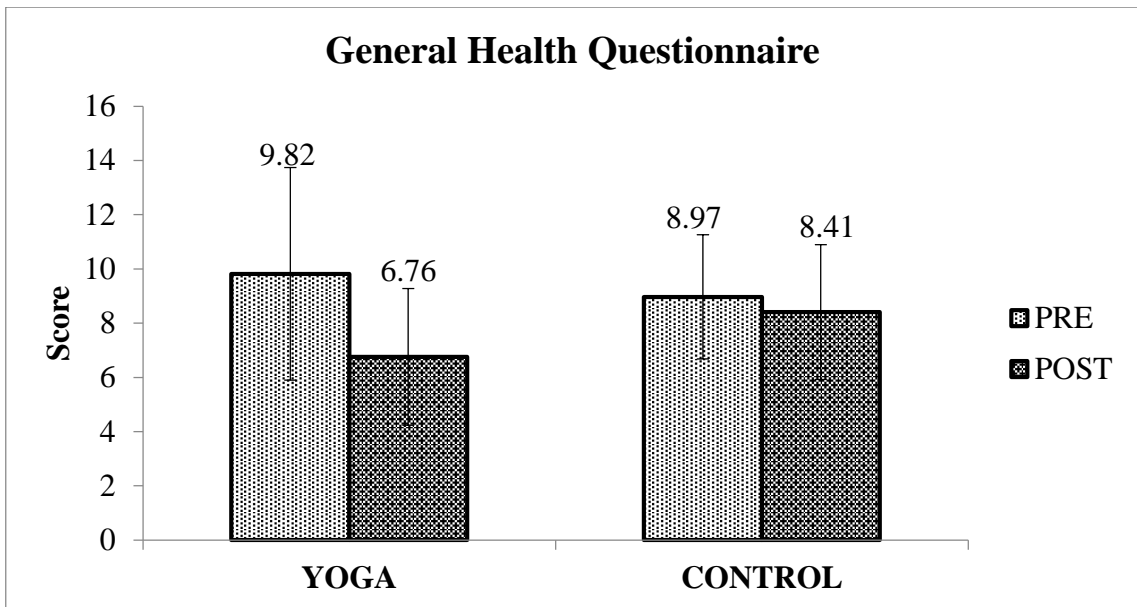
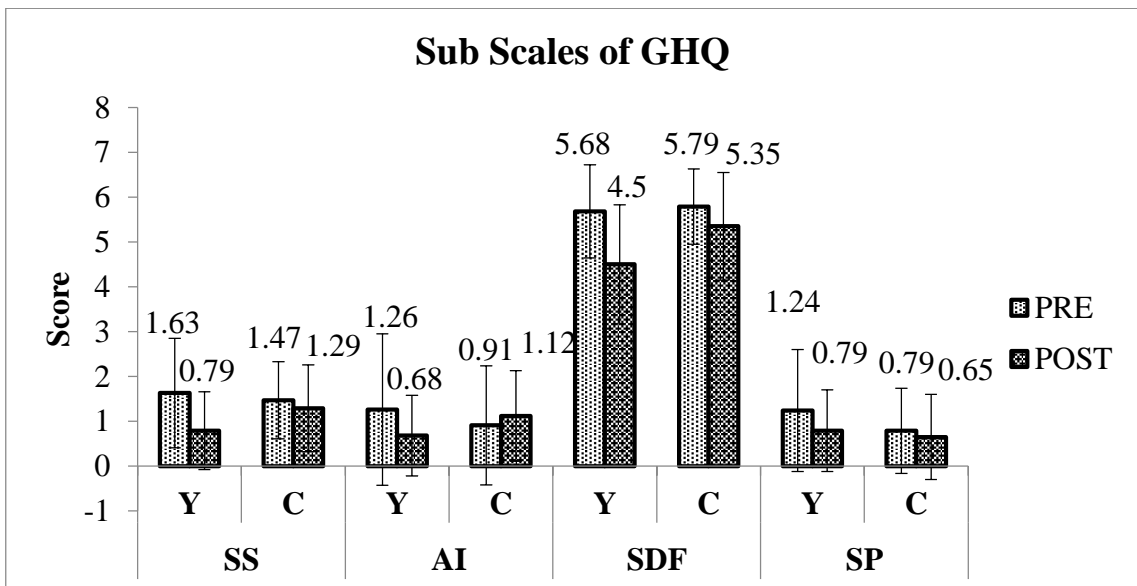


Figure 7.4.2.5B: Pre-Post Changes in sub scale of GHQ scores



Abbreviations: Y- Yoga, C-Control, GHQ- General Health Questionnaire, SS- Somatic Symptoms, AI- Anxiety and Insomnia, SDF- Social Dysfunction and SP- Severe Depression.

CHAPTER 8

DISCUSSION

Key Messages

- Rejecting the null hypothesis, yoga group showed significant improvement in all physical and psychological variables.
- The yoga intervention used in this study was an integrated module that included practices stretching the joints while maintaining mindful awareness.
- The practices followed by relaxation to produce calmness of mind and heightened internal awareness possibly influence the health level.
- Calming a restless mind is a major goal of yoga. Practice of meditation in particular strengthens mental resolve, decreasing depression, anxiety,
- No adverse events occurred during yoga classes in our study.
- Yoga may be considered as complementary therapy or alternative physical activity for students with VI.

8.0 DISCUSSION

The present study was a non-randomised, wait list control study. It examined effects of 16 weeks yoga training on physical and psychological health of children with VI. To impart yoga in an effective way, a special five step teaching method was developed for the children, for which 78.8% of children chose the physical guidance step as their preferred mode of learning. A yoga module was developed and validated, and its feasibility was evaluated for a visually impaired population. In the main study, a yoga group of 41 children was compared with a control group of 42 wait-listed children. All were aged 9 to 16 years. The yoga group showed significant improvement in muscle strength, muscle endurance, flexibility, motor speed, coordination, both static and dynamic balance, self-esteem and verbal memory, and statistically significant reductions in anxiety and depression after the intervention.

In the wait list control group, within group comparison showed significant improvement in both hands coordination; right ($p = 0.005$) and left hand ($p = 0.005$), and CDI ($p = 0.008$) and strong trends in PEFR ($p = 0.047$), HGS_LH ($p = 0.043$), STAI_T ($p = 0.043$), though the three could have been statistical fluctuations considering the overall number of individual tests. Magnitudes of improvement were consistently higher for the yoga group than controls. These encouraging findings confirm the applicability of the yoga module for enhancing physical and psychological health of children with VI.

8.1 PREFERRED MODE OF LEARNING YOGA AMONG THE FIVE STEPS

Summary

The first objective was to develop an acceptable yoga-teaching protocol for children with VI, focusing on their primary needs and challenges. Investigation of students' preferred method of learning revealed that of the five teaching techniques, "physical assistance with verbal guidance" was most favoured by the children, with "tactile modeling with verbal guidance" as

second choice. “Learning in a group,” “verbal guidance,” and “step-by-step teaching” were third, fourth, and fifth respectively. This indicates that children preferred the touch and feel mode of learning compared to the others.

Comparison

Findings are consistent with previous studies showing that physical guidance is a successful teaching method for acquiring skills in students with VI (Erwin, 1996; Lane, 1996). Another study found physical guidance to be the preferred instructional strategy for learning to swim (Cieslak, 2013). In contrast, another study suggested that those children with VI who happen to be hesitant about physical touch may prefer tactile modeling as a mode of teaching (O’Connell, Lieberman, & Susan, 2006). Our observations found students initially protective, but to prefer individual guidance over tactile models after becoming familiar with instructors. A possible reason: physical assistance clarifies movements required in each practice by physically aligning body parts (Lieberman, 2005), and may provide kinesthetic cues to transmit clear ideas about the posture.

Like physical guidance, tactile modeling is also effective, and has been found the preferred mode of teaching for some children with VI (O’Connell et al., 2006). For us, “tactile modeling” was second choice possibly because it was only used for some of the practices.

“Learning in a group” was the students’ third favoured method, but was close to their second choice, possibly because the sense of touch is used in both. Although “verbal guidance” is essential as the fundamental technique for transmitting mental images (Ishmael, 2015), it was only fourth choice. Possibly because students were first-time yoga practitioners, verbal guidance could not provide a clear conception of each practice. This is supported by the idea that the auditory sense is not the only compensatory sense used by those with VI when acquiring much needed practical skills (Kohler, 2006).

8.2 VALIDATION AND FEASIBILITY OF THE YOGA MODULE

The thesis reports development of an inclusive yoga module based on different yogic texts, recent scientific studies and suggestions from experts. Most traditional texts emphasize spiritual aspects of yoga practice rather than therapeutic aspects. In ancient times yoga may have been practised only for spiritual upliftment; complete health was achieved automatically when practising yoga to attain higher state of consciousness. But contemporary texts have presented detailed health benefits of its various practices. Hatha yoga texts emphasize improving health through yoga practices, so the yoga module was mainly based on them.

Experts included in the study were from different schools of yoga and 20% (5 of 25) experts followed multiple schools of yoga. This was considered important in their selection, so the module should not be biased by a particular school of yoga, as occurred in some earlier studies (Govindaraj, Varambally, Sharma, & Gangadhar, 2016; Hariprasad et al., 2013). All selected experts were actively involved in yoga teaching, especially for children. 36% (9 of 25) of them had a research background too. This balance strengthened the study as experts involved only in research sometimes lack practical experience. Inclusion of physical trainers of visually challenged children added strength to the validation process.

The validation process was completed after two rounds of iteration, after each of which CVR criteria were used to retain or reject each practice. The first iteration retained practices supported by more than 50% of the experts for the next round. This was done manually in accordance with the concept of CVR calculation (Lawshe, 1975). The iteration process was supported by earlier studies (Jagannathan et al., 2012). In the second round of iteration, the CVR was calculated for each practice; practices scoring CVR of 0.37 or more were retained. Application of CVR at two levels made the module more representative and less biased.

Experts (75%) suggested teaching jogging and jumping with caution, but students enjoyed these practices more. Experts recommended that the *Kriyas* (cleansing practices) should be added to the yoga module, but stipulated that each practitioner should be individually taught with special care. An earlier study of children with VI had incorporated cleansing practices in the list (Mohanty et al., 2014). In this study, the feasibility of these cleansing practices could not be evaluated as the time offered by the school authorities for yoga practice was inappropriate. The module was found feasible. It showed significant improvement on the Tennis Ball Throw Test, but change on the Standing Vertical Jump Test was not significant. This discrepancy may be due to the short intervention duration. Most of the children found it difficult to remember the entire sequence of the yoga module and complete it independently. Even yoga instructors found it difficult to instruct all practices within the one-month time period. Both the children and instructors suggested extending the training period for two to three months. The instructors observed that two to three full months would be required for the children to learn and memorise all the practices fully.

8.3 PHYSICAL FITNESS OUTCOMES

8.3.1 Muscle Strength

a) Handgrip Strength

Summary

The hand grip strength was measured bilaterally: strength of left hand increased by 7.72% in the yoga group and 3.04 % in the control group, and the strength of right hand increased by 32.26 % in the yoga group and 1.98% in the control group. Between group difference was significant in right hand strength ($p < 0.001$).

Comparison

Results agree with previous findings reporting significant improvement in both right hand (15.78kg to 18.5kg, 17.27%) and left hand (14kg to 18.6kg, 32.86%) in orphan children age

11–16 years after a 3 month yoga intervention (Purohit, Pradhan, & Nagendra, 2016). Another study similarly observed significant improvement in hand grip strength for both hands in 12–15 years school children after six months yoga *asanas* and *pranayama* training (Madanmohan et al., 2003). Benefits of yoga for muscle strength have also been seen in children diagnosed with bronchial asthma, aged 7 to 12 years after a 7 week yoga training (Chen et al., 2009). In contrast, two other yoga studies showed no significant improvement: one, after a 3 month yoga program for children aged 8 to 13 years (Telles et al., 2013), and a second on healthy school children aged 7 to 9 years (D' souza & Avadhany, 2014). This disparity may be attributed to many factors, including differences between intervention and population characteristics. Possible reasons for previous studies' inconsistent findings are comparative effects on yoga and controls. First, certain yoga intervention programs may not provide a sufficient duration to produce a change, particularly in those with low attendance, adherence, or intensity (< 1 session per week) or insufficient intervention periods (< 3 months). Secondly, yoga's efficacy to improve children's muscle strength may vary with types of yoga practices.

Comparison with other modes of intervention

A study was conducted comparing goalball team players and non-players with varying degrees of blindness. After 6 hours per week training the goalball groups had higher grip strength than control groups (Tuncay et al., 2004). Goalball includes various physical movements which are likely to increase the strength within short duration of intervention.

b) Pinch Strength (PS)

Summary

Results demonstrated significant improvements in PS for both hands: mean score for the RH increased from 2.62 to 3.64; for LH from 2.54 to 3.00 in in the yoga group. Practicing yoga is associated with increased neuro-muscular coordination and muscle strength, which may be the reason for the observed improvement.

Comparisons

To the best of our knowledge, this was the first study of the effect of yoga on pinch strength in children with VI. Lack of literature meant that we had nothing to compare results with. One study, which provides some data with which to compare with our study (El-Katab, Omichi, Srivareerat, & Davenport, 2015), considered PS and hand grip strength alternatives for assessing muscle strength.

c) Elbow Strength

Summary

Elbow strength was evaluated bilaterally in two different positions; flexion and extension. Elbow flexion strength significantly increased the mean score from 6.03 to 6.46 in the right hand and from 5.97 to 6.28 in the left hand; Elbow extension strength significantly increased the mean score from 4.92 to 6.03 in the right hand and from 4.56 to 5.74 in the left hand. In comparison, the control group did not demonstrate significant result in elbow strength in any position.

Comparisons

An earlier study of normal sighted children found significantly greater upper extremity strength: after practice of *Suryanamaskara* for 24 weeks, pectoralis, triceps and deltoids were assessed through bench press and shoulder press technique respectively (Bhutkar et al., 2011). Differences in intervention and strength outcome limits result comparison.

Comparison with other modes of intervention

A study of goalball players found no significant improvement in elbow flexion ($p = 0.757$) and extension ($p = 0.981$) compared to non-goalball players (Tuncay et al., 2004). However, practice effect size may not bring large enough changes in those muscle groups.

d) Knee Strength

Summary

Reduced level of lower body strength holds greater problems than upper body strength as it relates to balance and the possibility of falling. Knee strength was evaluated bilaterally in two different positions; extension and flexion. Mean score of extension strength increased from 6.23 to 6.57 in the right leg and from 6.22 to 6.72 in the left leg; mean score of flexion strength increased from 5.09 to 6.11 in the dominant leg and from 5.18 to 6.24 in the non-dominant leg in the yoga training group. The control group showed no improvement in either position. Group-time interaction differences were significant ($p < 0.05$) for all four cases.

Comparisons

Results agree with previous research that found yoga significantly improved lower body muscle strength and back muscle strength in normal sighted children (Bhutkar et al., 2011). A significant post intervention improvement has also been observed in calf muscle strength in a yoga group (D' souza & Avadhany, 2014).

Comparison with other modes of intervention

To the best of our knowledge no previous intervention studies have measured lower extremity strength in children with VI. Ours is the first.

e) Minimum Muscular Fitness

Summary

Pass rate on Minimum Muscular Fitness increased from 12.2 to 68.3% (5 to 28) participants in the yoga group, but only from 23.1 to 30.8 % (9 to 12) among controls. Pre-post assessment found that yoga group showed three times more improvement in muscles fitness performance whereas control group pass percentage was minimal. Results of the study show that 16 weeks yoga training increases minimum muscular fitness in children with VI, rejecting the null hypothesis.

Comparison

This is consistent with previous findings on normal school children where yoga practice achieved significant improvements in Minimum Muscular Fitness measured by the K-W test (Gharote, 1976). Other studies have also reported statistically significant increases in muscle strength, and flexibility in different groups of muscles through yoga practice (Chen et al., 2009; Madanmohan et al., 2003; Purohit et al., 2016; Telles et al., 2013).

Mechanism

Mechanisms underlying yoga's beneficial effects on muscle strength remain inadequately understood. Muscle strength depends on sustained stretch or contraction of muscle groups. Yoga practices such as *Suryanamaskara* and its various loosening practices alternately stretch and relax different muscle groups throughout the body providing benefits in short time durations (Bhutkar et al., 2011; Sengupta, 2012). Studies have found beneficial effects on muscle strength from *Suryanamaskara* practice in normal sighted individuals (Bhavanani et al., 2011; Bhutkar et al., 2011). *Pranayama* practice, which is also an important component of yoga, and part of our module, has also demonstrated positive effects on muscle strength (Raghuraj et al., 1997) in normal sighted children. Mental training (ability to concentrate) is thought to enhance cortical output signals, and drive muscles to higher levels of activation, increasing their strength (Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004). The yoga intervention used in this study was an integrated module that included practices of stretching muscles while maintaining mindful awareness, followed by relaxation to produce calmness of mind and heightened internal awareness; all these could have influenced muscle strength. In addition, the study also included *Bhujangasana*, *Shalabhasana*, and *Dhanurasana* involving sustained isometric contraction of muscle groups in the abdomen, chest, back, shoulders and arms. Improvement in strength and endurance of these muscles would explain the significant observed increase in muscle fitness in various muscle groups. These are the probable reasons for improvements observed in this

study. Isometric and isotonic muscle contractions can improve muscle strength; muscle stretch can improve muscle control through feedback information from muscles, tendons etc. A balanced set of yoga asanas could therefore improve overall muscle performance by increasing both control and strength.

8.3.2 Muscle Endurance

Summary

In this study, muscular endurance in the yoga group increased between 6.51% and 10.98 % after 16 weeks of training, whereas controls showed no significant improvement. Between group differences were significant ($p = 0.002$). Group-time interaction differences were also significant ($p < 0.001$).

Comparison

The result of this study is in accordance with a previous study which showed significant improvement in muscle endurance after six weeks of intervention (Madanmohan et al., 2003). In another study, the mean score increased from 9.61 to 12.18 after a 3-month intervention (Telles et al., 2013). Our study's longer intervention duration may explain why its result was better than the previous study.

Comparison with other mode of intervention

12 weeks of Gymnastic training resulted in a 26.53% increase in muscle endurance in a group girl with VI aged 7 to 10 years (Hashemi et al., 2012). Our study reported a far greater, 68.66% improvement. The difference may be because participants in that study were only girls in gymnastic training. That study did not mention muscle the stretch and relaxation practices in our yoga module; this again might help explain the differences in results.

Mechanism

Yoga is a mind-body exercise, unique for its slow and graceful movements. Alternate contraction and relaxation of different muscle groups help increase peripheral blood flow to

contracting muscles. Effects may be attributed to increased oxidative capacity of muscle fibres, or increased myoglobin content. Our study's observed increase in muscle endurance may be ascribed to the static, passive stretching of yoga postures. Another explanation may attribute increased muscle endurance to decreased neuromuscular activity in antagonist muscles (Tran, Holly, Lashbrook, & Amsterdam, 2001); so yoga practices in our study, involving relaxation and mindful movements, may have reduced antagonist muscle activity.

8.3.3 Flexibility

Summary

Development and maintenance of levels of flexibility are important components of general health enhancement programs. This study shows that regular long-term practitioners of yoga exhibited better trunk and hamstring flexibility than the control group.

Comparison

Results confirm those of Chen et al., (2009) who reported significantly superior performance by children diagnosed with bronchial asthma after a 7-week yoga intervention compared to controls. They also agree with another study on orphan children where the yoga group showed significant improvement after a 12-week intervention (36.15 to 39.84) while performance of controls reduced significantly (37.45 to 35.73) (Purohit et al., 2016).

Comparison with other modes of intervention

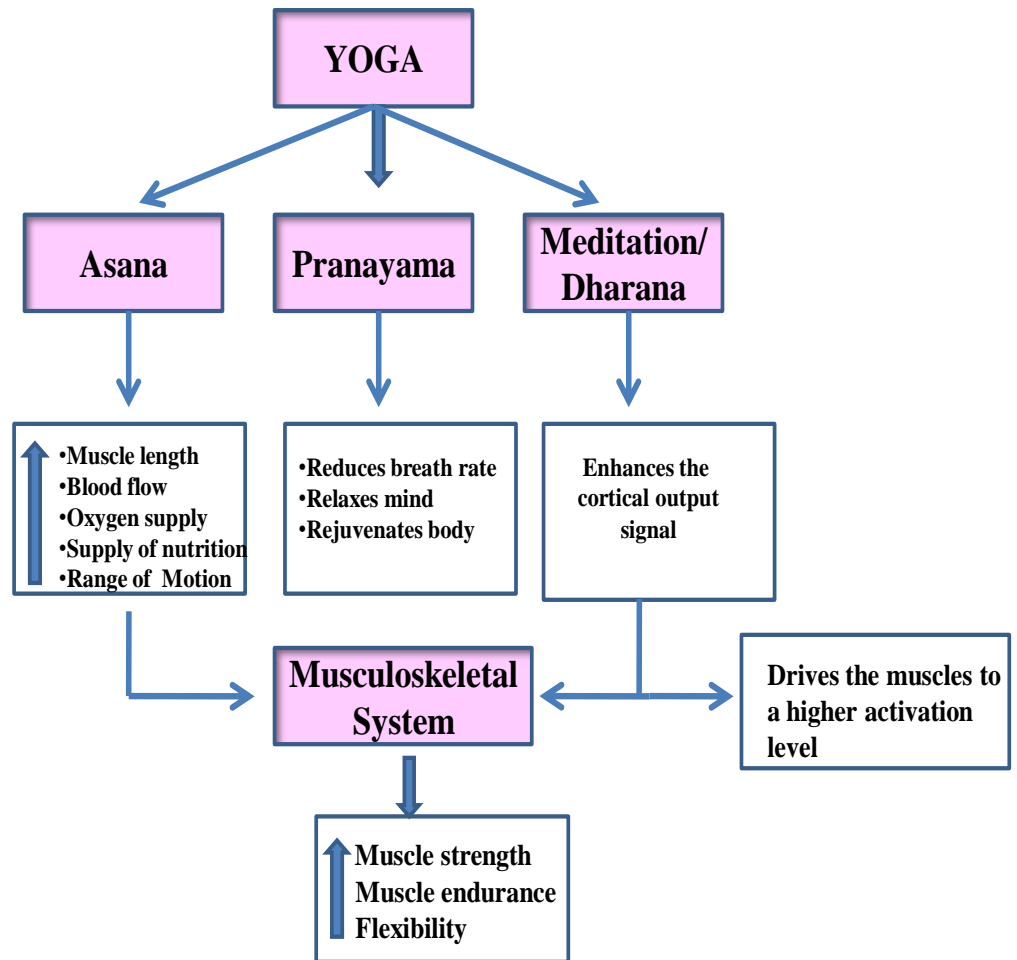
Our results are in agreement with previous research on children with VI using different modes of intervention; a 10-week Rope Jumping training significantly improved flexibility in 16 visually impaired children (Chena & Linb, 2011). 12 weeks Gymnastic Skills training significantly improved trunk and hamstring flexibility (0.998 to 2.42) in visually impaired girls aged 7 to 10 years, compared to reduced scores in the control group (1.23 to 0.986) (Hashemi

et al., 2012). Greater flexibility scores were observed in goalball players compared to non-goalball players with all degrees of visual impairment (Tuncay et al., 2004).

Mechanisms

Yoga sessions bend joints through their full range of motion, squeezing and soaking not often used areas of cartilage with synovial fluid bringing fresh nutrients, oxygen and blood to those areas. Continued practice increases range of motion, gradually loosening muscles and connective tissues surrounding bones and joints. Increased connective tissue length can occur by plastic elongation (Kottke, Pauley, & Ptak, 1966), while increased muscle length can be brought about by addition of sarcomeres to the ends of muscle fibres (Barnett, Holly, & Ashmore, 1980; Williams & Goldspink, 1971). Yoga asanas involve static stretching, which exerts beneficial effects on flexibility by increasing the length of both connective and muscle tissue (Williams & Goldspink, 1973). Yoga practice combines rotation movements of head, trunk, and extremities, and asymmetrical diagonal arm and leg movements around the waist. All these elements can benefit hip, trunk, and arm rotation ability. Increased trunk and hamstring flexibility, improve sit and reach scores. All these are possible reasons for improvements observed in this study.

Figure 8.3.1 Mechanisms by which yoga may improve musculoskeletal system problems



8.3.4 Motor Speed

Summary

Significant changes in the finger tapping task were observed in both RH and LH after 16 weeks of yoga training while control group changes did not attain significance. The yoga group’s speed of RH tapping increased by 9.79% while the control group changed by 0.64%; the yoga group’s speed of LH tapping increased by 8.58%, while control group changes, 1.44%, failed to reach significance.

Comparison

Finger Tapping Task results concur with studies on young adults (Telles, Sharma, Yadav, Singh, & Balkrishna, 2014), and computer professionals (Telles, Dash, & Naveen, 2009).

Comparison with other modes of intervention

The Finger Tapping Task is a measure of fine motor coordination (Zöller, Rembeck, & Bäckman, 1997) that has not previously been measured for children with VI. A study has assessed fine motor skills in children with VI aged 6 to 12 years using both a manual skills test and a children's movement assessment (Reimer, Cox Nijhuis-Van der Sanden, & Boonstra, 2011). Results showed age-related progress in children's fine-motor skills.

8.3.5 Coordination

Summary

After the 16 week intervention, both Yoga and control groups showed significant decreases in time needed to perform the plate tapping test in both hands. Greater reductions were observed for the yoga group in both LH (14.39%) and RH (16.57%) compared to controls, LH (2.97%) and RH (3.43%).

Comparison

To our knowledge this is the first study reporting effects of yoga on coordination in children with VI. Very few studies have looked at effects of yoga on coordination in normal sighted children. A 12-week program of yoga practice found significant improvement in coordination in children aged 8 to 13 years (Telles et al., 2013). Also; a recent study found increased coordination after a 3-month yoga training program for orphans (Purohit et al., 2016).

Comparison with Other Modes of Intervention

A 3-month motor training program for visually impaired children showed significant improvement in bilateral and upper limb coordination in the training group (Aki et al., 2007).

Mechanism

The somatosensory cortex, located in the brain's mid region, is responsible for motor control. The basal ganglia, a group of structures deep in the brain, work with other brain regions to smoothly coordinate movement, while the cerebellum integrates input from the brain and spinal cord and helps in the planning of fine and complex motor actions. Yoga practices in the present study must have activated sensory and motor circuits, a possible mechanism for the increases in coordination and motor speed. Another reason may be, with vision absent, proprioception plays a prime role in providing spatial information about limb positions (Ren & Crawford, 2009). A 30-day yoga intervention improves joint proprioception in children with VI (Mohanty et al., 2014), a result confirmed by this study. A possible mechanism is better coordination by improved feedback from stretch in muscle spindles and tendons to the brain (Hindle, Whitcomb, Briggs, & Hong, 2012).

8.3.6 Balance

Summary

In all comparisons of static and dynamic balance, the yoga group showed significant improvements compared to the control group, while neither group showed any improvement in static balance at 20 sec. One possible explanation may be that 20 secs is an insufficient time period for children with VI to maintain balance. At such short times, proprioception may not be optimised or have come into play fully, and visual cues are not there to compensate for proprioceptive build-up. This area requires further research: proprioceptive versus visual contributions for short and long term balance in those with and without VI.

Comparison

The Yoga group had better post intervention scores on Balance than the non-yoga group after 12-weeks training (Berger et al., 2009). An RCT on 30 mentally retarded girls found significant improvement in both static and dynamic balance (Parisa et al., 2015). Despite variations in

balance outcome measures, mode of intervention, and participants, these two studies, like ours, found yoga practice to improve balance. In contrast, two studies fail to find improvements in static balance: the Flamingo Balance Test on 98 school children (Telles et al., 2013), and the Bruininks-Oseretsky Test of Motor Proficiency on 33 girls (Donahoe-Fillmore et al., 2010). Intensity of practice may not have been sufficient to give observable improvements in balance scores in these studies.

Comparison with other modes of intervention

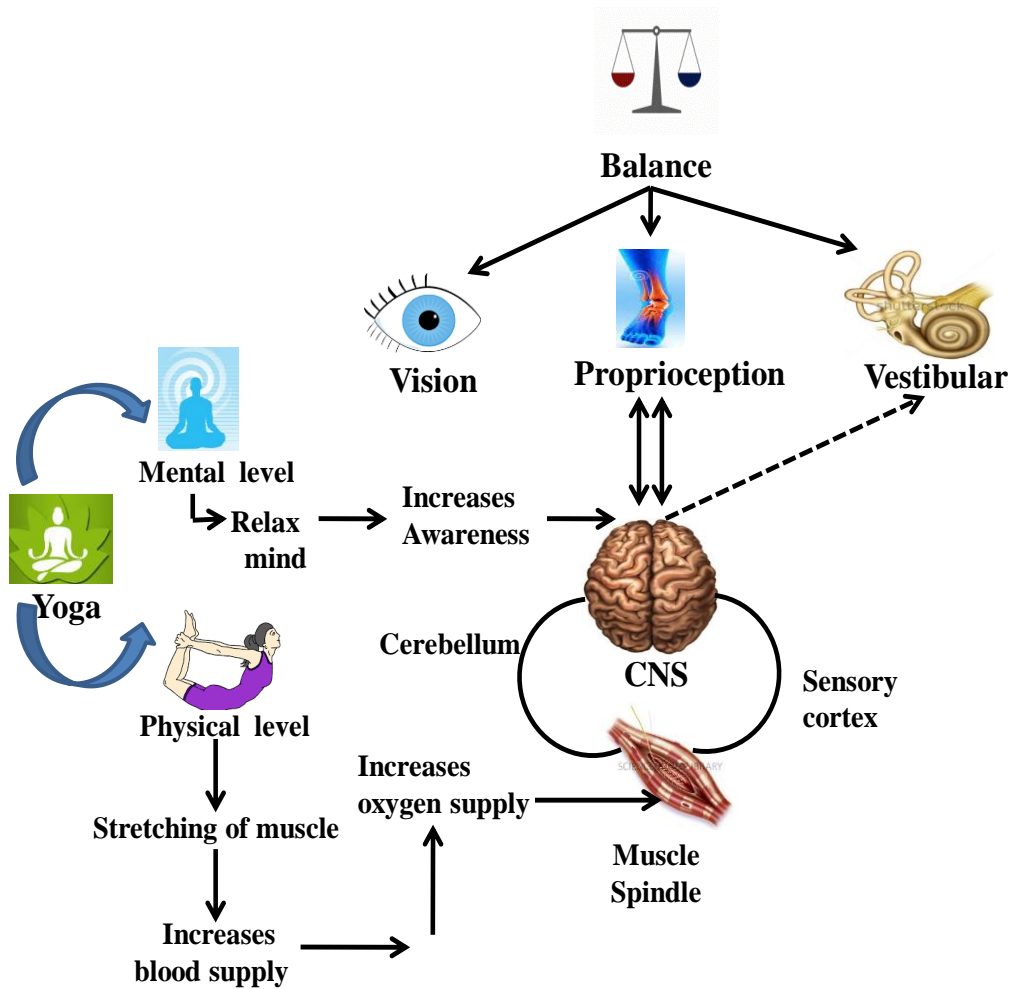
One study found significant improvement in dynamic balance after 8 weeks balance-training: mean score increased from 11.11 to 34.11 (Jazi et al., 2012). Skiing game was found effective on balancing skills in children with VI (Morelli et al., 2014). Combined training in Greek dance and Pilates (Mavrovouniotis et al., 2013) and gymnastic skills (Hashemi et al., 2012) showed significant improvement in both static and dynamic balance in the experimental groups with no improvement in controls. Findings have extensive variation in mode of intervention and balance measures; without a gold standard for balance evaluation, results of different studies cannot be compared to determine the most effective training program.

Mechanism

Balance is maintained, controlled, and monitored integrated proprioceptive, vestibular, and visual sensations, and the somatosensory system. Study results on balance ability may be better interpreted by noting that observed effects could also have been enhanced by changes in: a) Muscle strength: important for posture, stability, and balance (Horvat et al., 2003). Studies find that individuals with stronger knee and ankle muscles have better balance ability (Jadelis, Miller, Ettinger, & Messier, 2001). In one study, knee extension increased by 28% in young adults after 8 weeks hatha yoga practice (Tran et al., 2001). b) Proprioception: An essential factor affecting balance ability (Guo et al., 2014). Yoga inculcates conscious awareness of body position and extremity movements, improving joint proprioception, also improved by 30 days

training in children with VI (Mohanty et al., 2014). c) Vestibular signals: Yoga practice brings greater sensitivity to internal vestibular and proprioceptive signals than external visual cues in a multisensory integration perceptual task (Fiori, David, & Aglioti, 2014). All are plausible reasons for increased static and dynamic balance scores.

Figure 8.3.6: Mechanism of yoga in improving balance



8.3.7 Respiratory Function

Summary

PEFR increased significantly in both the yoga and control groups, more for the yoga group for which mean score increased from 181.22 to 199.51 (10.09%) while controls increased from 204.25 to 208.75 (2.2%). Group-time interaction was also significant ($p < 0.001$).

Comparison

Two studies showed significant improvement in yoga group PEFR after 6 months training (Madanmohan et al., 2003) and 3 months training (D'Souza & Avadhany, 2014). Controls showed no improvement in either study. Specific yoga practices such as *Nadi Shodhana Pranayama* (Sivapriya et al., 2010), *Suryanamaskar* (Kumar et al., 2011), and a slow and fast form of it (Bhavanani et al., 2011) have seen children's PEFR scores significantly improve.

Mechanism

Findings of increased PEFR are not unexpected, the yoga practices include breathing exercises (involving holding breath in stretched positions) and *Pranayama* which may exert beneficial effects on respiratory muscle thus engendering positive results.

8.4 PSYCHOLOGICAL TESTS

8.4.1 Depression and Anxiety

Summary

The Yoga group showed significant decreases in scores on State-Trait anxiety on all subscales: Their reductions of 29.37% (STAI-S) and 14.39% (STAI-T) were larger than those of controls 5.51% and 2.97%. Controls reduction in STAI-T anxiety was significant.

Comparison

No studies have previously assessing effects of yoga on State-Trait anxiety in children with VI. Comparison of our results with similar groups of participants is not possible. They are consistent with previous yoga studies on children with normal vision where anxiety scores

decreased significantly (Carei et al., 2010; Thygeson et al., 2010). In a study of children diagnosed with eating disorders yoga training failed to yield positive effects on anxiety scores (Mitchell et al., 2007). The disparity can be attributed to many factors, including differences between intervention type and duration, population characteristics, and the environment.

8.4.2 Self-Esteem

Summary

Our findings demonstrated significant beneficial effects of yoga for self-esteem ($p < 0.001$). Yoga group mean scores increased from 20.92 to 23.11 (10.47%), while controls mean scores changed from 20.71 to 21.44 (3.52%), not a significant change.

Comparison

Results are consistent with previous studies on children with normal vision, where scores on SE increased significantly after a 3-month yoga intervention (Telles et al., 2013), and an 8-week mindfulness training through yoga (Bridges & Madlem, 2007; White, 2012). But one study found no significant change after a 8-week intervention (Benavides & Caballero, 2009).

8.4.3 Verbal Memory

Summary

In the present study, yoga intervention showed significant improvement in both N-Back test trials. Reduction was seen in missed scores. The controls showed no significant differences.

Comparison

In one study, normal sighted children (Manjunath & Telles, 2004), the Yoga group showed a significant 43% increase in spatial memory score, while the control group showed no change. Verbal working memory is a cognitive system responsible for temporary storage and manipulation of information (Hertzog, Dixon, Hultsch, & MacDonald, 2003). The finding is important because verbal working memory is involved in many daily tasks, from remembering

sequences of numbers such as phone numbers, to understanding long and difficult sentences in normal conversations.

8.4.4 Mental Wellbeing

Summary

The 16 week yoga intervention observed significant difference in total score and all four GHQ subscales, while the control group showed no significant change on any measure.

Comparison

These results agree with previous research finding significantly improved GHQ scores in yoga groups of healthy volunteers (Deshpande, Nagendra, & Raghuram, 2008).

Mechanism

Regarding possible mechanisms, we may hypothesize that yoga's benefits are mediated by: triggering neurohormonal mechanisms that suppress sympathetic activity and reduce levels of psychophysiological arousal (Vempati & Telles, 2002); balancing autonomic nervous system responses (Telles, Nagarathna, Nagendra, & Desiraju, 1993); reduction in neuroendocrine arousal (West, Otte, Geher, Johnson, & Mohr, 2004) and improved HPA axis regulation (Pascoe & Bauer, 2015) resulting in reduction in stress and anxiety (Hoge et al., 2013). More specifically, improvements in psychological health and wellbeing may also be attributed to use of relaxation techniques (Hoge et al., 2013). Calming restless minds is a major goal of yoga (Nagarathna & Nagendra, 2013). Practice of meditation strengthens mental resolve, decreasing anxiety (Telles, Nagarathna, & Nagendra, 1998). Other relevant findings include: a study reporting a 27% increase in GABA levels following a single 60 minute yoga session (Streeter et al., 2007). Lowered levels of: serum cortisol (stress hormone) (Bershadsky et al., 2014), blood pressure (Okonta, 2012), heart rate (Raghavendra et al., 2013) and increased heart rate variability and vagal tone (Papp et al., 2013). All such findings of reduced sympathetic activity

suggest that yoga is effective for treating psychological load in disorders in general population, including load caused by visual impairment in children with VI.

Figure 8.4: Mechanism of yoga in improving psychological health

